Postharvest Evaluation of Raspberry and Blackberry Selections for Use in Tunnels in Warm Production Areas

Final Report

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Research Proposal

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Objective 1 Develop and test raspberry postharvest protocol

Objective 2 Evaluate raspberry and blackberry germplasm for fresh markets from field and tunnel production and fruit composition

Objective 3 Tunnel effects on postharvest quality of caneberries

Justification:

Raspberries and blackberries have become established market items in supermarkets, largely because increased production within and outside the U.S. has helped keep year-round shelf space in the produce aisle. Consumers continue to become more educated buyers, and actively seek fruits that are both flavorful and healthful. Raspberries have become a recognized source of ellagic acid, thought to have considerable potential as a chemopreventive agent, especially for esophageal cancer (Stoner et al., 2007). Blackberries are as high in total phenolics and antioxidant scores as blueberries, and also are a good source of fiber (USDA, 2008).

The production of raspberries and blackberries under tunnels is common in Europe, especially Spain and the U.K. In California, almost 100% of the raspberry production is under tunnels (Bolda pers comm.). Growers in the northern U.S. have found that tunnel production results in higher yields and higher quality fruit (Pritts, 2008). However, in the

south and eastern U.S., growers have not implemented tunnel production to any extent, due to many unknowns including economics and basic production protocol. But there is great interest and the researchers and Extension personnel at NCSU have established field trials of both blackberries and raspberries under tunnels.

A protocol for the post harvest evaluation blackberries grown in the field has been developed by Perkins-Veazie et al. (1996) and is used by breeders on the east coast. However, a protocol for the evaluation of raspberries in the field or under tunnels and blackberries grown under tunnels does not exist. Therefore we propose to develop a protocol for postharvest evaluation of raspberries. This protocol could be used for either field or tunnel production. We think that decreasing flower/berry wetness and wind action in a tunnel system may keep raspberry fruit firmer and free of decay by reducing spore infection and plant stress. In addition, we will compare fruit quality and composition of both raspberries and blackberries grown in the field and under tunnels. This is important to screen for selections most suitable for commercial markets in flavor, shelf life, and antioxidants.

Materials and Methods

Raspberries (floricane and primocane fruiting. Fruit were hand harvested from selections into clamshells, using two to four half pints per cultivar and system every week from fruit grown in the field or tunnels. Clamshells of fruit were held at 5 C for 4 to 8 days. All fruit were picked at commercial ripeness (at least 75% fully colored), but not overripe, and were free of visible decay and insect damage. As in 2009, individual berries were rated for the presence/absence of firmness, decay, leak, and visually scored for color and shrivel. An overall rating score was calculated based on decay, leak, and soft fruit. Fruit of initial and rated harvests was frozen and held at -80 C until used for compositional analysis.

Blackberries A system similar to that of raspberry will be used for harvesting and storage of floricane-fruiting blackberries present in tunnels and rows at Salisbury, NC. Evaluations will be made using the protocol developed by Perkins-Veazie et al. (1996), where fruit are rated after 7 days at 5 C for decay (presence/absence), leak (presence/absence), red drupelet (presence/absence) and firmness (a 1 to 5 rating for firm to mush), and an overall score is calculated based on these ratings.

Compositional analysis: Subsamples of fruit, consisting of at least 50 g or 20 berries per sample, were taken from frozen samples. Berries were pureed in a blender or polytron. The soluble solids content was measured by placing about 1 ml of puree on a digital refractometer. The pH of the puree was determined using a pH meter. Three to 5 ml of puree was extracted with methanol for anthocyanin and phenolic determination. Methods of Giusti and Wrolstad (1999) were used to determine total anthocyanins, and those of Singleton et al. (1999) were used for total phenolics. FRAP (ferric reducing ability of plasma) was done by spectrophotometric assay using the method of Benzie and Strain (1996).

Results:

Objective 1. Raspberry postharvest protocol Tables 1,2

The protocol developed in 2009 was tested on raspberries harvested from Salisbury (Piedmont), Mills River (lower mountain), and Laurel Springs (upper mountain) locations from June through September. Results for 2010 indicated similar trends for storage life among the same selections. Overall, values were slightly improved, probably because of a dry season compared to 2009. One variety, Latham, scored significantly different between 2009 and 2010; may be due to the lack of a rust on fruit in 2010 that was present in 2009.

Overall, the raspberry selections with best postharvest quality over multiple locations were NC344, Nantahala, and Nova. Joan J and Caroline were marginal, performing better when grown in the cooler Laurel Springs environment. Himbo Top did not perform well even when grown under tunnel in the mountain locations. Primary problems in raspberries provided with a standard fungicidal protocol were color darkening and leaky or soft fruit.

