being the major positive contributors, whereas bitterness, sourness, and astringency have greater effects on negative evaluations (Baviera-Puig et al., 2023). Therefore, AHP has a unique advantage in building consumer-oriented evaluation systems.

However, AHP depends on expert experience and thus contains a certain degree of subjectivity, whereas PCA, although objective, lacks a direct reflection of consumer preference. For this reason, recent studies increasingly tend to adopt combined objective-subjective weighting methods, such as integrating PCA with AHP, or further combining entropy weighting, grey relational analysis, TOPSIS, and other multi-criteria decision-making methods (Tian et al., 2025; Zhou et al., 2025). These approaches can introduce preference information while preserving statistical objectivity, making weight allocation more consistent with real application needs. In other words, PCA mainly provides "importance from the data-structure perspective," whereas AHP and related methods provide "importance from the decision-making perspective." Their combination helps establish evaluation models that are both scientific and practical. On this basis, by constructing comprehensive quality functions, classification models, or predictive models, it becomes possible to quantitatively evaluate samples under different cultivation conditions, cultivars, or regions, and to provide support for cultivation decisions, cultivar recommendation, and commercial grading. Therefore, weight determination and model construction are not merely statistical issues, but crucial steps in transforming multidimensional quality information into actionable decision-making tools.

6.3 Regionalized and standardized evaluation systems

The relative importance of peach quality traits varies with ecological conditions, production systems, major cultivars, and target markets across regions. Therefore, when constructing a quality evaluation system, both standardization and regional adaptability must be considered. In other words, an ideal system should combine a "standardized framework + regional calibration" rather than relying on a single uniform model. From the perspective of standardization, unified evaluation indicators, measurement methods, and reference systems are the basis for ensuring comparability of results across studies, regions, and experimental sites. For example, the large collaborative project represented by the EUFRIN Peach and Apricot Working Group proposed about 40 standardized indicators for new cultivar evaluation, covering phenological stages (such as flowering time and harvest date), yield, external quality, internal quality, and susceptibility to diseases, and achieved consistency in multi-environment trial results through unified measurement protocols and reference cultivars (Giovannini et al., 2021). This framework not only provides a common technical language for breeders, growers, and the industry chain, but also lays a methodological foundation for interregional quality comparison and cultivar promotion.

At the same time, peach fruit quality shows clear regional characteristics. Different ecological regions differ in light, temperature, water availability, soil conditions, and cultivation systems, so the importance of certain quality indicators also differs among regions. For example, in areas with large diurnal temperature differences and abundant light, sugar accumulation and coloration are usually more emphasized; whereas in humid regions or under protected cultivation, texture stability, flavor harmony, and disease resistance may be of greater evaluative value. This means that although the comprehensive evaluation system requires a unified basic framework, its indicator weights and application priorities should be recalibrated according to regional realities.

Studies have shown that comprehensive evaluation systems constructed using variance analysis, correlation analysis, PCA, cluster analysis, and AHP can recalculate principal components and weights by incorporating local cultivar resources, regional environmental data, and consumer preferences, thereby achieving regionalized evaluation (Mihaylova et al., 2021). On the one hand, such regional adjustments improve the suitability of the evaluation system to local production realities; on the other hand, they also provide a scientific basis for regional branding and the positioning of specialty cultivars. In addition, the recent development of non-destructive detection technologies has provided a new technical basis for integrating regionalized and standardized evaluation systems. Studies have shown that methods such as Vis/NIRS and hyperspectral imaging, after localized calibration under region-specific rootstocks, crop load levels, canopy positions, and light environments, can stably acquire