Eating Quality of Old and New University of Florida Strawberry Cultivars

ANNE PLOTTO*1, VANCE WHITAKER2, and CRAIG CHANDLER2

1USDA-ARS, Citrus and Subtropical Products Research Laboratory, 600 Avenue S, N.W., Winter Haven, FL 33881
2University of Florida, IFAS, Gulf Coast Research and Education Center, 14625 CR 672, Wimauma, FL 33598

ADDITIONAL INDEX WORDS. Fragaria xanana, flavor, sensory evaluation, descriptive analysis

The University of Florida strawberry breeding program has developed cultivars highly adapted to west-central Florida since the 1970s. In this trial, four advanced selections and 11 released cultivars, from ‘Florida Belle’ (1975) to ‘Florida Radiance’ (2008), were grown in a randomized complete-block design with 10-plant plots as the unit of replication. Fruit were harvested bi-weekly and evaluated once a month by a trained sensory panel, from January to March 2010. In January, FL-05-107 had the highest ratings for positive attributes (firmness, sweetness and strawberry flavor). ‘Florida Belle’; ‘Earlibrite’, ‘Strawberry Festival’ and FL-06-38 had high scores for sweetness and strawberry flavor, but were not as firm as FL-05-107. In February, the highest ratings for positive attributes were given to ‘Florida Elyana’ and ‘Strawberry Festival’ while FL-06-38 and ‘Florida Radiance’ were rated high in strawberry flavor. In March, ‘Florida Elyana’, ‘Florida Belle’, ‘Florida Radiance’ and FL-06-38 were also rated high in sweetness and strawberry flavor. FL-05-107 and FL-05-85 were consistently rated high in firmness. On the contrary, ‘Sweet Charlie’ had high sweetness but low firmness ratings in March. The lowest rating for strawberry flavor was given to ‘Dover’ both in January and February, and a high rating given for “overripe/fermented” in January and March, and “sour” in February. ‘Winter Dawn’ also had high ratings for “overripe/fermented” and “woody/musty” in January and March.

Strawberries are grown in central Florida during the winter months and supply the bulk of the market in the eastern United States during that time (National Agricultural Statistics Service, 2009). For many years in the 1960s and 1970s, the main commercial cultivars originated from California (Chandler et al., 1988); they produced attractive and large fruit, and had good shipping qualities. However, well-known California cultivars Selva, Pajaro, and Chandler were quite susceptible to anthracnose, a disease with major economic impact for Florida strawberry growers, and had low early-season yields. There was therefore a strong need to create cultivars adapted to the Florida climate and industry needs. Drs. Charles Howard and Craig Chandler conducted the breeding program at the University of Florida from 1968 to 1987 and from 1987 to 2010, respectively. A summary of cultivars released by these two breeders is given in Table 1. The breeding program has sought to improve fruit quality attributes over time through recurrent cycles of selection and hybridization. Some traits such as fruit size and overall appearance are easily selected in the field from visual observations. Other traits influencing flavor such as soluble solids content (SSC), titratable acidity (TA), and volatile compounds have been selected only indirectly by tasting fruit in the field. The objective of this study was to evaluate released cultivars and new advanced selections in a replicated trial in order to examine differences in eating quality.

**Materials and Methods**

**Fruit sampling.** Fifteen strawberry cultivars and selections (Table 1) were grown in four replicated plots with 10 plants per plot, on two sites in central Florida: the University of Florida Gulf Coast Research and Extension Center in Balm, and at the headquarters of the Florida Growers Association in Dover. Plants were planted on 14 and 15 Oct. 2009 at Balm and Dover, respectively, and were maintained under commercial standards for irrigation, fertilization, and pesticide application. Fully-ripe fruit were harvested twice weekly; fruit harvested on 26 Jan., 24 Feb., and 24 Mar. 2010 were immediately transported to the U.S. Department of Agriculture laboratory in Winter Haven for evaluation. Twelve (January and March) or 13 (February) cultivars were evaluated per day as not all 15 cultivars had enough fruit for the taste panel each time. Fruit were stored at 5 °C overnight before evaluation. On the morning of taste panel, fruit were washed with running tap water, drained, patted dry with paper towels, and served as one or two fruits per panelist, depending on fruit size.

