providing new approaches for improving complex traits. Future trends in molecular breeding are expected to include multi-trait improvement (quality, stress resistance, and processing suitability), multi-omics-driven precision breeding, and the integration of high-throughput phenotyping with artificial intelligence models. Nevertheless, as tea plants are perennial crops with long breeding cycles, new cultivars still require long-term multi-regional trials to verify quality stability and processing adaptability. Therefore, the deep integration of molecular technologies with traditional breeding methods will remain the key pathway for improving Longjing tea cultivars.

8 Existing Issues and Future Perspectives

The current evaluation system for tea cultivars used in Longjing tea processing remains inadequate, mainly manifested in limited indicators, inconsistent standards, and a lack of systematic approaches. Existing studies often focus on sensory quality or partial physicochemical parameters, lacking a unified multi-dimensional evaluation system that integrates appearance, aroma, taste, and chemical composition, resulting in poor comparability among studies. In addition, differences in cultivar selection and quality evaluation standards across production regions have hindered the establishment of a standardized system specifically for Longjing tea cultivars. The strong subjectivity in evaluation, coupled with insufficient objective and quantitative indicators, further limits the scientific basis for cultivar selection and promotion. Therefore, it is necessary to develop a comprehensive evaluation system integrating sensory assessment and physicochemical analysis, while promoting the standardization and unification of evaluation criteria.

The formation of Longjing tea quality is the result of interactions among cultivar, environment, and processing techniques; however, systematic research on these interactions remains insufficient. Most studies focus on single factors, such as cultivar differences or process optimization, while comprehensive analyses of cultivar performance under varying ecological conditions and their responses to processing are relatively scarce. In practice, the same cultivar may exhibit significant differences in chemical composition and quality traits under different climates, soils, and altitudes, and the optimal processing parameters may also vary accordingly. The lack of integrated multi-factor studies limits a deeper understanding of the mechanisms underlying quality formation. Future research should emphasize multi-location and multi-year experiments and establish integrated "cultivar-environment-processing" interaction models to support precision production.

With the transformation of the Longjing tea industry toward high-quality development, the integration of specialized cultivar breeding and intelligent processing technologies will become a key direction. On the one hand, breeding efforts should target high aroma intensity, strong freshness, and low bitterness–astringency, while also considering yield and stress resistance to achieve a balance between quality and productivity. On the other hand, with the advancement of intelligent manufacturing technologies, automated and digital processing equipment is increasingly being applied in tea production, enabling precise control of processing conditions through temperature regulation, time management, and real-time monitoring. However, given that different cultivars respond differently to processing parameters, future research should focus on optimizing the compatibility between cultivars and intelligent processing systems. Promoting the coordinated development of "improved cultivars + optimized techniques + intelligent equipment" will be essential for enhancing quality stability and industrial competitiveness of Longjing tea.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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