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Postharvest Berry Quality of Six Rabbiteye Blueberry Cultivars in Response to Temperature

D. S. NESMITH[1], A. NUNEZ-BARRIOS[2], S.E. PRUSSIA[3], AND D. AGGARWAL[4]

Abstract

The effect of storage and handling temperature regimens on berry firmness and mass loss of six rabbiteye blueberry (*Vaccinium ashei* Reade) cultivars was examined. 'Climax', 'Premier', 'Brightwell', 'Tifblue', 'Powderblue', and 'Yadkin' were studied at 1, 12, 22 or 32°C. Firmness immediately after harvest (determined using a FirmTech II instrument) for all cultivars ranged from 161.0 to 214.6 g/mm. 'Brightwell' had the greatest initial firmness, followed by 'Tifblue', 'Climax', and 'Yadkin'. 'Powderblue' and 'Premier' had the lowest initial firmness. Following 7 days storage, firmness followed a similar cultivar order with 'Brightwell' having the highest value (195.6 g/mm) across all temperatures and 'Powderblue' having the lowest (136.9 g/mm). Rate of firmness loss was similar among cultivars at 1°C and 12°C, except for 'Premier', which lost firmness more rapidly. At 22°C 'Brightwell' had the lowest rate of firmness loss. The greatest difference in rate of firmness loss among cultivars was observed at 32°C, where 'Powderblue' had a 6-fold increase over 'Brightwell' in rate of loss. Storage temperature also affected rate of loss of berry mass, but with fewer differences among cultivars. However, 'Powderblue' had the greatest rate of quality deterioration as measured by loss of mass at the highest temperature.

Introduction

The fruit quality of fresh blueberries can be affected by harvest method, cultivar, and postharvest handling and storage temperatures. Minimal mechanical damage and storage at low temperatures help maintain berry quality (1, 9). Increasing storage and/or handling temperature can increase loss of fruit quality by mass deterioration and fruit softening, with differences between cultivars (6, 8). For example, mass loss of the highbush blueberry (*Vaccinium corymbosum* L.) cultivars Darrow, Coville and Dixi stored at 1°C for two weeks varied from 2.5% to 17.5% between cultivars (2). For rabbiteye blueberries (*V. ashei* Reade), firmness of 'Climax' at harvest was 27.9% greater than that of 'Woodard', and the difference increased to 37.6% following two weeks of storage at 3°C (5).

Delays in moving berries to cool conditions also significantly diminish blueberry fruit quality. Depending on cultivar, holding berries for 48 h at 10°C followed by 24 h at 21°C substantially increased both mass loss and fruit softening as compared to keeping berries at 1°C for 7 days (6). 'Brightwell' rabbiteye blueberry, had only a 3 to 8% loss of firmness when berries remained at ambient temperature (25 to 30°C) for 24 h as compared to cooling fruit over a bed of ice in the field immediately after harvest (8). The effect of pre-storage temperatures on fruit quality depends upon both temperature and the length of the pre-storage interval. Pre-storage temperature had little effect on the market quality of lowbush blueberries (*V. angustifolium*) for intervals up to 21 h, but significant changes in firmness occurred when pre-storage delays at ambient temperature were as great as 45 h (4). Thus, changes in blueberry fruit quality are affected by the interaction among cultivars, handling temperatures and pre-storage time intervals. The objective of this study was to determine the effect of storage and handling temperatures on fruit firmness and mass loss of several rabbiteye blueberry cultivars.

Materials and Methods

The rabbiteye blueberry cultivars Climax, Premier, Brightwell, Powderblue, Tifblue,

[1]Professor, Dept. of Horticulture, Univ. of Georgia, 1109 Experiment Street, Griffin, GA 30223

[2]Visiting Research Scientist from INIFAP/UACH, Mexico, Dept. of Horticulture, Univ. of Georgia, 1109 Experiment Street, Griffin, GA 30223

[3]Professor, Dept. of Biological and Agricultural Engineering, Univ. of Georgia, 1109 Experiment Street, Griffin, GA 30223