**Sensory evaluation.** Twelve panelists, trained to evaluate fruit including strawberries, met in a 1-h session at the beginning of the season to refresh descriptors and reference standards specific to strawberry flavor evaluation (Table 2). Descriptors were rated using an 11-point category scale, anchored with the words “low” (0–1), “medium” (5), and “high” (10) for the basic taste and flavor descriptors, “smooth” to “rough” for surface mouth feel/graininess (indicating the feeling on the tongue of protruding seeds on the surface of the fruit), and “soft” to “very firm” for firmness. Samples were presented in a completely randomized design (Williams design) and data were collected using Compusense® five (Compusense Inc., Guelph, Ontario, Canada).
Panelists were instructed to taste one set of samples in the morning, and another set in the afternoon, to avoid fatigue from eating up to 13 samples (each set was comprised of five to seven samples). Taste panels took place in isolated booths under red lighting; panelists were provided with drinking water and unsalted crackers to rinse their mouth between samples. Samples were served at room temperature.

**Fruit Analysis.** Fruit were homogenized using a Waring blender (Waring Products Div., Dynamics Corp. of America, New Hartford, CO) and frozen at –20 °C for further analyses. The supernatant of thawed homogenates, centrifuged at 12,100 g for 15 min, was analyzed for TA, pH, and SSC. For TA, 6 g of the supernatant was diluted with 50 mL DI-water and titrated with 0.1 N NaOH to a pH 8.1 endpoint using a Metrohm 808 Titrando and Metrohm 730 sample changer (Metrohm USA Inc., Westbury, NY). SSC was determined with a digital ATAGO PR-101 refractometer, 0% to 45% Brix range (Atago Co., Tokyo, Japan).

**Statistical Analysis.** Sensory data were analyzed by analysis of variance (ANOVA) each month using Senpaq (QiStatistics Ltd., Berkshire, UK), using a mixed model with panelist as a random variable. Separation of means was performed with the Fisher LSD test, with \( \alpha = 0.05 \). Principal components analysis (PCA) of the means across panelists was performed using XLSTAT software (Addinsoft, Paris, France). Pearson correlation tests were performed each month among sensory variables and between sensory and instrumental variables using XLSTAT.

### Results and Discussion

**January Harvest.** Selection 05-107 had the highest sweetness rating, followed by ‘Earlibrite’ and ‘Rubygem’ (Table 3). It also had high strawberry flavor, firmness and low sourness ratings. Sweetness is generally an indicator of good eating quality in strawberries (Jouquand et al., 2008), along with strawberry flavor. On the contrary, ‘Carmine’ and ‘Rosa Linda’ had high sourness and astringent ratings (Table 3). The PCA biplot shows how sensory variables are correlated with each other, and shows which variable (descriptor) is predominant in samples (Fig. 1). In January, the...
Table 3. Average sensory ratings (n = 12) for 15 University of Florida strawberry genotypes harvested 20 Jan., 24 Feb., and 24 Mar. 2010.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>05-107</th>
<th>05-85</th>
<th>06-38</th>
<th>06-45</th>
<th>Carmin</th>
<th>Dover</th>
<th>April</th>
<th>Festival</th>
<th>Radiance</th>
<th>Rosa Linda</th>
<th>Rubygem</th>
<th>Sweet Grass</th>
<th>Winter Dawn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface mouthfeel</td>
<td>4.0</td>
<td>4.3</td>
<td>3.9</td>
<td>3.5</td>
<td>3.4</td>
<td>3.5</td>
<td>2.8</td>
<td>3.7</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Firmness</td>
<td>4.8</td>
<td>5.5</td>
<td>4.8</td>
<td>3.7</td>
<td>2.0</td>
<td>3.7</td>
<td>3.7</td>
<td>4.8</td>
<td>4.4</td>
<td>3.2</td>
<td>2.9</td>
<td>4.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Sweetness</td>
<td>5.3</td>
<td>3.3</td>
<td>3.9</td>
<td>3.6</td>
<td>3.2</td>
<td>4.9</td>
<td>4.2</td>
<td>3.7</td>
<td>3.2</td>
<td>3.9</td>
<td>4.3</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Sourness</td>
<td>3.2</td>
<td>3.5</td>
<td>4.9</td>
<td>5.8</td>
<td>3.2</td>
<td>4.5</td>
<td>4.7</td>
<td>5.2</td>
<td>3.2</td>
<td>3.4</td>
<td>4.6</td>
<td>5.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Astringent</td>
<td>2.5</td>
<td>2.1</td>
<td>2.8</td>
<td>3.7</td>
<td>3.6</td>
<td>3.4</td>
<td>3.2</td>
<td>2.6</td>
<td>2.5</td>
<td>3.2</td>
<td>4.2</td>
<td>3.2</td>
<td>2.8</td>
</tr>
<tr>
<td>Strawberry flavor</td>
<td>5.0</td>
<td>4.0</td>
<td>4.2</td>
<td>4.5</td>
<td>3.2</td>
<td>5.2</td>
<td>4.7</td>
<td>4.3</td>
<td>3.4</td>
<td>3.8</td>
<td>3.8</td>
<td>4.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Green flavor</td>
<td>1.7</td>
<td>2.9</td>
<td>3.5</td>
<td>2.4</td>
<td>2.2</td>
<td>2.2</td>
<td>2.2</td>
<td>3.6</td>
<td>2.7</td>
<td>2.5</td>
<td>2.5</td>
<td>2.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Overripe</td>
<td>2.4</td>
<td>0.3</td>
<td>0.8</td>
<td>1.8</td>
<td>3.2</td>
<td>1.6</td>
<td>1.0</td>
<td>1.8</td>
<td>2.2</td>
<td>2.1</td>
<td>2.1</td>
<td>2.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Woods/musty</td>
<td>1.4</td>
<td>1.1</td>
<td>1.5</td>
<td>1.5</td>
<td>1.0</td>
<td>1.4</td>
<td>0.7</td>
<td>0.7</td>
<td>1.0</td>
<td>1.0</td>
<td>0.9</td>
<td>1.4</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Means followed by the same letter within a row were not significantly different by the Least Significant Difference (LSD), α = 0.05.

