Variability in Sugars, Acids, Firmness, and Color Characteristics of 12 Peach Genotypes

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Abstract. A wide range of color, sugar, and acid composition was found among 12 peach [Prunus persica (L.) Batsch] genotypes. Among the high-acid genotypes, a trend of increasing Hunter 'a' values, fructose, soluble solids concentration (SSC); titratable acidity (TA) ratio, and decreasing TA and citric acid levels was noted with decreasing mesocarp firmness. Mesocarp firmness was correlated with both skin and flesh 'a' values within all genotypes. Among genotypes, the Hunter 'a'/firmness relationship varied. ‘Elberta’, a cultivar known to retain a greenish ground color, had a lower Hunter ‘a’ value when soft than did more recent releases such as ‘Dixiland’, ‘Redhaven’, and ‘Suwanee’. ‘Sam Houston’, a low-acid cultivar, had lower TA and malic, citric, and quinic acid levels than the other cultivars. The dominant acid for all genotypes was malic (50% to 60% of total) with about equal amounts of citric and quinic acids. Soluble sugars included sucrose (54% of total), fructose (31%), and glucose (15%). ‘Sam Houston’ had lower SSC, a higher percentage of sucrose, lower levels of glucose and fructose, but the same relative sweetness values as the high-acid cultivars.

Materials and Methods

Twelve early to late-maturing peach genotypes (Table 1) were employed in these studies. All were high-acid types except for ‘Sam Houston’. Notable high-acid types were ‘Elberta’, ‘Loring’, and ‘Redhaven’. ‘Elberta’ was an important cultivar until 1940 at which time improved commercial types became available (Meyers et al., 1989). ‘Loring’ is widely known as a high-quality midseason peach, and ‘Redhaven’ is the most widely planted cultivar in the world (Iezzoni, 1987).

Peaches were picked between June and August from the orchards at Texas A&M Univ. Research orchard in College Station. Fruit of each genotype were harvested from random locations on two trees. About 60 peaches of each genotype were picked, brush创造了 before being measured. Skin color was measured from an area of the peach judged to be least blushed. The skin was then removed and the flesh color measured from the same area.

Table 1. Peach genotypes used in study.

| Genotype     | Chilling requirement | FDP | Ripe date | Release date | State of origin |
|--------------|----------------------|-----|-----------|--------------|----------------|
| Harvester    | 750                  | 92  | 15 June   | 1973         | La.            |
| Redhaven     | 950                  | 95  | 16 June   | 1940         | Mich.          |
| Sam Houston  | 650                  | 100 | 13 June   | 1965         | Texas          |
| Y5-64        | 550                  | 105 | 14 June   | ---          | Texas          |
| Fireprince   | 850                  | 105 | 22 June   | 1985         | Ga.            |
| Suwanee      | 650                  | 106 | 18 June   | 1962         | Ga.            |
| Loring       | 750                  | 118 | 10 July   | 1946         | Mo.            |
| Ouachita Gold| 850                  | 133 | 25 July   | 1981         | La.            |
| Dixiland     | 750                  | 135 | 23 July   | 1962         | Ga.            |
| Elberta      | 850                  | 136 | 27 July   | 1840         | Ga.            |
| Jerseyqueen  | 850                  | 137 | 29 July   | 1964         | N.J.           |
| La Jewell    | 850                  | 143 | 3 Aug.    | 1988         | La.            |

Chilling requirement in chill units determined by relative bloom time with respect to the standard cultivars: Texstar (550 chill units), Harvester (750 chill units), and Springold (850 chill units).

Date of first commercial harvest at College Station, Texas.

*Material and Methods*

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Abbreviations: SSC, soluble solids concentration; TA, titratable acidity.
The same area as flesh color, by use of an Effegi penetrometer (Effegi, 48011, Afnolnsie, Italy) equipped with an 8-mm cylindrical plunger.

A composite sample of mesocarp tissue derived from five fruit grouped on the basis of firmness was homogenized using a blender, and the homogenate was filtered through cheesecloth to obtain the juice for chemical measurements. The filtered juice was partitioned into three subsamples. These were measured for percent SSC with a refractometer (Bausch and Lomb, Abbé) and for TA by titration with 0.1 N NaOH. Titration data are expressed as milliequivalents of anhydrous malic acid per milliliter of juice (meq H+/ml).