[4]Visiting Research Scientist, Dept. of Biological and Agricultural Engineering, Univ. of Georgia, 1109 Experiment Street, Griffin, GA 30223

and Yadkin were harvested at the University of Georgia Experiment Station Blueberry Research Farm at Griffin, Ga. during the summer of 2002. The planting used was established in 1998, and plants were grown using supplemental irrigation and typical practices for rabbiteye blueberries. The cultivars are early (Climax and Premier), mid (Brightwell and Tifblue) and late (Powderblue and Yadkin) ripening. Berries were hand-harvested at commercial maturity, immediately placed in ice chests, and transported to the Postharvest System Laboratory at Griffin for data collection. At the laboratory, bulk berries of each cultivar were randomly divided into sub-samples of 24 berries each. After initial firmness and mass measurements were made, 5 sub-samples of berries from each cultivar were randomly assigned to four different temperatures: 1, 12, 22 and 32°C. Walk-in coolers were used for temperatures of 1 and 12°C, and storage temperatures of 22 and 32°C were achieved by using an enclosed closet at room temperature and a portable food cooler/heater, respectively. All storage temperatures were monitored by data loggers and found to be within a range of ±1°C of the desired temperature. Berries for all cultivars and temperatures were stored in plastic clamshell containers inside a polyethylene bag where relative humidity was maintained at >90%.

In order to manage samples efficiently, mass and firmness data were taken every 12 h for berries stored at 32°C, every 24 h for berries stored at 22°C, every 48 h for berries stored at 12°C, and every 72 h for berries stored at 1°C. Measurements continued for 2 weeks for the cooler temperatures (1and 12°C), but for only 1 week for 22 and 32°C because berry firmness began increasing due to high water loss and the formation of raisin-like blueberries. Firmness (g/mm, force per unit deformation from force-deformation curves) of each berry was measured nondestructively with a FirmTech II (Bioworks, Inc.) compression testing instrument (10, 11). The instrument is designed to rapidly provide firmness values for small fruits such as cherries, blueberries and grapes. The instrument was set at a maximum compressive force of 250g and a minimum force of 50g. Load cell and table speed was set to 7mm/sec. and 0.28 rotations/min., respectively. Calibration tests showed that the average coefficient of variation of the instrument was 1.7% for seven rubber balls whose firmness was measured 33 times under identical conditions. To determine mass loss, berries were weighed with a Mettler-Toledo PR 503 balance (max. mass 510g; resolution 0.001g). Mass measurements were taken before firmness measurements with the balance inside the 12°C walk-in cooler to minimize error from condensation.

To calculate rate of berry firmness and mass loss in response to temperature, the method described by Tetteh *et al.* (11) was used. Briefly, linear regressions were applied to plots (data not shown) of percentage mass and firmness verses time, for each storage temperature. These provided slopes for the percent rate of change for each temperature. These slopes were then plotted against various respective temperatures, and exponential regressions were applied to the data to describe rates of mass and firmness loss for each cultivar. In addition to the regression analyses, mean separation was accomplished using the Duncan multiple range test.

Results and Discussion

The effect of cultivars on initial and post-storage berry firmness, as averaged across all temperatures, is shown in Table 1. 'Brightwell' had the highest initial firmness value, followed by 'Tifblue' and 'Climax', respectively. 'Yadkin', 'Powderblue', and 'Premier' had the lowest initial berry firmness values. Firmness values after 7 days storage indicated a similar ranking, with 'Brightwell' having the highest value, and 'Yadkin', 'Powderblue', and 'Premier' having lower values. Across all temperatures, the percent decrease in fruit firmness during the 7-day storage varied among cultivars. Differences in fruit firmness among blueberry cultivars has been shown by others (6, 7). Berry firmness of 'Tifblue' was 18.4% greater than 'Woodward' (6). 'Brightwell', 'Austin', 'Climax' and 'Alapaha' had a loss of firmness ranging from 5.7 to 14% after a storage period of 10 days at 4 to 6°C (7). In the current study initial firmness appeared to be a good indicator of overall storage performance.

