Table 1 Descriptive sensory exterior appearance attributes of fresh-market peach and nectarine genotypes evaluated on a 15-point scale (Adopted from Felts et al., 2019)

Genotype	Uniformity of color	Color-yellowness	Color-redness	Amount of bruises	Separation of pit	Pit size
A-827	10.1 cd2	9.8 bc	4.4 ab	2.1 abc	10.8 ab	8.7 bc
A-850	13.1 a	13.0 a	1.6 d	1.9 abcd	6.9 c	9.5 ab
A-865	10.8 bc	9.6 c	3.4 bc	1.1 bcde	11.9 ab	7.9 bc
Amoore Sweet	13.2 a	13.5 a	1.0 d	0.4 e	13.9 a	8.3 bc
Bowden	13.3 a	13.2 a	0.9 d	0.8 cde	13.1 a	8.1 bc
Effie	12.7 ab	12.2 ab	1.9 cd	0.6 de	13.6 a	9.4 ab
Loring	10.0 cd	10.1 bc	4.2 ab	2.5 a	8.6 bc	10.9 a
Souvenirs	9.9 cd	9.8 bc	4.4 ab	1.0 cde	11.8 ab	7.3 c
White River	8.5 d	7.9 c	5.9 a	2.3 ab	9.5 bc	11.0 a
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Table caption: 0= less of the attribute; 15 = more of the attribute in terms of intensity; Genotypes were evaluated in duplicate by trained panelists; Means with different letter(s) for each attribute are significantly different ($P<0.05$) using Tukey's honestly significant difference test (Adopted from Felts et al., 2019)

5.2 Modern analytical techniques

With the advancement of analytical technology, modern instrumental methods have been increasingly applied in peach quality research and have gradually become important tools for analyzing fruit flavor, nutritional components, and functional compounds. Compared with traditional physicochemical methods, modern analytical techniques can reveal the chemical basis of peach quality at higher resolution and greater depth, especially in the analysis of volatile aroma compounds, trace metabolites, and complex compositional networks. Chromatographic techniques are among the most mature methods currently used in peach quality research. High-performance liquid chromatography (HPLC) is mainly used to analyze non-volatile compounds such as sugars, organic acids, polyphenols, and vitamins, allowing accurate quantification of glucose, fructose, sucrose, malic acid, citric acid, and related compounds (Sun et al., 2023). These data are important for understanding the formation of sweet-sour flavor, nutritional quality differences, and metabolic characteristics among cultivars. Meanwhile, gas chromatography-mass spectrometry (GC-MS) is widely used to identify and quantify volatile aroma compounds in peach. Gas chromatography-ion mobility spectrometry (GC-IMS), due to its rapid analysis and high sensitivity to volatile compounds, has increasingly been used for aroma fingerprinting of peach fruit. Studies have shown that the combined use of GC-IMS and GC-MS can identify key aroma compounds and thereby distinguish aroma styles among cultivars (Sun et al., 2022).

When combined with sensory evaluation, chromatographic techniques can further identify key flavor markers affecting consumer preference. For example, by integrating sugar-acid data obtained by HPLC, volatile compound data identified by GC-MS, and sensory evaluation results, researchers can more systematically elucidate the chemical basis of sensory attributes such as “sweetness,” “fruity aroma,” “ripe aroma,” or “green notes” in peach fruit (Sun et al., 2023). Such studies are of great significance for germplasm screening, elite cultivar breeding, and flavor-oriented cultivation management. In addition to chromatography, spectroscopic techniques have rapidly expanded in peach quality evaluation because of their speed, high throughput, and potential for non-destructive analysis. Visible/near-infrared spectroscopy (Vis/NIR) estimates internal quality traits such as SSC, dry matter content (DMC), firmness, polyphenols, and pigments by measuring the interaction between light and fruit tissues. Studies have shown that high-accuracy prediction of SSC and DMC can be achieved using models such as partial least squares regression (PLS), multiple linear regression (MLR), and least-squares support vector machine (LS-SVM), often with coefficients of determination (R^2) above 0.94 and RMSEP values around 0.3%-0.6% (Minas et al., 2020). Hyperspectral imaging further integrates spatial and spectral information, allowing not only estimation of SSC and firmness but also visualization of the spatial distribution of these quality parameters within the fruit, as well as prediction of fruit size and weight (Xuan et al., 2022).