Quality of Two Florida Blueberry Cultivars after Packaging and Storage

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Abstract. Blueberry cultivars Sharpblue (mainly *Vaccinium corymbosum* L.) and Climax (*V. ashei* L.) were hand-harvested on three occasions and manually packaged into 0.275 liter fiber-pulp cups or automatically packaged in vented polystyrene cups. Berries were evaluated after 1, 2, or 3 weeks of storage at 1°C and after 2 additional days of storage at 16°C, a time frame that simulated a merchandising period. Weight loss of fruit packaged in polystyrene cups was <1% during 3 weeks of storage at 1°C, whereas weight loss of berries packaged in fiber-pulp cups was ≈5.0% after similar storage. 'Sharpblue' berries were softer at harvest and after each storage duration than 'Climax' berries. Decay increased to ≈7% for 'Climax' and 28% for 'Sharpblue' after 3 weeks of storage at 1°C. Package type did not affect decay incidence after 3 weeks of storage; but after 2 additional days at 16°C, decay incidence was slightly higher for berries packaged in polystyrene compared with those packaged in fiber-pulp cups. 'Sharpblue' should be packaged only in fiber-pulp cups and marketed quickly after harvest to avoid excessive decay.

Florida blueberry hectareage increased from <40.5 ha in 1973 to 429 ha in 1985 (Crocker and Lyrene, 1985) and 853 ha in 1989 (Crocker and Willis, 1989). Due to climate and the use of low-chill cultivars, Florida has an early blueberry season compared with other states. Continued growth of this industry in Florida depends on the introduction of early maturing cultivars to extend the state's production season. 'Sharpblue', a highbush cultivar, was one of the first hybrids specifically developed for Florida's soil and climatic conditions. It is still the leading early producer, accounting for >80% of early blueberries in Florida (Lyrene and Sherman, 1988). Comprehensive post-harvest information on 'Sharpblue' is lacking because early plantings were made mostly by homeowners for noncommercial use, and only in recent years has 'Sharpblue' become an important commercial cultivar.

In this study, various postharvest quality characteristics of 'Sharpblue' fruit were compared with those of 'Climax' fruit. 'Climax' is a well-established rabbiteye cultivar that produces high-quality fruit that exhibit

good shelf life during marketing (Miller and Smittle, 1987). Since 'Sharpblue' matures early and there is little competition from other blueberry cultivars, it commands a high revenue per unit in the marketplace. Therefore, growers have an incentive to ship it to distant markets that are willing to pay higher prices.

Harvest dates of 'Sharpblue' and 'Climax' do not overlap, and factors such as weather at harvest time and cultural and handling methods influence postharvest fruit quality. Growers need improved postharvest information on highly perishable commodities such as blueberries, which are mostly exported via air cargo under less than optimum environmental conditions.

The purpose of this study was to compare postharvest quality characteristics of 'Climax' and 'Sharpblue' berries packaged manually in fiber-pulp cups or automatically in polystyrene cups. Comparisons were made after extended periods of simulated commercial storage and subsequent merchandising conditions.

All berries were harvested from a large plantation in Alachua County in north-central Florida. 'Sharpblue' fruit were harvested three times at 7-day intervals starting 17 Apr. 1990, whereas 'Climax' were harvested once on 18 May 1990. All berries were hand-harvested into plastic pails (3.8 liters) which, when filled, were dumped into plastic field bins (18.3 liters). Filled bins were transported from the field to the packinghouse for grading and packaging. Immediately after harvest, half of the berries was commercially packed by hand in 0.275 liter fiber-pulp cups with a cellophane cap retained by a rubber band. The remaining half was packaged by machine into polystyrene cups of similar size, formed from flat polystyrene stock just before filling, and covered

with Mylar film (100 gauge, 27 µm thick), each cover with nine 2-mm ventilation holes. Covers were automatically heat-sealed in place at the top perimeter surface of the cup. Twelve tilted cups of berries were placed into each shipping tray and transported to the Orlando laboratory by air-conditioned automobile (about 2-h travel time).

