

health-promoting value and shows considerable potential in functional foods, juices, wines, vinegars, dried fruit, and bioactive compound extraction (Zhang et al., 2022). Therefore, further studies on harvesting, preservation, storage, transportation, and processing technologies are needed to extend the industrial chain and increase product added value. Meanwhile, the establishment of unified green production standards, quality evaluation systems, and regional branding systems could enhance consumer trust and promote the transformation of the Chinese bayberry industry from a fresh-fruit-oriented market toward a diversified model integrating “fresh consumption + processing + functional products + ecological branding.”

8 Concluding Remarks

In recent years, research on Chinese bayberry fruit quality has gradually evolved from the early basic description of ripening changes to multi-omics analyses of the genetic and biochemical regulatory mechanisms underlying fruit quality formation. Early EST and RNA-Seq studies identified a large number of differentially expressed genes during fruit ripening, revealing coordinated upregulation of anthocyanin biosynthesis-related genes and significant alterations in sugar and organic acid metabolism, which together determine fruit color and flavor quality. With the development of high-quality genome assembly technologies, including the recent telomere-to-telomere (T2T) reference genome and earlier draft genomes, researchers have further elucidated antioxidant, flavonoid, and terpenoid metabolic pathways and identified key expanded gene families and candidate regulatory factors associated with antioxidant capacity and flavor traits. Genome-wide association studies (GWAS) based on large germplasm populations linked 29 measurable fruit quality traits to more than 1,000 genes and identified important MYB/MLP loci closely associated with fruit color formation. At the same time, studies of the MYB family revealed key transcription factors regulating metabolic flux between anthocyanins and flavonols. In addition, the development of molecular marker technologies such as SSR, EST-SSR, SNP, and InDel markers, together with the establishment of multi-omics databases, has further promoted germplasm identification, genetic diversity analysis, and molecular breeding research in Chinese bayberry, thereby providing a more robust platform for fruit quality improvement.

In addition to genetic research, cultivation management and postharvest handling practices have gradually been recognized as important approaches for regulating Chinese bayberry fruit quality. Field studies have shown that insect- and rain-proof nets can not only effectively control major pests but also improve fruit size, edible rate, and sugar-acid ratio while optimizing fruit-surface microbial community structure, thereby significantly enhancing commercial fruit quality and yield. Protected cultivation and LED supplemental lighting technologies can precisely regulate orchard microenvironments and fruit coloration parameters, significantly increasing fruit weight, soluble solids, and vitamin C content while reducing acidity in some sensitive cultivars, although responses differ considerably among cultivars. Postharvest studies have demonstrated that ethylene regulation and low-temperature storage conditions play crucial roles in maintaining fruit quality. Cold storage at approximately 4°C can slow firmness decline, stabilize sugar-acid changes, and extend shelf life, indicating that storage environment is an important factor influencing consumer acceptance. In addition, studies on flesh compartment development and hormonal regulation suggest that cultivation practices affecting hormonal balance, canopy structure, and source-sink relationships interact with intrinsic fruit developmental programs and jointly determine final fruit texture and juiciness. Overall, optimized cultivation and postharvest management technologies tailored to different cultivars are equally important as genetic background for achieving stable production of high-quality Chinese bayberry fruit.

Looking forward, the integration of genomics, physiology, and modern agricultural technologies will provide broad prospects for upgrading the Chinese bayberry industry. Applications of high-resolution genomes, GWAS signals, and high-density molecular markers make marker-assisted breeding and even genomic selection possible, helping overcome the long juvenile period of Chinese bayberry and accelerating the breeding of superior cultivars with improved flavor, coloration, antioxidant capacity, and environmental adaptability. At the same time, abundant local germplasm resources and regional genetic diversity provide important foundations for exploiting heterosis and selecting superior hybrid combinations. In the production sector, integrating insect- and rain-proof nets, precise light management, and low-input green cultivation systems with optimized postharvest handling