Cultivar and Maturity Affect Postharvest Quality of Fruit from Erect Blackberries

P. Perkins-Yeazle and J.K. Collins
U.S. Department of Agriculture, Agricultural Research Service, South Central Agricultural Research Laboratory, Lane, OK 74555

J.R. Clark
Department of Horticulture, University of Arkansas, Fayetteville, AR 72701

Additional index words: Rubus spp., fruit composition, firmness

Abstract. Fruit at three stages of ripeness were harvested from four erect blackberry (Rubus spp.) cultivars, 'Navaho', 'Choctaw', 'Cheyenne', and 'Shawnee', for 2 years to evaluate fresh-market shelf life during 7 days of storage at 2C, 95% relative humidity. Ethylene production was highest from dull black fruit and varied within and among cultivars, ranging from 1.3 to 5.1 mmol kg⁻¹ d⁻¹ for 'Navaho' and 'Choctaw' fruit, respectively. Weight loss ranged from 0.8% (Shawnee) to 3.3% ('Navaho') after storage. Mottled (50% black) fruit of all cultivars were higher in fruit firmness and titratable acidity and had lower soluble solids and anthocyanin concentrations than fruit at other stages of maturity. Cultivars did not differ in total anthocyanin concentration, but dull black fruit had a higher anthocyanin concentration than shini black fruits. Dull black 'Choctaw', 'Shawnee', and 'Cheyenne' fruit were softer and had more leakage and decay than shiny black fruit. Both shiny and dull black 'Navaho' fruit had less leakage than fruit of other cultivars. All cultivars at the shiny black stage were considered marketable after 7 days at 2C because fruit were firm with little decay or leakage. However, red discoloration appeared more frequently on shiny black than on dull black fruit. Mottled fruit of erect cultivars should not be harvested, while shiny black fruit of 'Cheyenne', 'Shawnee', and 'Choctaw' might be suited for regional markets. Either shiny black or dull black 'Navaho' fruit could be shipped to distant markets.

Consumption of fresh blackberries has increased in the past 3 years; 31% of U.S. consumers purchased blackberries from retail stores in 1994 (Pomerantz, 1995). This increase in consumption may have resulted from a 77% increase in commercial blackberry production between 1980 and 1990 (Clark, 1992). Currently, 65% of total blackberry production east of the Rocky Mountains is of erect-type cultivars (Clark, 1992). Erect-type blackberry production requires less labor since plants can be mechanically pruned and do not need trellising. Local pick-your-own and fresh markets for erect-type blackberries have increased and there is interest in shipping these fruit (Steik, 1992). Blackberry fruit undergo distinct color changes during ripening. Fruit change from green to red then turn black (Burden and Sexton, 1993). The latter stages of ripeness occur rapidly in erect cultivars grown in warm climates (i.e., 1 to 3 days). These ripest stages are commercially di

Received for publication 8 June 1995. Accepted for publication 31 Dec. 1995. We thank Sheila Magby, Sherry Wasing, and Lesa Lackey for their technical assistance. Mention of a trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agriculture and does not imply its approval to the exclusion of other products of vendors that may also be suitable. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked 'advertisement' solely to indicate this fact.

Materials and Methods

Fruit were harvested from established blackberry plots grown with standard cultural practices in a hedgerow system in Clarksville, Ark. No fungicides were applied. Fruit at mottled (50% black), 2 days from dull black, shiny black (1 day from dull black), and dull black ripeness stages from thorny 'Cheyenne', 'Choctaw', and thornless 'Navaho' were harvested twice each 4-6 times in 1992 and 1994, representing field ripeness of 30% and 60%, respectively. Each cultivar had a 2- to 3-week harvest period at this location. Two harvests per year for each cultivar and color stage were used. Fruit of each ripening stage and cultivar were harvested into 250-ml pulp boxes and held at 70 to 72C during the 4-hour transport by car to Lane, Okla. On the day following harvest, six individual fruit per cultivar were placed in 150-ml jars and held for 0.5 h at 20C in darkness. To determine CO₂ evolution rates, 1 ml headspace samples were injected into a Shimadzu gas chromatograph equipped with a thermal conductivity detector and a 3.1 x 0.25 mm stainless steel column packed with Porapak N (80/100 mesh) with a 5A column (3 mm) in series with a 5% on 100/120 mesh Carboxen 1000). Fruit were stored in dark at 20C. Results of color change and fruit decay were determined after 7 days. In addition, 7-day headspace samples were injected into a Shimadzu gas chromatograph equipped with a flame ionization detector and a 3.1 x 0.25 mm stainless steel column packed with activated alumina.