On arrival, the berries were weighed, and the cups of berries were randomized into eight storage lots. For each test (replication), storage lots consisted of three cups of fruit for each cultivar/package type combination. The storage regimes were 1) initial (overnight at 1°C); 2) initial plus 2 days at 16°C [90% relative humidity (RH)]; 3) 7 days at 1°C (90% RH); 4) 7 days at 1°C plus 2 days at 16°C; 5) 14 days at 1°C; 6) 14 days at 1°C plus 2 days at 16°C; 7) 21 days at 1°C; and 8) 21 days at 1°C plus 2 days at 16°C.

After each storage period, air samples were drawn by syringe from the head space in the polystyrene cups and analyzed by gas-liquid chromatography (model 5880; Hewlett Packard, Avondale, Pa.) for concentrations of O₂ and CO₂. Berry weights for each cup were recorded and fruit were removed from the packages. Each berry was inspected and rated according to firmness, juice leakage, decay, and whether the berry was mummified, not mature-blue, or damaged by handling (cull). Berries were subjectively rated firm or soft, according to the degree of berry yield to lightly applied finger pressure. Decay was rated according to the presence of mold or juice leaking at the stem scar or whether the berries were extremely mushy. The percentage of fruit in each condition category was determined on a fresh-weight basis. All berries were salable except culls and those with decay.

A 150-g sample of fruit (soft and firm) was obtained (50 g from each of three cups) from each treatment lot after inspection and frozen for later measurements of soluble solids concentration (refractometer), pH, and acidity (Smittle and Miller, 1988). Remaining berries were placed on plates for a seven-member taste panel to evaluate flavor and texture based on a hedonic scale ranging from 0 to 100, nonacceptable to excellent.

For each inspection, analyses of variance procedures were used to analyze the data as a split-plot experiment, with cultivars as the main plot and package types as the subplots. Differences among cultivars and among package types and their interactions were tested for statistical significance.

Eighty-six percent of 'Climax' berries was rated firm after overnight storage, and 56% was firm after 3 weeks of storage at 1°C. The percentage of soft fruit increased from 12% to 38% during this storage time (Table 1). Decay developed on 5% of 'Climax' berries after 3 weeks of storage at 1°C, and increased to 12% after 2 additional days of storage at 16°C. Culls represented 1% to 2% of fruit weight, and the percentage was not affected by cultivar or storage duration.

The percentage of 'Sharpblue' berries rated firm remained relatively constant (except after the final storage period), ranging from 43% to

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48% during 3 weeks of storage at 1 C, and from 31% to 48% after 2 additional days of storage at 16C (Table 1). The percentage of firm berries was not affected by cultivar ($P < 0.05$) after 1 and 2 weeks of storage at 1C or 1C + 2 days of storage at 16C, or after 3 weeks of storage at 1C + 2 days of storage at 16C.

During storage, as the percentage of decay in 'Sharpblue' berries increased, the percentage of firm fruit remained relatively constant, but the percentage of soft fruit decreased. For 'Sharpblue', after 1, 2, or 3 weeks of storage at 1C plus 2 additional days at 16C, berry decay increased to 18%, 32%, and 48%, respec-

tively. Decay increased faster at 16C than at 1C storage for both cultivars, and there was significantly more decay in 'Sharpblue' fruit than in 'Climax' fruit (Table 1). After 3 weeks at 1C, 94% and 69% of fruit were rated sound [(firm plus soft) - (decayed + leakers + culls)] for 'Climax' and 'Sharpblue', respectively,

Table 1. Percent weight loss and percentage of blueberries rated firm, soft, or decayed by cultivar (CV) and package (PK) type according to storage duration and temperature regime.

