astringency and body. Therefore, such cultivars are particularly suitable as important supplementary raw materials outside the core traditional production areas, meeting the needs for early harvesting and yield, while also providing more options for developing Longjing-type products with different market positions.

3.3 Newly bred cultivars and their biological characteristics

In recent years, as tea breeding objectives have shifted from simply pursuing high yield toward high quality, functional flavor, and precise processing suitability, a number of newly bred cultivars and special germplasm suitable for Longjing tea processing have gradually attracted attention. During the breeding process, these new materials place greater emphasis on targeted improvement, such as high amino acid content, high aroma potential, low bitterness and astringency, and strong environmental responsiveness, thereby providing a new resource base for the premiumization and diversification of Longjing tea. Among them, albino or color-variant materials are currently one of the most actively studied groups. Represented by cultivars such as "Baie No.1," their spring tender shoots are jade white or pale yellow and are characterized by high amino acid content and relatively low catechin levels, making them more likely to produce tea with fresh, sweet, and mild taste and lower bitterness and astringency (Li et al., 2025; Yan et al., 2025). Metabolomic studies have shown that these materials are rich in various amino acids and sugars, whereas bitterness-related components are significantly reduced, resulting in a fresher and sweeter flavor profile in the final tea (Bassiony et al., 2024).

From the perspective of genetics and metabolic mechanisms, newly bred cultivars not only exhibit significant sensory differences but also have analyzable molecular bases. In population studies constructed using Longjing 43 and albino materials, key QTL regions controlling the accumulation of theanine and multiple free amino acids have been identified, providing clear targets for breeding high-umami cultivars (Yan et al., 2025). In terms of processing response, the metabolic pathways also differ among cultivars. For example, Baie No.1 shows obvious dynamic changes in volatile compounds during processing, with floral and fresh aroma compounds dominating in the early stage and chestnut-like aroma-related compounds gradually accumulating in the later stage, showing a distinct aroma formation trajectory compared with traditional cultivars (Li et al., 2025). At the same time, under the same processing conditions, different cultivars show significant differences in non-volatile metabolite composition, reflecting different quality formation patterns.

In addition, newly bred cultivars also show important potential in environmental adaptability. For example, Longjing 43 exhibits specific flavonoid synthesis and light-response regulation characteristics under shading conditions, providing a basis for screening cultivars with stable quality under different ecological conditions (Li et al., 2025; Cui et al., 2026). However, these new varieties still face challenges in their promotion and application, including insufficient regional adaptability verification and limited evidence for long-term quality stability. Some special cultivars may show outstanding freshness or aroma, but whether they conform to the traditional Longjing style and market perception still requires further evaluation. Therefore, future studies should combine multi-location and multi-year trials, metabolomic analysis, and sensory evaluation to systematically verify the processing suitability and quality stability of new cultivars, so as to support their scientific promotion and application.

4 Differences in Quality Traits Among Cultivars

4.1 Differences in appearance quality

The inherent differences in bud–leaf morphology among tea cultivars are an important basis affecting the appearance quality of Longjing tea. Longjing tea has high requirements for raw material morphology, and fresh leaves with tender buds and leaves, moderate length, soft texture, and balanced thickness are generally more conducive to forming the typical "flat, smooth, straight, and even" appearance. Studies have shown significant differences among germplasm resources in bud length, leaf size, leaf thickness, and hundred-bud weight, which gives some cultivars greater shaping potential, whereas cultivars with thicker leaves or coarser buds are more likely to show insufficient flatness or reduced uniformity during processing (Li et al., 2025). For example, Longjing 43 has relatively short buds and high uniformity, making it easier to form a smooth and straight appearance, whereas population varieties, due to their strong genetic heterogeneity, exhibit greater variation in