Fig. 1. Principal components analysis plot of sensory descriptors for University of Florida strawberry cultivars and selections tested in Jan. 2010. Principal components 1 (F1) and 2 (F2) account for 47.7% and 22.1% of the variation, respectively.

First principal component (F1) explained 47.7% of the variation, and was mostly defined by firmness (positive side) and overripe (negative side) descriptors. Principal component 2 (F2) explained 22.1% of the variation and was defined mostly by sourness on the positive side, and also overripe on the negative side (Fig. 1). Selection 05-85 had the highest firmness rating, and also rated high for surface graininess (Fig. 1). ‘Florida Belle’ and 05-107 also had high ratings for surface graininess and firmness, and they had the lowest sourness ratings; this explains their position in the PCA biplot (Fig. 1). ‘Strawberry Festival’, ‘Earlibrite’, and 06-38...
were on the upper positive side of the biplot, explaining a balance of sweetness, strawberry flavor, green flavor, and firmness. As seen from results in Table 3, ‘Carmine’ and ‘Rosa Linda’ had high sourness ratings, as well as astringency. ‘Winter Dawn’ and ‘Dover’ had high overripe ratings, with low strawberry flavor and sweetness (Fig. 1 and Table 3). Sweetness and strawberry flavor were correlated with each other; so were sourness and astringency, but these two groups were not correlated (Table 4 and Fig. 1). Correlations between descriptors that are found in association in products, such as “sweet” and “fruity,” are well known (Pfeiffer et al., 2006). The correlation between sourness and astringency may be explained by high levels of citric acid, perceived as both sour and astringent (Corrigan Thomas and Lawless, 1995).

It is to be noted that the January data may not be representative of a typical behavior of strawberry selections because the weather was abnormally cold in 2010, with night freezing temperatures from 3 to 13 Jan., and 1 inch of rain right before harvest. Nevertheless, the data provide information on strawberry quality when plants were subjected to climatic stress.

**February harvest.** ‘Florida Elyana’ and ‘Strawberry Festival’ had the highest sweetness and strawberry flavor ratings, with fairly high firmness (Table 3 and Fig. 2). Selection 05-85 also had high strawberry flavor (Table 3). As in January, selections 05-107 and 05-85 had high firmness and lowest sourness, together with ‘Florida Belle’ (Table 3, Fig. 2). ‘Carmine’ and ‘Rosa Linda’ had high sourness/astringent ratings; however, ‘Dover’ had the highest sourness and lowest sweetness ratings (Table 3, Fig. 2). ‘Carmine’ and ‘Rosa Linda’ had fairly high firmness (Table 3 and Fig. 2). Selection 05-85 also had high firmness and lowest sourness, together with ‘Florida Belle’ (Table 3, Fig. 2). ‘Carmine’ and ‘Rosa Linda’ had high sourness/astringent ratings; however, ‘Dover’ had the highest sourness and lowest sweetness ratings (Table 3, Fig. 2). ‘Winter Dawn’ and 06-45 were defined by green flavor, and also as sour, overripe and 06-45 were defined by green flavor, and also as sour, overripe and woody/musty. The PCA biplot explained 66.3% of the total variation, with F1 (42.1%) defined as sourness, astringent and surface graininess on the positive side, and strawberry flavor, green flavor and firmness on the negative side. The PCA biplot explained 66.3% of the total variation, with F1 (42.1%) defined as sourness, astringent and surface graininess on the positive side, and strawberry flavor, green flavor and firmness on the negative side.
sweetness and firmness on the negative side (Fig. 2). F2 (24.2%) was defined as overripe, strawberry flavor and sweetness on the positive side, and green on the negative side.