Skin firmness was measured on 20 fruit per sample at days 0 and 7 using a Correx penetrometer (10-, 30-, 50-, and 100-g gauge, Wagner Instruments, Greenwich, Conn.) with a 3.6 in. (0.3 mm) in diameter, 4 mm in length) on the side of the fruit. Three measurements were made per fruit—two at the base, center, and tip locations—by holding the pin perpendicular to the droplet surface and keeping the pin in contact with the fruit. The presence or absence of red discoloration and decay on fruit was evaluated. For compositional analysis, 10 fruit per sample were ground with an equivalent weight of water in a Waring blender, centrifuged, and filtered through cheesecloth to remove debris. Ten milliliters of filtrate was added to 90 ml distilled water and titrated to pH 8.2 with 0.1 N NaOH. Titratable acidity (TA) was calculated as percent citric acid. Soluble solids concentration (SSC) was determined by placing 40.5 ml of remaining filtrate on the stage of a Cahn JL refractometer. Anthocyanin was extracted by double extraction of 5 g of fruit with 20 ml of saturated 1.0 M HCl, 90% ethanol. Absorbance was read at 532 nm.
in a spectrophotometer (Shimadzu UV-160), and data were expressed as absorbance units/mm (mL fruit weight).

The experiment was designed as a splitplot arrangement consisting of four cultivars x three stages of ripeness. To represent an average response to the fruit (1:3 weeks) harvest period, storage trials were replicated over time using harvest dates and years as replications for each cultivar and ripeness stage, and data were subjected to analysis of variance.

Results and Discussion

Dull black fruit were heavier than fruit from the other color stages (Table 1). Mottled fruit had only 60% of the fresh weight of dull black fruit. “Shawnee” had the heaviest berries at all color stages. Weight loss among cultivars ranged from 0.9% to 3.3% after 7 days at 2°C and was influenced by cultivar and color stage. Dull black ‘Shawnee’ fruit lost less weight than those of the other cultivars, probably because “Shawnee” had the heaviest and, consequently, large berries (7 g vs. 4.5 g). ‘Navaho’ and ‘Choctaw’ fruit tended to lose more weight than the others at all color stages.

Fruit skin firmness depended on cultivar, ripeness stage, and storage duration (Table 1). ‘Choctaw’ fruit was softer than those of ‘Navaho’ or ‘Cheyenne’ at all color stages. Within cultivars, mottled fruit had the highest skin firmness and dull black the lowest. Following storage, ‘Navaho’ fruit had higher skin firmness values than the other cultivars, regardless of color stage. Occasionally, skin firmness values were higher after storage. This phenomenon happened most often with ‘Navaho’ and may have resulted from weight loss and subsequent epidermal cell desiccation, as reported for strawberries (Sasunk, 1963).

Subjective ratings for firmness differed among cultivars and color stages (Table 1). Mottled fruit was rated firmer, and no cultivar was rated excessively soft. However, ‘Choctaw’ and ‘Shawnee’ dull black fruit were soft after storage. Both dull and shiny black fruit of ‘Navaho’ had high firmness ratings and were no softer than other cultivars. These results were similar to those reported by Moore and Clark (1988), who found that ‘Navaho’ had better subjective firmness ratings than ‘Shawnee’ or ‘Cheyenne’. Subjective firmness ratings were positively correlated with pen penetrometer readings (P < 0.001). Regression analysis failed to yield an r value greater than 0.17 for linear, quadratic, or cubic relationships.

SST was higher in dull black than in mottled fruit for all cultivars (Table 2). This trend is similar to that reported for semi-early blackberries (Walsh et al., 1983). Except for ‘Navaho’, there was little difference in SST between shiny and dull black fruit among cultivars and fruit of all ripeness stages increased in SST during storage. However, only dull or shiny black ‘Shawnee’ fruit significantly increased in SST during storage. An increase in SST was expected, since weight loss concentration cell sap. However, the increase in SST in this study exceeded values predicted from weight loss. Increased SST during storage may be due to a gain in sugars or hydrolysis of cell wall materials. Dull and shiny black ‘Navaho’ and ‘Choctaw’ fruit were higher in SST than ‘Shawnee’ and ‘Cheyenne’ before and after storage. Our data for SST are similar to those reported for black ‘Shawnee’, ‘Choctaw’, and ‘Navaho’ fruit (Clark and Moore, 1990; Moore and Clark, 1988, 1994; Moore et al., 1983).

There were greater changes in TA than in SST as ripening progressed (Table 2). TA decreased as much as 70% between mottled and shiny black ripeness stages. Decreased TA during blackberry fruit ripening also has been reported for semi-early cultivars (Walsh et al., 1983). Between shiny and dull black stages, fruit TA decreased 10% to 30%, depending on cultivar. Cultivars, ‘Navaho’ fruit had the highest TA at the shiny and mottled stages. TA decreased 15% to 30% for all cultivars in mottled fruit and 15% to 30% in shiny or dull black fruit during storage for all cultivars except ‘Navaho’. ‘Shawnee’ dull black and dull ‘Navaho’ fruit were 30% to 40% higher in TA following storage than initially. About 10% of this increase could be accounted for by concentration of acidity due to weight loss. The high TA and low SST found in mottled fruit even after storage would make these fruits unacceptable for floral market.

