attractive reddish-purple appearance but also exhibits strong antioxidant, anti-inflammatory, and anti-diabetic activities (Li et al., 2023). In addition, by-products such as leaves, kernels, and pomace also contain abundant bioactive compounds that can be used for the development of functional foods and natural antioxidant products (Mo et al., 2024). Fruit quality of Chinese bayberry includes both external quality traits, such as fruit size, color, and firmness, and internal quality traits, such as sugar-acid ratio, aroma volatiles, and functional nutritional components. Among them, sucrose is the major soluble sugar in ripe fruits, while citric acid is the predominant organic acid, and together they determine the characteristic sweet-sour flavor of Chinese bayberry.

At present, research on the formation and regulation mechanisms of Chinese bayberry fruit quality has been continuously advancing worldwide. Existing studies have demonstrated that genetic background, ecological environmental conditions, and cultivation management practices significantly affect fruit quality. Different cultivars exhibit obvious differences in fruit size, coloration, sugar-acid content, and accumulation of bioactive compounds, while sugars, organic acids, phenolics, and volatile substances change rapidly during fruit ripening. Ecological factors such as light, temperature, water availability, and soil conditions influence nutrient accumulation and flavor formation, whereas proper fertilization, water management, flower and fruit thinning, protected cultivation, and LED supplemental lighting can effectively improve both external and internal fruit quality (Tang et al., 2025). In addition, technologies such as preharvest melatonin treatment, ozonated water treatment, and low-temperature storage have shown favorable effects in delaying fruit senescence and extending shelf life (Chen et al., 2024).

This study aims to explore the current research status and progress of fruit quality traits and cultivation regulation measures in Chinese bayberry. With the development of molecular biology and omics technologies, important progress has been achieved in understanding the genetic and molecular mechanisms underlying fruit quality formation. Transcription factor families such as MYB and WRKY play important roles in regulating anthocyanin biosynthesis and flavonoid metabolism. Meanwhile, the construction of high-density genetic maps and multi-omics databases has provided new theoretical foundations and technical support for the analysis of fruit quality-related traits and molecular-assisted breeding. Although related studies have increased rapidly in recent years, comprehensive research integrating industrial development status, fruit quality formation mechanisms, cultivation management practices, and postharvest regulation technologies remains relatively limited. Therefore, this study further discusses external quality, internal quality, and quality evaluation systems of Chinese bayberry, and systematically analyzes the effects of cultivar, environment, and cultivation management on fruit quality formation, with the aim of providing theoretical references for high-quality cultivation, fruit quality improvement, and sustainable development of the Chinese bayberry industry.

2 Research on Fruit Quality Traits of Chinese Bayberry

2.1 External quality traits

The external quality of Chinese bayberry fruit is an important basis for consumers to evaluate commercial value and is also a key target affecting market competitiveness, fruit grading, and breeding selection. It mainly includes fruit size, fruit shape, peel color, fruit surface integrity, and ripening uniformity (Zhang et al., 2022; Xue et al., 2024). Among these traits, single-fruit weight, longitudinal and transverse diameters, and fruit shape index directly influence commercial grade and market price, and large-fruited bayberries are generally more favored by consumers. Significant differences in fruit size and shape exist among different cultivars and germplasm resources. For example, large-fruited cultivars such as ‘Dongkui’ possess high commercial value, whereas some local cultivars mainly produce medium- or small-sized fruits. Large-scale phenotypic analyses have shown that fruit size, fruit shape, and related appearance traits in Chinese bayberry generally exhibit continuous distributions with large coefficients of variation, suggesting that these traits may be quantitatively inherited and jointly influenced by genetic background, tree nutritional status, crop load, and cultivation environment (Zhang et al., 2024).

Peel color is one of the most recognizable external quality traits of Chinese bayberry and is closely associated with fruit maturity and anthocyanin accumulation. Fruit color can gradually transition from white and pink to red, dark red, and nearly black, and this color gradient is mainly determined by differences in anthocyanin content and