**March Harvest.** ‘Florida Elyana’, ‘Florida Belle’, 05-107, ‘Strawberry Festival’ and ‘Florida Radiance’ had high ratings for firmness, sweetness and strawberry flavor (Table 3 and Fig. 3). ‘Sweet Charlie’ also had high sweetness, but low firmness and sourness (Table 3). ‘Carmine’ and 06-45 had high ratings for sourness/astringent and surface graininess. ‘Dover’ and ‘Winter Dawn’ were predominantly overripe and woody, with low firmness (Table 3 and Fig. 3); in addition, ‘Dover’ had low sweetness and strawberry flavor ratings (Table 3). The PCA biplot was defined with F1 (45.7% of the variation) as sourness, astringent, surface graininess and green flavor on the positive side, and sweetness and strawberry flavor on the negative side, and F2 (29.2% of the variation) as firmness in the positive side, and overripe and woody/musty on the negative side.

**Instrumental Measurements.** SSC ranged from 5 to 12 °Brix, pH from 3.4 to 4.1 and TA from 0.5% to 1.1% citric acid, with higher SSC values in February than January or March, and TA values lower in March than the first 2 months (data not shown). Samples with high SSC were ‘Elyana’ (11.5–7.5 °Brix), ‘Sweet
Charlie’ (9.8–7.3 °Brix), ‘Florida Belle’ (9.6–6.7 °Brix) and 06–38 (10.6–6.4 °Brix), and low SSC were ‘Winter Dawn’ (7.3–6.2 °Brix), ‘Radiance’ (7.8–5.3 °Brix) and ‘Dover’ (8.2–5.6 °Brix).

There was a sharp decrease in overall SSC in March, which has been observed when temperatures increase (MacKenzie and Chandler, 2009). Samples with highest pH were 05-107 (3.9–4.0) and ‘Florida Belle’ (3.8–3.9), whereas ‘Dover’ (3.6–3.7) and ‘Winter Dawn’ (3.5–3.7) had lower pH. Likewise, the same samples had low and high TA, respectively.

In all three taste panels, TA and SSC/TA were correlated with sweetness and sourness: SSC/TA positively correlated with sweetness and negatively correlated with sourness, with TA having the opposite correlations with the same descriptors (Table 4).

In January, pH was also negatively correlated with sourness and woody/musty. In February, correlations were higher, and SSC, pH and SSC/TA explained sweetness and strawberry flavor, and TA explained sourness, while TA was negatively correlated with sweetness and SSC/TA negatively correlated with sourness and astringent (Table 4). In March, pH and SSC/TA were positively correlated with sweetness and SSC, pH and SSC/TA negatively correlated with sourness. TA was positively correlated with sourness and negatively correlated with sweetness.

Overall, this study confirmed high eating quality of ‘Florida Elyana’ with high strawberry flavor, sweetness and low sourness, and also of ‘Strawberry Festival’, ‘Florida Radiance’ and ‘Florida Belle’, that also had high firmness. It also confirmed that ‘Sweet Charlie’ has good eating qualities but tends to lack firmness. There were seasonal and/or ripening effects for ‘Earlibrite’ and ‘Rubygem’, which had good eating quality in January, and ‘Sweet Charlie’, which was good in March. Overall, ‘Dover’ and ‘Winter Dawn’ were of poor quality, either overripe and woody/musty (in January and March), or under-ripe and too sour (in February). ‘Carmine’ and ‘Rosa Linda’ had consistent high sourness ratings. Among the new selections, 05-107 and 06-38 were of good eating quality, with high sweetness and strawberry flavor, and 05-107 was always rated with high firmness, along with 05-85.

**Literature Cited**