Authentication concentrated differed among color stages but not among cultivars. Data are not shown. The anthocyanin concentration of dull black fruit declined during 7 days of storage from 14.9 to 9.3 absorbance units/gram, that of shiny black and mottled fruit did not change appreciably during storage (data not shown). The anthocyanin content of these fruit is similar to that reported for the black fruit of ‘Black Satin’ and ‘Wolf Thornless’ blueberries (Sagers et al., 1986).

The percentage of fruit exhibiting decay after storage ranged from 0% to 40% depending on stage of ripeness and cultivar (Table 3). Dull black than mottled or shiny black fruit was decayed. There were more decayed dull black ‘Cherrywine’ berries than ‘Choctaw’ or ‘Navaho’. Shiny black ‘Choctaw’, ‘Shawnee’, and ‘Cheyenne’ had 5% to 10% decayed berries. Less than 1% of shiny black fruit.
'Navaho' fruit had decayed after 7 days of storage, meeting USDA number 1 grade standards (U.S. Dept. of Agriculture, 1928). Clark and Moore (1990) reported that 'Chocaw' and 'Shawnee' fruits were unmarketable after 7 days of storage at 5°C because of softness and decay. The better quality for these cultivars found in our study may have been the result of prompt postharvest cooling.

The percentage of berries with leakage for exceeded those with decay (Table 3). 'Navaho' dull and shiny black fruit had much less leakage (30% to 40%) than the other cultivars. The percentage of berries exhibiting red discoloration was higher for shiny black than for dull black fruit and was used as an evaluation criterion for infected berries (Table 3). Of the shiny black berries, discoloration occurred least often on 'Navaho' fruit. Discoloration of black fruit ('reddening') has been reported for frozen berries (Cahoon and Sapers, 1986). The causes of discoloration may be due to less mature fruit being harvested, resulting in less total pigment content and a lower pH, or differences in the relative concentrations of various pigments (Mazza and Mininno, 1993; Morris et al., 1981; Sapers et al., 1986). Our data support the view that blackberry discoloration occurs more often on less ripe fruit (Jennings, 1988). However, our results indicate a strong cultivar influence on expression of this postharvest problem.

At 20°C, the respiration rate of blackberry fruit ranged from 1150 to 1480 mmol kg⁻¹ day⁻¹, depending on cultivar and color stage (Table 4). The maximum respiration rate occurred at a different ripeness stage for each cultivar. 'Navaho' fruit had the highest respiration rate at the mottled stage, 'Shawnee' and 'Cheyenne' at the shiny black stage, and 'Chocaw' at the dull black stage. The rate of respiration among the color stages was similar to that reported for 'Chester' and 'Hull Thornless' semi-erect blackberries (Walsh et al., 1983).

There was a strong positive correlation between subjective firmness ratings and ethylene content for cultivars at the dull black and mottled color stages (P = 0.001). Mottled fruit were hard and had little or no ethylene production, while dull black fruit were usually soft and had high ethylene production. 'Chocaw' fruit produced more ethylene and were softer than 'Navaho' fruit. Shelf life is inversely related to ethylene production rates (Walsh et al., 1983). The high percentage of 'Cheyenne' and 'Shawnee' berries with leakage after 7 days suggests that ethylene production may be related to this postharvest problem.

For all cultivars, mottled fruit did not darken appreciably during storage. In 1992, none of the mottled fruit changed to black, while in 1994, 30% to 80% of mottled 'Navaho' and 'Shawnee' fruit from the last harvest became darker, possibly due to higher day and night temperatures (mean 35/20°C) during that harvest than in 1992. The SSC and anthocyanin levels were very low in mottled fruit and TA very high relative to other color stages, even after storage. Therefore, using mottled fruit for processing or fresh-market use is not recommended.

Walsh et al. (1983) suggested that only dull black blackberries of semi-erect cultivars should be used for fresh market use due to higher SSC and lower TA. Data from our study indicate that the appropriate stage of ripeness for harvest depends greatly on the cultivar. Although 'Cheyenne', 'Shawnee', and 'Navaho' fruit did not differ appreciably in SSC or TA between the shiny black and dull black stages, dull black fruit had excessive leakage and decay after 7 days of storage. Therefore, fruit of these cultivars destined for fresh markets should be harvested at the shiny black stage. Since SSC was higher and TA lower in dull black 'Navaho' fruit compared to shiny black fruit, and dull black fruit were firm following storage, dull black 'Navaho' might be suitable for fresh markets.

Dull and shiny black 'Navaho' fruit had much less softening, decay, leakage, and discoloration than 'Chocaw', 'Cheyenne', or 'Shawnee'. Therefore, 'Navaho' fruit would be most suited to shipping to distant markets. More research needs to be done to determine the maximum shelf life and commercial acceptance of these blackberry cultivars.

Literature Cited