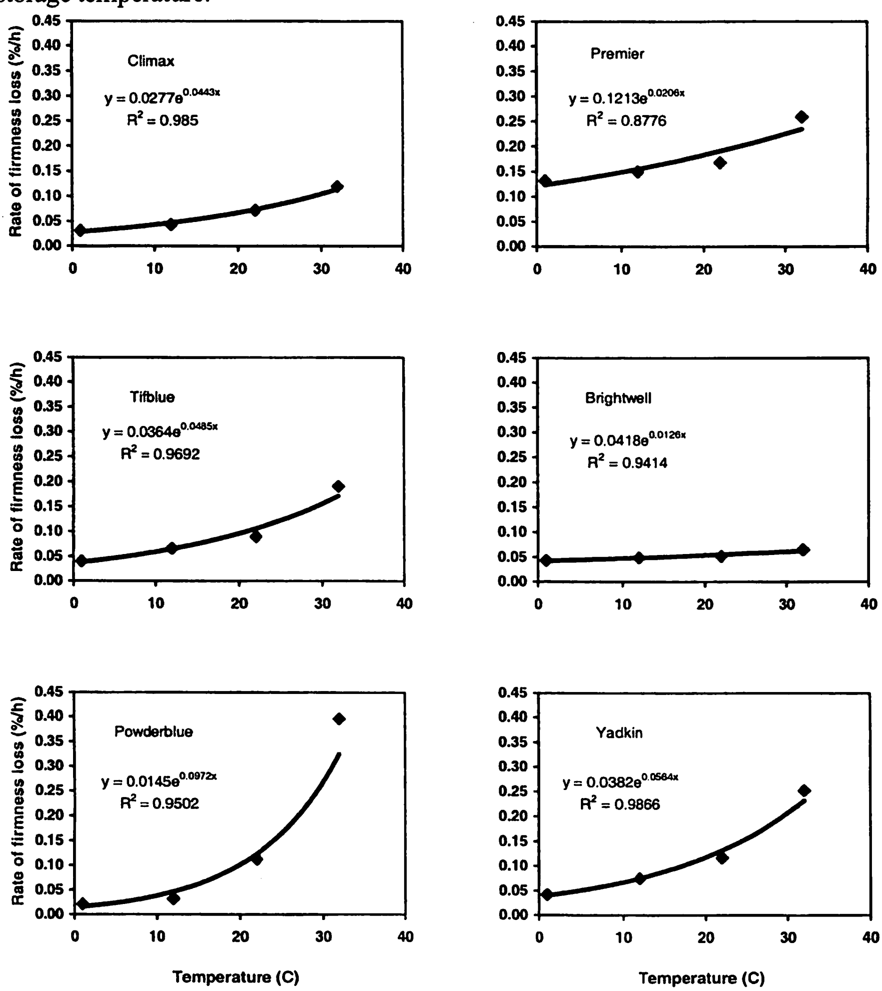
Cultivars differed in response of rate of firmness loss over various temperatures (Fig.1). Rate of firmness loss was similar

Table 1. Initial and final firmness of six rabbiteye blueberry cultivars measured after a 7-day storage period and averaged across storage temperatures.

Cultivar	Initial firmness (g/mm)$^{\prime}$	Final firmness (g/mm)$^{Y\prime}$	Firmness loss (%)
Brightwell	214.6 a^{z}	195.6 a	8.9
Tifblue	194.3 b	166.1 b	14.5
Climax	183.4 bc	161.2 b	12.1
Yadkin	178.2 c	145.1 c	18.6
Powderblue	167.8 cd	136.9 c	18.4
Premier	163.9 d	139.6 c	14.8

^{z} Values within a column followed by a letter in common were not significantly different by Duncan's multiple range test (α=0.05).