		Percent				Percent			
CV and PK type	df	Wt loss	Firm	Soft	Decayed	Wt loss	Firm	Soft	Decayed
Overnight at 1C					Overnight at 1C + 2 days at 16C				
Climax									
Poly ^z		0.2	85.3	11.7	1.1	0.3	84.2	11.6	2.1
Pulp ^y		0.9	87.4	11.2	0.5	1.7	89.7	9.0	0.6
Avg		0.5	86.4	11.5	0.8	1.0	87.0	10.3	1.4
Sharpblue									
Poly		0.3	46.9	44.6	7.1	0.5	47.2	40.3	11.3
Pulp		1.0	42.3	48.5	7.4	3.2	43.2	43.7	11.3
Avg		0.6	44.6	46.6	7.3	1.8	45.2	42.0	11.3
ANOVA									
CV	1	0.03 ^{ns}	15323*	10779*	367*	6.0*	15724*	9037*	887*
PK	1	4.2*	0.2 ^{ns}	4.4 ^{ns}	1.2 ^{ns}	38.1*	5.6 ^{ns}	1.1 ^{ns}	5.5 ^{ns}
CV × PK	1	0.03 ^{ns}	113 ^{ns}	65 ^{ns}	0.7 ^{ns}	4.0*	205 ^{ns}	84 ^{ns}	5.3 ^{ns}
Error ^a	4	0.06	672	477	19.2	0.5	313	131	61.8
1 wk at 1C					1 wk at 1C + 2 days at 16C				
Climax									
Poly		0.4	76.0	19.2	1.7	0.6	86.3	9.7	2.1
Pulp		2.6	75.4	23.1	0.4	3.0	71.9	24.7	0.7
Avg		1.5	75.7	21.2	1.0	1.8	79.1	17.2	1.4
Sharpblue									
Poly		0.4	44.7	43.2	10.6	0.8	55.1	25.3	17.8
Pulp		2.3	40.4	46.4	11.0	4.3	40.3	38.5	19.0
Avg		1.3	42.5	44.8	10.8	2.5	47.7	31.9	18.4
ANOVA									
CV	1	0.2*	9899*	4994*	863*	5.3*	8861*	1954 ^{ns}	2609*
PK	1	38.0*	54.8 ^{ns}	114 ^{ns}	2.2 ^{ns}	76.9*	1921*	1787*	0.05 ^{ns}
CV × PK	1	0.3 ^{ns}	29.6 ^{ns}	1.1 ^{ns}	6.4 ^{ns}	2.6*	0.4 ^{ns}	7.2 ^{ns}	15.0 ^{ns}
Error	4	0.01	149	139	3.4	0.12	126	673	252
2 wk at 1C					2 wk at 1C + 2 days at 16C				
Climax									
Poly		0.8	72.3	23.5	1.7	0.9	72.8	13.7	12.9
Pulp		3.9	53.5	43.2	2.3	4.3	63.4	30.0	5.7
Avg		2.3	62.9	33.4	2.0	2.6	68.1	21.8	9.3
Sharpblue									
Poly		0.1	53.3	25.0	20.3	1.0	50.4	13.5	34.9
Pulp		4.2	41.8	36.0	19.5	6.7	46.4	23.9	28.9
Avg		2.1	47.5	30.5	19.9	3.8	48.4	18.7	31.9
ANOVA									
CV	1	0.3 ^{ns}	2137 ^{ns}	74.3 ^{ns}	2879*	13.8*	3505 ^{ns}	89.5 ^{ns}	4572 ^{ns}
PK	1	120*	2071*	2118*	1.0 ^{ns}	188*	409*	1608*	394*
CV × PK	1	2.6 ^{ns}	122 ^{ns}	168*	4.9 ^{ns}	12.1*	64.2*	82.6 ^{ns}	3.6 ^{ns}
Error	4	1.2	563	401	314	1.7	1035	274	837
3 wk at 1C					3 wk at 1C + 2 days at 16C				
Climax									
Poly		0.9	74.0	19.0	5.4	0.8	71.5	12.8	15.1
Pulp		5.3	37.7	56.2	5.5	6.4	50.3	40.6	8.3
Avg		3.1	55.9	37.6	5.4	3.6	60.9	26.7	11.7
Sharpblue									
Poly		0.8	52.3	14.5	31.5	1.0	39.7	8.9	49.7
Pulp		6.1	41.4	30.5	25.2	7.4	23.1	28.6	46.7
Avg		3.5	46.8	22.5	28.4	4.2	31.4	18.1	48.2
ANOVA									
CV	1	1.3 ^{ns}	739 ^{ns}	2060 ^{ns}	4740*	3.0 ^{ns}	7842*	575 ^{ns}	12006*
PK	1	212*	5022*	6359*	87.0 ^{ns}	320*	3196*	5086*	221 ^{ns}
CV × PK	1	1.9*	1453*	1019*	92.8 ^{ns}	1.3 ^{ns}	48.3 ^{ns}	150 ^{ns}	31.3 ^{ns}
Error	4	2.1	397	705	235	4.0	353	311	443

^zPolystyrene package.

^yFiber-pulp package.

