

functional components, standardization of processing technologies, and innovation in product forms (Gupta et al., 2023). Hangbaiju is rich in flavonoids and exhibits strong antioxidant and anti-inflammatory activities, making it an important raw material for developing functional foods and tea beverages (Lu and Liu, 2025). Consequently, while retaining its natural floral aroma and health-promoting properties, the upgrading of traditional Hangbaiju tea beverages should focus on defining active compounds, quality markers, and processing standards, thereby transforming conventional brewed flower tea into modern tea beverages with clear functional attributes and technological support.

In terms of product forms, portable products such as individually packaged tea bags, pyramid tea bags, freeze-dried flower tea, and ready-to-drink (RTD) Hangbaiju tea can be developed to meet the diverse needs of office, travel, household, and gift-giving scenarios. Research has shown that green extraction technologies, including ultrasonic-assisted extraction and enzymatic extraction, can increase flavonoid yields from Hangbaiju while helping maintain the stability of active compounds, thereby providing technical support for the development of high-content, low-additive Hangbaiju tea beverages (Gupta et al., 2023; Lu and Liu, 2025). Meanwhile, modern extraction methods, non-thermal sterilization, improved packaging, and flavor optimization technologies can further enhance sensory quality, shelf life, and brewing convenience (Tong et al., 2019; Liu et al., 2024; Qin and Zhou, 2024). Through raw material grading, packaging design, geographical indication certification, and traceability system construction, traditional Hangbaiju tea can be transformed from a low-value bulk product into a high-value beverage characterized by regional identity, quality assurance, and brand recognition (Zhang et al., 2022).

2.2 Development of compound hangbaiju tea beverage products

Compound tea beverages represent an important development direction in the functional beverage market. Beverages combining multiple plant resources and functional ingredients can integrate bioactive substances such as polyphenols, vitamins, minerals, and amino acids, enriching sensory characteristics while providing synergistic health benefits (A'yuni et al., 2022; Gupta et al., 2023; Onsun et al., 2025; Munarso et al., 2026). With its mild floral aroma and rich flavonoid content, Hangbaiju is suitable as a core ingredient in compound tea beverages. It can be blended with green tea, white tea, oolong tea, matcha, herbal extracts, or fruit ingredients to develop functional beverages targeting antioxidant, liver-protective, soothing, or immune-support functions (Yang et al., 2022; Najman et al., 2023; Lu and Liu, 2025). For example, blending Hangbaiju with green tea or white tea can enhance flavor complexity, while combining it with medicinal and edible ingredients such as goji berries, cassia seeds, honeysuckle, and monk fruit can create eye-care, soothing, and wellness-oriented tea beverages.

From a technological perspective, the development of compound Hangbaiju beverages requires not only appropriate ingredient combinations but also solutions to issues related to solubility, stability, and flavor compatibility among multiple active compounds. Research has demonstrated that the rational blending of plant extracts can increase total phenolic content, antioxidant capacity, and consumer acceptance of color, aroma, and taste, providing valuable guidance for Hangbaiju beverage formulation (A'yuni et al., 2022; Maulida et al., 2024). Encapsulation and embedding technologies can improve the dispersion of active ingredients and protect heat-sensitive flavonoids, helping maintain stability in aqueous systems and during storage (Gupta et al., 2023; Munarso et al., 2026). In addition, selecting suitable sweeteners, acidulants, and natural flavorings can harmonize the floral aroma and slight bitterness of Hangbaiju with fruity, tea-like, or spicy flavor profiles. In the future, product lines such as beauty-enhancing teas for women, eye-care teas for office workers, wellness teas for older adults, and recovery beverages for athletes can be developed according to seasonal trends, consumer preferences, and target demographics, thereby enhancing product segmentation and market competitiveness.

2.3 Innovation of new-style hangbaiju tea beverages

With the rapid development of new-style tea beverages and functional drinks, the application scenarios of Hangbaiju have expanded from traditional brewed tea to ready-to-drink beverages, cold-brew tea, sparkling beverages, functional shots, instant powdered drinks, and fermented beverages. Related studies suggest that the new-style tea beverage market is evolving toward personalization, fashion, health orientation, and scenario-based