Sugars and organic acids were analyzed using the gas–liquid chromatographic method described by Marcy and Carroll (1982). Samples (3 ml) of juice filtrate were filtered through an activated Sep-pak C18, cartridge and freeze-dried before derivatization. Qualitative analysis of trimethylsilyl-oxime derivatives of organic acids and soluble sugars was accomplished by comparing retention times of unknown peaks to those of known standards. Quantification was by the internal standard method. Averages of three calibration standards determined at several concentrations were used as the relative response factors.

The fruit were grouped according to the following mesocarp firmness categories (FC): 1 = O−22 N, 2 = >22 N and ≤44 N, 3 = >44 N and ≤66 N, and 4 = >66 N. Firmness category 1 fruit were soft ripe, FC 2 were firm ripe, FC 3 corresponded to threshold maturity as described by Delwiche and Baumgardner (1983), and FC 4 fruit were considered immature. The mature category of Delwiche and Baumgardner (1983) is at the high extreme of FC 2 and the lower extreme of FC 3. Mean values of composite samples were used in all the statistical analyses.

### Results and Discussion

**Color.** Ground color as opposed to the blush overcolor is considered to be well correlated with flesh firmness of fresh-market peaches (Delwiche and Baumgardner, 1983, 1985) and contributes to the brightness of the fruit. With canning clingstone cultivars, the color of the flesh as determined by the ‘a’ value can be used as a measure of maturity (Kader et al., 1982). The less green (lower ‘a’ values) the color, the more mature the fruit. Among the peach cultivars studied, firmness was well correlated with ‘a’ values from both skin and flesh (Tables 2 and 3). The flesh values were less variable than those from the skin (Table 4), probably because of the red overcolor of the skin.

The range in mean skin ground color ‘a’ for the cultivars surveyed was 3.1 to 10.3 (Table 4). The range is 2-fold greater than that reported by Delwiche and Baumgardner (1983) in their survey of 13 fresh-market cultivars and is similar to the differences among canning clingstone cultivars reported by Kader et al. (1982). ‘Elberta’, Y5-64, and ‘Harvester’ have been noted for greenish ground color when firm ripe, and this was reflected in lower skin ‘a’ values (Table 4). Generally, breeders have selected cultivars with a less green ground color while still firm enough to market. The cultivars examined here differed in color and in the rate of change in color with respect to firmness.

**Organic acid composition.** Over all genotypes, malic was the predominant acid (50% to 60% of total) with citric (20% to 25%) and quinic (20% to 25%) being present in lesser quantities (Table 5). Only citric acid levels and TA consistently decreased as firmness decreased (Table 2). These trends agree with previous work (Kader et al., 1982; Meredith et al., 1989; Wills et al., 1983), although Wills et al. (1983) reported a higher level (percent of total acid) of citric acid (35%) and a lower level of quinic acid (20%) than we observed.

‘Sam Houston’, the low-acid cultivar, had lower TA than the high-acid peaches (2.1 vs. 8.7 H+ meq·ml⁻¹), and the highest SSC : TA ratio (6.0 vs. 1.6) of the cultivars assayed (Table 4). This cultivar had lower levels of all three acids than the average of the high-acid types: malic acid (5.0 vs. 8.4 mg·ml⁻¹), citric acid (1.1 vs. 3.5), and quinic acid (2.7 vs. 3.2). Although ‘Elberta’ and ‘Fireprince’ had levels of malic acid similar to the low-acid ‘Sam Houston’, they had three to four times the TA level of ‘Sam Houston’. ‘Sam Houston’, ‘Fireprince’, and ‘La Jewell’ were lower in TA than ‘Loring’ and ‘Redhaven’, two widely grown commercial cultivars. In addition, ‘Fireprince’ and ‘Sam Houston’ had lower and ‘Suwanee’ and ‘Y5-64’ had higher levels of malic acid than ‘Loring’ or ‘Redhaven’.