^aAnalysis of variance (ANOVA) mean square for harvest date (CV) used as error term.

^{ns}*Nonsignificant or significant at $P \leq 0.05$, respectively, with associated mean square value.

compared with 88% and 50% sound fruit after 2 additional days at 16C.

All berries packaged in polystyrene cups were generally firmer than those in pulp cups after 1,2, or 3 weeks of storage, regardless of the time/temperature regime. The difference in the percentage of firm berries by package

type was significant ($P < 0.05$) after 2 or 3 weeks of storage, and the effect of storage on each cultivar depended on package type after storage for 3 weeks at 1C. Although berries stored for 2 or 3 weeks at 1C in fiber-pulp cups were significantly softer than those stored in polystyrene cups, package type generally did

not affect the incidence of decay (except after 2 weeks of storage at 1C + 2 days at 16C).

Berry weight loss averaged 3.3% after 3 weeks of storage at 1C, and weight loss generally was not affected by cultivar during 1C storage. Weight loss was significantly less for berries packaged in polystyrene cups than for

Table 2. Total soluble solids (TSS) concentration, acid, and flavor and texture index values for blueberries by cultivar (CV) and package (PK) type according to storage duration and temperature regime.

CV and PK type	df	TSS (%)	Acid (%)	Taste index	Texture index	TSS (%)	Acid (%)	Taste index	Texture index
<i>Overnight at 1C</i>					<i>Overnight at 1C + 2 days at 16C</i>				
Climax									
Poly ^a		15.6	0.18	92.5	87.5	16.1	0.16	70.8	67.5
Pulp ^a		15.7	0.17	92.5	87.5	15.9	0.16	72.2	74.2
Avg		15.7	0.18	92.5	87.5	16.0	0.16	71.5	70.9
Sharpblue									
Poly		13.1	0.27	74.6	79.0	13.0	0.25	73.3	82.5
Pulp		12.6	0.30	69.0	79.2	12.7	0.30	71.4	82.8
Avg		12.8	0.29	71.8	79.1	12.8	0.28	72.4	82.6
ANOVA									
CV	1	24.1*	365*	1285*	212 ^{NS}	30.4*	415*	2.2 ^{NS}	416*
PK	1	0.1 ^{NS}	4.3 ^{NS}	23.0*	0.01 ^{NS}	0.3 ^{NS}	17.3 ^{NS}	0.2 ^{NS}	36.4 ^{NS}
CV × PK	1	0.3 ^{NS}	11.2 ^{NS}	23.0*	0.01 ^{NS}	0.001 ^{NS}	11.2 ^{NS}	8.2 ^{NS}	31.0 ^{NS}
Error ^a	4	2.0	11.7	21.5	33.1	1.5	8.4	16.6	45.4
<i>1 wk at 1C</i>					<i>1 wk at 1C + 2 days at 16C</i>				
Climax									
Poly		15.9	0.17	77.0	74.3	15.9	0.16	77.5	78.4
Pulp		16.1	0.17	74.3	77.7	15.9	0.16	69.2	77.1
Avg		16.0	0.17	75.7	76.0	15.9	0.16	73.3	77.7
Sharpblue									
Ploy		13.1	0.26	72.4	80.2	12.9	0.27	74.1	83.5
Pulp		12.7	0.27	71.6	80.3	12.8	0.28	74.0	79.7
Avg		12.9	0.27	72.0	80.3	12.8	0.27	74.1	81.6
ANOVA									
CV	1	29.1*	282*	40.7 ^{NS}	55.5 ^{NS}	28.5*	372*	1.7 ^{NS}	44.9*
PK	1	0.04 ^{NS}	0.4 ^{NS}	9.2 ^{NS}	9.4 ^{NS}	0.001 ^{NS}	1.9*	50.8 ^{NS}	19.8 ^{NS}
CV × PK	1	0.2 ^{NS}	1.3 ^{NS}	2.5 ^{NS}	8.0 ^{NS}	0.02 ^{NS}	2.4*	53.3 ^{NS}	4.8 ^{NS}
Error	4	1.6	23.6	71.7	34.5	2.0	11.2	11.7	3.9
<i>2 wk at 1C</i>					<i>2 wk at 1C + 2 days at 16C</i>				
Climax									
Poly		15.8	0.16	66.3	75.7	15.6	0.16	69.0	76.1
Pulp		16.1	0.20	74.7	75.7	15.7	0.18	73.3	75.5
Avg		16.0	0.18	70.5	75.7	15.7	0.17	71.2	75.8
Sharpblue									
Poly		13.1	0.26	78.0	84.8	12.1	0.28	69.4	78.7
Pulp		12.9	0.30	75.8	84.9	12.6	0.32	72.3	79.8
Avg		13.0	0.28	76.9	84.8	12.4	0.30	70.8	79.2
ANOVA									
CV	1	25.5*	319*	123 ^{NS}	252*	32.7*	529*	0.3 ^{NS}	34.7 ^{NS}
PK	1	0.001 ^{NS}	43.7*	28.8 ^{NS}	0.01 ^{NS}	0.2 ^{NS}	20.0*	39.2 ^{NS}	0.2 ^{NS}
CV × PK	1	0.1 ^{NS}	0.2 ^{NS}	82.2*	0.01 ^{NS}	0.1 ^{NS}	6.0 ^{NS}	1.7 ^{NS}	2.1 ^{NS}
Error	4	1.4	28.1	42.4	27.2	2.8	10.1	140.0	77.9
<i>3 wk at 1C</i>					<i>3 wk at 1C + 2 days at 16C</i>				
Climax									
Poly		16.0	0.18	71.1	74.7	15.9	0.16	69.7	71.6
Pulp		16.0	0.18	67.0	65.0	15.7	0.18	74.2	74.2
Avg		16.0	0.18	69.1	69.8	15.8	0.17	72.0	72.9
Sharpblue									
Poly		12.2	0.29	75.4	82.7	12.6	0.27	74.8	81.5
Pulp		12.9	0.31	74.8	78.8	12.4	0.34	74.6	82.4
Avg		12.5	0.30	75.1	80.8	12.5	0.30	74.7	81.9
ANOVA									
CV	1	35.7*	434*	110 ^{NS}	359*	31.4*	551*	23.2 ^{NS}	245 ^{NS}
PK	1	0.3 ^{NS}	4.1 ^{NS}	16.8 ^{NS}	139*	0.12 ^{NS}	55.0*	13.4 ^{NS}	9.0 ^{NS}
CV × PK	1	0.4 ^{NS}	2.1 ^{NS}	9.0 ^{NS}	24.7 ^{NS}	0.0 ^{NS}	11.4 ^{NS}	16.1 ^{NS}	2.1 ^{NS}
Error	4	3.1	1.8	45.8	2.5	2.2	5.2	56.3	35.9