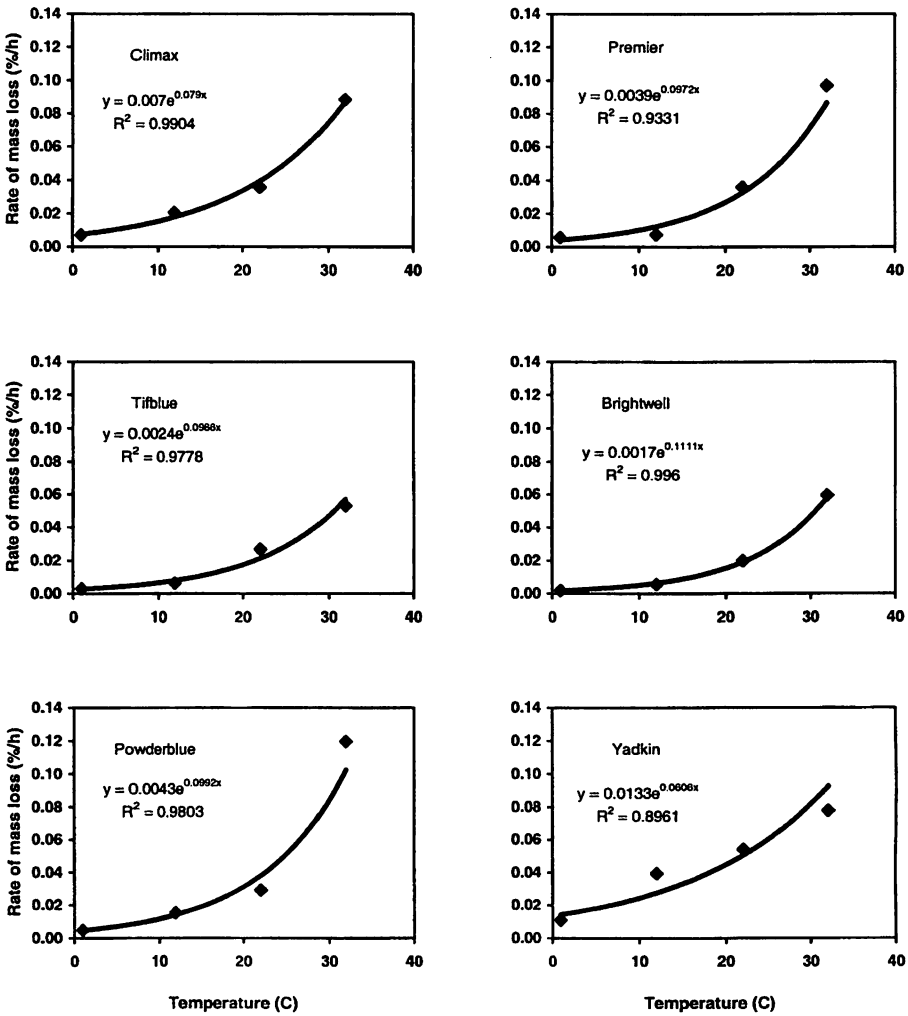
Figure 1. Rate of berry firmness loss for six rabbiteye blueberry culitvars in response to pre-storage temperature.



for five of the six cultivars at 1°C. However, 'Premier' had a notably higher rate of firmness loss at the lowest temperature. A similar ranking of cultivars was observed at 12°C. When temperatures reached 22°C, 'Brightwell' maintained the lowest rate of firmness loss and 'Premier' the highest. The rate began to increase for 'Yadkin' and 'Powderblue' at this temperature. The greatest difference among cultivars in rate of firmness loss was observed at 32°C, where 'Powderblue' had a 6-fold greater increase in the rate than 'Brightwell'.

Fewer differences among cultivars were apparent in rate of berry mass loss in response to temperature (Fig. 2). This was especially true at temperatures of 12°C and lower. When storage temperatures increased to 22°C, 'Yadkin' begin to show an increased rate of mass loss to a small extent. At the highest temperature, rate of mass loss was similar for all cultivars except 'Premier'. As with rate of

Figure 2. Rate of berry mass loss for six rabbiteye blueberry culitvars in response to pre-storage temperature.



firmness loss, rate of mass loss for this cultivar greatly accelerated at 32°C as compared to the others.

Firmness for some perishable fruit declines rapidly at temperatures above 20°C (12). Other researchers have shown that loss of blueberry quality due to softening and decay increases when fruit are stored at temperatures above 1°C, and when storage temperature rises above 20°C, 15 to 20% of the berries will have unacceptable quality within 1 to 5 days (1, 3). The current results for rabbiteye blueberry suggest that the magnitude of loss of quality will likely vary among cultivars.