The organic acid levels were well correlated with TA. The ratio of SSC to TA was negatively correlated with TA, malic, and citric acid levels (Table 3). A negative correlation between firmness and SSC : TA (r = −0.48), reflecting an increase in SSC and a decrease in TA with decreasing firmness (i.e., ripening) was also reported by Delwiche and Baumgardner (1983). Malic acid content was correlated to skin yellowness (b) and skin brightness (L) values. These relationships have not been reported previously, although Delwiche and Baumgardner (1983) reported significant but low correlations between TA and ‘a’ (r = 0.50) and ‘b’ (r = 0.20) values.

**Sugar composition.** As with other studies (Long and Chism, 1987; Robertson et al., 1988; Wills et al., 1983), we found sucrose was the major soluble sugar (Table 5). The sucrose content of the peach genotypes examined ranged from 45% to 65% of total soluble sugars. In previous reports, glucose and fructose were found in about equal levels. In the present study,

![Table 2. Mean value for fruit maturity variation in flesh color, firmness, and chemical composition of 11 high-acid peach cultivars.](https://example.com/table2)

### Table 2. Mean value for fruit maturity variation in flesh color, firmness, and chemical composition of 11 high-acid peach cultivars.

| Firmness category* | Color (CDM) | Firmness (N) | TA (meq H+/ml) | Acid (mg·ml⁻¹) | SSC (°Brix) | Sugar (mg·ml⁻¹) | Rel swt | SSC : TA |
|-------------------|-------------|--------------|----------------|----------------|-------------|----------------|---------|---------|
| 4                 | 3.5         | 4.8          | 75             | 10.1           | 8.9         | 4.4            | 3.6     | 13.5    | 41       | 22       | 79       | 17       | 1.4     |
| 3                 | 5.8         | 7.6          | 36             | 8.9            | 8.3         | 3.4            | 3.2     | 13.2    | 47       | 24       | 81       | 18       | 1.6     |
| 2                 | 8.4         | 9.3          | 36             | 8.7            | 8.9         | 3.6            | 3.4     | 14.3    | 43       | 22       | 76       | 17       | 1.7     |
| 1                 | 13.0        | 11.4         | 16             | 7.8            | 8.1         | 2.9            | 3.3     | 15.0    | 56       | 25       | 75       | 19       | 2.1     |

# Significance

*Significance: *** = 0−22 N, ** = >22 N and ≤44 N, * = >44 N and ≤66 N, 4 = >66 N.*

*Rel swt = relative sweetness, sugar content weighted by sweetness relative to sucrose (1.00). Calculated as sum of sucrose content (x 1.00), fructose content (x 1.73), and glucose content (x 0.74), divided by 10.

**Regression analysis, nonsignificant and significant at P = 0.05, 0.01, and 0.001, respectively.**
the level of fructose for all genotypes was twice that of glucose (Tables 2 and 5). There was a general increase in SSC and sugar levels with the decrease in firmness, but this increase was significant only with fructose (Table 2). There were large differences in sugar levels, °Brix, and relative sweetness between the peach genotypes (Tables 4 and 5). ‘Loring’, ‘Dixiland’, and ‘Redhaven’ had the highest SSC but not the highest levels of fructose, glucose, sucrose, or relative sweetness.

SSC was not correlated with individual sugar levels or the composite relative sweetness (Table 3) because SSC values measured using a refractometer reflect the presence of all soluble optically active compounds including pectins, salts, acids, and sugars (Jacobs, 1944). A similar observation has been reported in citrus (Echeverria and Ismail, 1990).

### Summary and Conclusion

A wide range of color and compositional components was observed in the peach genotypes examined. Ground color, as measured with the Hunter ‘a’ value, was well correlated with firmness, but genotypes differed in their firmness/Hunter ‘a’ relationship. Peaches that have a green ground color when soft (<22 N), such as ‘Elberta’, had lower ‘a’ values. Most of the commercially grown cultivars were similar in sugar and acid content to ‘Loring’ or ‘Redhaven’. ‘Sam Houston’, the low-acid peach, had a TA three to five times lower and a higher sucrose content than the high-acid cultivars. Individual organic acid contents were well correlated with TA. The sugar content or the relative sweetness index was not correlated with SSC. The differences between cultivars need to be characterized to better define the acceptable range of color and chemical components in particular types of cultivars (low-acid vs. high-acid types).

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