^aPolystyrene package.

^bFiber-pulp package.

^cAnalysis of variance (ANOVA) mean square for harvest date (cultivar) used as error term.

^{NS}Nonsignificant or significant at $P \leq 0.05$, respectively, with associated mean square value.

those in pulp baskets after all storage regimes of 2 days at 16C (Table 1).

Berries packed in polystyrene cups lost <1.0% in fresh weight during 3 weeks of storage at 1C, whereas berries packed in fiber-pulp cups lost $\approx$ 1.6% fresh weight/week. During the additional 2 days of storage at 16C, 'Sharpblue' fruit lost more ($P < 0.05$) weight than 'Climax' fruit, regardless of prior storage time, and the effect of cultivar on weight loss generally depended on package type.

Soluble solids concentration and titratable acidity differed ($P < 0.05$) by cultivar and averaged 16.0% and 0.18% for 'Climax' berries, and 12.5% and 0.29% for 'Sharpblue' berries, respectively, after the 1C storage regime; values were similar after 2 additional days of storage at 16C (Table 2). Acidity was generally lower ($P < 0.05$) in berries packaged in polystyrene cups after 2 additional days at 16C, regardless of prior storage duration. The pH ranged from 3.0 to 3.2 among all treatment combinations, and the pH of 'Climax' berries was significantly higher than that of 'Sharpblue' berries except after overnight and 1 week of storage at 1C. Mean pH for 'Climax' and 'Sharpblue' was 3.16 and 3.04, respectively, over all storage regimes.