In a previous study (4), pre-storage temperatures had no effect on blueberry fruit quality when delays did not exceed 21 h. However, greater delays resulted in a marked loss of fruit quality such as increased amount of split berries and decreased firmness. Data presented here indicate that pre-storage temperatures affect quality loss of cultivars differently, and certain cultivars need to be handled with special care. For example, it appears that 'Premier' fruit soften rapidly at all temperatures; therefore, this cultivar should be cooled as quickly as possible and moved through the marketing chain. In contrast, 'Brightwell' berries apparently maintain a rather low rate of quality loss across a range of temperatures, so, the cultivar can be stored at higher temperatures or allowed to experience longer delays in cooling with less adverse effects. Such information is valuable for use in packing houses.

In summary, cultivar differences play an important role in maintaining rabbiteye blueberry fruit quality during postharvest handling and storage. Data suggest that higher initial firmness may result in a longer shelf life for cultivars. Also, cultivars respond differently to increasing storage temperatures, especially with regard to berry firmness. The implications for growers and berry packers is to work with cultivars in a systematic fashion in order to maximize fruit quality and postharvest shelf life.

Literature Cited

1. Ballinger, W.E,. E.P. Maness, and W.F. McClure. 1978. Relationship of stage of ripeness and holding temperatures to decay development of blueberries. J. Amer. Soc. Hort. Sci. 103: 130-134.
2. Bounous, G., G. Giacalone, A. Guarinone, and C. Peano. 1997. Modified atmosphere storage of highbush blueberries. Acta Hort. 446: 197-203.
3. Cappellini, R.A., M.J. Ceponis, and G. Koslow. 1982. Nature and extent of losses in consumer-grade sample of blueberries in greater New York. HortScience 17: 55-56.
4. Jackson, E.D., K.A. Sanford, R.A. Laurence, K.B. McRae and R. Stark. 1999. Lowbush blueberry quality changes in response to prepaking delays and holding temperatures. Postharv. Biol. Technol. 15:117-126.
5. Miller, W.R. and D.A. Smittle, 1987. Storage quality of hand-harvested and machine-harvested rabbiteye blueberries. J. Amer. Soc. Hort. Sci. 112:487-490.
6. Miller, W.R., R.E. MacDonald, C.F. Melvin and K.A. Munroe. 1984. Effect of package type and storage-time temperature on weight loss, firmness and spoilage of rabbiteye blueberries. Hortscience 19: 638-640.
7. NeSmith, D.S., S.E. Prussia, and G. Krewer. 1999. Response of some rabbiteye and southern highbush blueberries to mechanical harvesting. A 1999 research report. pp. 17-20. In D.S. NeSmith (ed.), Blueberry research at the University of Georgia. Res. Rep. 662. Univ. of Georgia College of Agric. and Environ. Sciences, Athens, GA.
8. NeSmith, D.S., S.E. Prussia, M. Tetteh, and G. Krewer. 2002. Firmness losses of rabbiteye blueberries (*Vaccinium ashei* Reade) during harvesting and handling. Acta Hort. 574: 287-293.
9. Sanford, K.A., P.D. Lister, K.B. McRae, E.D Jackson, R.A. Lawrence, R. Stark, and R.K Prange. 1991. Lowbush blueberry quality changes in response to mechanical damage and storage temperature. J. Amer. Soc. Hort. Sci. 116:47-51.
10. Tetteh, M.K. 2002. Measuring blueberry firmness and modeling quality changes for delays in cooling using the FirmTech II. M.S. Thesis, Univ. of Georgia, Athens, Ga.
11. Tetteh, M.K., S.E. Prussia, D.S. NeSmith, B.P. Verma, and D. Aggarwal. 2004. Modeling blueberry firmness and mass loss during cooling delays and storage. Trans. Amer. Soc. Agri. Engin. 47: 1121-1127.
12. Thai, C.N. and R.L. Shewfelt. 1990. Peach quality changes at different constant storage temperatures: Empirical models. Trans. Amer. Soc. Agri. Eng. 33:227-233.