texture analysis possess important scientific value, but they have not yet been transformed into practical industrial evaluation procedures and standard thresholds (Suo et al., 2023; Gao et al., 2024).

Furthermore, unified relationships among genetic markers, laboratory detection indices, and market grades for fresh and processed products are still lacking. Although GWAS studies have identified 29 quantifiable quality traits and related loci, these molecular indicators have not yet been systematically translated into breeding selection standards, cultivar certification indices, or commercial grading criteria (Zhang et al., 2024). Meanwhile, different consumer groups exhibit varying preferences for Chinese bayberry quality; some focus more on sweetness and taste, whereas others emphasize nutritional functionality, safety, or processing suitability. Therefore, future studies should establish multidimensional comprehensive evaluation systems covering appearance quality, flavor quality, nutritional and functional quality, safety quality, postharvest quality, and processing quality, while promoting the integration of non-destructive detection, intelligent evaluation, and molecular marker data with industrial standards.

7 Future Development Directions

7.1 Breeding of high-quality new varieties

With increasing consumer demands for Chinese bayberry fruit quality, the breeding of high-quality new cultivars will become a core direction for the future development of the industry. Current market demands have gradually shifted from focusing solely on fruit size and yield to comprehensive traits such as flavor quality, nutritional value, functional components, storability, transportation tolerance, and green safety. Therefore, breeding objectives for Chinese bayberry should shift from traditional high-yield orientation toward coordinated improvement of high quality, efficiency, multifunctionality, and adaptability. By developing new cultivars with balanced sugar-acid ratios, attractive coloration, tender flesh, and high contents of anthocyanins and flavonoids, the market competitiveness and industrial value of Chinese bayberry can be further enhanced (Zhang et al., 2024; Saeed et al., 2025).

In recent years, genomics and multi-omics technologies have provided an important foundation for molecular design breeding in Chinese bayberry. Telomere-to-telomere reference genomes and GWAS analyses of 173 germplasm accessions have identified 1,937 SNP loci and 1,039 candidate genes associated with 28 fruit quality traits, among which MYB and MLP-like gene regions on chromosome 6 are closely related to fruit coloration and anthocyanin accumulation (Zhang et al., 2024). The Chinese bayberry database integrates multi-omics information including genomes, transcriptomes, molecular markers, phenotypes, and fruit images, thereby providing a platform for quality trait marker development, candidate gene screening, and computer-assisted breeding (Ren et al., 2021). In addition, high-density SNP genetic maps and QTL mapping studies have laid the foundation for marker-assisted selection of traits related to tree growth, leaf characteristics, and yield performance (Zhang et al., 2021).

These molecular research achievements have gradually begun to integrate with breeding practice. For example, the new hybrid line ‘BD-107’, developed from a cross between ‘Biqi’ and ‘Dongkui’, showed superior fruit firmness, sugar content, and vitamin C content compared with both parents, and also contained richer terpene and flavonoid compounds, demonstrating the potential of hybrid breeding for improving flavor, texture, and functional quality (Saeed et al., 2025). In addition, studies on developmental regulatory genes such as MrSPL4 suggest that these genes may influence vegetative growth and flowering time, thereby providing new strategies for breeding early-maturing, highly adaptable, and facility-suitable cultivars (Zhang et al., 2022). In the future, breeding of Chinese bayberry cultivars should further focus on the coordinated improvement of flavor quality, nutritional functionality, storability, pest and disease resistance, stress tolerance, maturity regulation, and processing suitability.

7.2 Precision and intelligent cultivation

Precision and intelligent cultivation represent important trends in the development of modern fruit industries and are also key approaches for improving fruit quality stability and production efficiency in Chinese bayberry. Traditional Chinese bayberry cultivation mainly relies on empirical management, which often results in