Further cultivar-focused studies show that different combinations of amino acids and catechins correspond to distinct taste characteristics. Certain amino acids are associated with a mellow taste, whereas gallic acid and theobromine tend to enhance astringency (Guo et al., 2023). At the same time, variations in volatile compound proportions directly influence aroma style (Zhang et al., 2024). Environmental factors also regulate quality expression by altering metabolite accumulation; for instance, high-altitude conditions are conducive to enhancing sweet and mellow flavors (Bassiony et al., 2024). Overall, quality traits are the result of multi-component interactions dominated by cultivar and modulated by the environment.

6 Processing Suitability and Cultivar Response

6.1 Adaptability of different cultivars to processing techniques

The processing suitability of tea cultivars in Longjing tea production is mainly reflected in the responses of their biochemical composition and physical structure to various processing steps. Longjing tea processing involves key stages such as withering, fixation, shaping, and pan-firing. Due to differences in bud–leaf structure, moisture content, and internal composition, cultivars exhibit distinct behaviors during heat treatment and moisture loss, thereby affecting appearance, aroma, and taste (Li et al., 2023a; Shan et al., 2023; Teng et al., 2024). Overall, cultivar differences determine the range of processing adaptability and the potential for quality expression.

From a general processing perspective, some cultivars exhibit strong adaptability. For example, Longjing 43 can produce markedly different metabolic profiles under various tea processing methods and thermal treatments, indicating its broad adaptability across multiple processing conditions (Chen et al., 2024). In addition, its relatively high chlorophyll b content contributes to the formation of the typical dry tea color, further demonstrating its suitability for the Longjing processing pathway (Zeng et al., 2024). In contrast, different cultivars show significant variation in both volatile and non-volatile components during thermal processing, reflecting differences in flavor formation pathways.

At specific processing stages, bud–leaf structure and moisture status are critical for shaping. Leaves that are soft and of moderate thickness are more likely to form a flat and smooth appearance, whereas thicker or unevenly tender leaves tend to break or fail to achieve sufficient flatness (Yu et al., 2023). Studies indicate that when leaf moisture content is within 30%-50%, plasticity is optimal, facilitating stable shaping and reducing breakage (Li et al., 2023a). Furthermore, cultivars differ in their responses to fixation and withering; for example, cultivars with high amino acid content require careful temperature control to preserve freshness, whereas those with high polyphenol content are more prone to increased bitterness and astringency if improperly processed (Shan et al., 2023).

6.2 Stability and consistency of finished tea quality

The stability and consistency of finished tea quality are key indicators for evaluating cultivar suitability. Stability refers not only to the reproducibility of quality under the same processing conditions but also to the ability to maintain consistent quality across different years or environmental fluctuations. Generally, clonal cultivars with uniform genetic backgrounds exhibit more stable fresh leaf traits and metabolic profiles, making them more likely to produce consistent finished tea quality.

Studies have shown that under identical processing conditions, cultivar effects on flavonoid and other metabolites are greater than those of production region or storage factors, indicating that cultivars play a dominant and stable role in quality formation. This means that major cultivars can maintain their characteristic flavor profiles within a certain range of environmental variation, thereby supporting standardized production. Further research indicates that although different cultivars follow similar metabolic trends during processing, differences in concentration levels lead to distinct and stable quality expressions (Zeng et al., 2024).

However, environmental conditions and processing parameters still influence quality consistency. For instance, Longjing 43 can maintain relatively high catechin levels under shading conditions, demonstrating strong metabolic stability (Li et al., 2023b). In processing, controlling key parameters—such as maintaining leaf moisture at around 70% after withering—can significantly improve taste and liquor color (Shan et al., 2023).