The taste panel preferred the flavor and texture of 'Climax' berries at the initial inspection over the flavor and texture of 'Sharpblue' berries, whereas for berries stored longer than 1 week at 1C, the panel had no preference. After 2 and 3 weeks of storage at 1C, the panel slightly preferred the flavor and texture of 'Sharpblue' berries. Flavor was not affected by cultivar after storage at 16C for 2 days, regardless of storage duration at 1C. The panel generally favored the texture of 'Sharpblue' berries over that of 'Climax' berries. Type of packaging material generally did not affect the flavor or texture of the blueberries. Although all flavor and texture evaluations were made

by the same panelists, it is important to note that cultivars necessarily were rated at different times.

Atmospheres around berries packed in polystyrene cups (with small holes) averaged 21% O_2 and 0.4% CO_2 for both cultivars and did not change during 7, 14, or 21 days of storage at 1C. After 2 additional days at 16C, the CO_2 concentration increased to 0.6%, but was unaffected by cultivar. Berries packed in fiber-pulp cups were assumed to be at normal atmosphere, since these cups were constructed with eight large vents and had unsealed cellophane covers.

'Sharpblue' berries were softer immediately following harvest than 'Climax' berries, and they remained soft during storage. Previous reports show that soft fruit may not become firmer even when held at near optimum temperatures (Smittle and Miller, 1988). Therefore, we do not recommend 'Sharpblue' berries for distant export markets. Even for domestic sales, 'Sharpblue' berries should be picked as soon as possible after reaching marketable maturity, since blueberries from later harvest dates are ripe, and fruit quality decreases faster during postharvest storage than the quality of fruit from earlier harvests (Ballinger and Kushman, 1970; Ballinger et al., 1978; Galletta et al., 1971; Kushman and Ballinger, 1968; Miller et al., 1988). Shippers can successfully export 'Climax' berries to distant markets, even when transportation time approaches 2 weeks, provided proper temperatures are maintained. Decay in 'Climax' fruit remained relatively low, and vented polystyrene packaging did not affect incidence of decay in 'Climax' berries compared with the fiber-pulp packaging. Hence, the choice of packaging material used for 'Climax' berries depends on market factors. We realize that the 'Sharpblue' cultivar has the earliest harvest date of any commercial blueberry cultivar in

North America, and the incentive for shippers to market 'Sharpblue' berries to distant export markets will likely continue; however, shippers should be aware of the risks of quality decline inherent with these berries.

Literature Cited

- Ballinger, W.E. and L.J. Kushman. 1970. Relationship of stage of ripeness to composition and keeping quality of highbush blueberries. *J. Amer. Soc. Hort. Sci.* 95:239-242.
- Ballinger, W.E., E.P. Maness, and W.F. McClure. 1978. Relationship of stage of ripeness and holding temperature to decay development of blueberries. *J. Amer. Soc. Hort. Sci.* 103: 130-134.
- Crocker, T.E. and P.M. Lyrene. 1985. Survey of blueberry acreage in Florida. *Proc. Fla. State Hort. Soc.* 98:162-164.
- Crocker, T.E. and L. Willis. 1989. Survey of southern highbush and rabbiteye blueberries in Florida. *Proc. Fla. State Hort. Soc.* 102:204-206.
- Galletta, G.J., W.E. Ballinger, R.J. Monroe, and L.J. Kushman. 1971. Relationships between fruit acidity and soluble solids level of highbush blueberry clones and fruit keeping quality. *J. Amer. Soc. Hort. Sci.* 96:758-762.
- Kushman, L.J. and W.E. Ballinger. 1968. Acid and sugar changes during ripening in 'Wolcott' blueberries. *J. Amer. Soc. Hort. Sci.* 92:290-295.
- Lyrene, P.M. and W.B. Sherman. 1988. Cultivation of highbush blueberry in Florida. *Proc. Florida State Hort. Soc.* 101:269-272.
- Miller, W.R., R.E. McDonald, and T.E. Crocker. 1988. Fruit quality of rabbiteye blueberries as influenced by weekly harvest, cultivars, and storage durations. *Ho&Science* 23:182-184.
- Miller, W.R. and D.A. Smittle. 1987. Storage quality of hand- and machine-harvested rabbiteye blueberries. *J. Amer. Soc. Hort. Sci.* 112:487-490.
- Smittle, D.A. and W.R. Miller. 1988. Rabbiteye blueberry storage life and fruit quality in controlled atmospheres and air storage. *J. Amer. Soc. Hort. Sci.* 113:723-728.