Objective 2. Postharvest testing of blackberries and raspberries. Tables 1,2,3,4,5,6

Surprisingly, the anthocyanin content of fresh raspberries was generally lower in 2010 than in 2010. This may be due to the easier picking of fruit in 2010-the warmer seasonal temperatures loosened the raspberries from their calyxes more rapidly, resulting in slightly less mature fruit. However, after storage, anthocyanin contents were similar between years. FRAP values were also higher in 2010 than in 2009 although total phenolics did not vary as much. One possible explanation could be time in the freezer-2010 samples were run within a few weeks of harvest compared to about 9 months for 2009 samples.

Among raspberry cultivars and selections, total phenolic content ranged from 1700 to 3000 mg/kg gallic acid equivalents and changed little with storage (Table 3). Anthocyanin content ranged from 200 to 900 mg/kg and was high in dark colored raspberries such as Joan J. More detailed analysis of specific aglycons and glycosylation of aglycons needs to be done as a way to examine those that don't seem to fit the pattern of dark fruit/more anthocyanin, such as Dorman Red and Himbo Top (high in total anthocyanin content yet light red in visible color). It is also possible that some raspberries have higher carotenoids than others, altering the visible color of raspberries. All raspberries gained in total anthocyanin after storage, increasing from 10 to 40%. FRAP values ranged from 10 to 32 umol/g trolox equivalents among selections; it is difficult to see any effect of storage or germplasm because of the high values of the 2010 fruit relative to the 2009 fruit.
In blackberry, total phenolic content was 2500 to 3500 mg/kg, Frap was 20-30 umol/g, and total anthocyanin was 600 to 2000 mg/kg. NC430 was considerably lower in total anthocyanin than the other selections (about 600 mg/kg). Values between years were very similar for all compositional components.

In 2010, a poor keeper (Carolina) was added to the test as were Tupy (a commercially important shipping berry from Brazil) and Black Diamond from the USDA Oregon program (Table 4). Tupy and Black Diamond had respectable overall ratings (53 and 59); Apache did not fare as well, possibly from virus issues in the field. Selections from the Univ. Arkansas program did extremely well. NC430 scored as well as Navaho and Ouachita.

Standard postharvest shelf life tests indicate that NC430 is as good or better in postharvest life as other selections tested in both 2009 and 2010 (Table 5). A selection overall rating score of 40 and above is considered a good storage berry; Apache and Chester Thornless did not meet this in 2010.

Objective 3. Tunnel effects on caneberries Tables 1,2,7

In 2010, we did not collect enough tunnel fruit for blackberries to do shelf life studies. However, in 2009, postharvest life of blackberries from tunnels was less than that of field grown fruit (Table 7). In raspberries, tunnel grown fruit appeared to have a slightly better postharvest life than field grown fruit (Tables 1, 2). This seemed to be primarily in decreased decay and slightly firmer fruit. The effect may be one of enhanced temperatures under tunnels-higher temperature often stimulates ease of raspberry removal from calyxes, so those from tunnels may have been less ripe than those from the field, with correspondingly lighter fruit and better structural integrity. In a sub experiment, unripe fruit and ripe raspberries were harvested from tunnels; we found that the unripe fruit could develop full color after storage and yet had very little decay compared to those harvested fully ripe (data not shown).

Conclusions

Conclusions:
In the warm temperatures of the North Carolina Piedmont, raspberry selections that have light color after storage and good firmness are the best options for a fresh market harvest. In this study, NC344 consistently performed well. Joan J, Caroline, and Autumn Britten were too dark for marketability, although Joan J does have good firmness even in dark red fruit.
In raspberry, a target for total anthocyanin content is 200 to 400 mg/kg cyanidin3-glucoside in selections, as a possible predictor for delayed postharvest darkening.
Using an overall rating system appeared to give fairly consistent results over the two years of the study. While numbers were not always close together, the same trends were seen (above 0 or well below 0), indicating that this test can be useful in separating the selections with outstanding storage quality. An overall rating of 10 or above indicates germplasm with suitable postharvest life; this value may rise as more fresh market germplasm is developed.

Raspberry postharvest quality appeared to benefit from tunnels, but blackberry had less response to this production system.

In blackberry, NC430 shows excellent postharvest shelf life. Although it had half of the anthocyanin content of the other selections, red drupelet was not a severe problem on stored fruit.

Impact Statement

-Raspberry selections grown in the east coast suitable for fresh market use have been found, and a rapid means to evaluate shelflife of raspberries has been developed.

-A total anthocyanin content of 200 to 400 mg/kg cyaniding-3-glucoside equivalents can be used by breeders to screen for raspberries that will not darken in postharvest storage.

-High tunnel production of blackberries and raspberries in the south appears to help postharvest quality of raspberry but not of blackberry

Citations

Perkins-Veazie, P. 2010. Postharvest handling and storage of blackberries and raspberries. North American Bramble Growers Proceedings.

Perkins-Veazie, P.; Fernandez, G.; Ballington, J. 2010. Postharvest Comparison of Raspberry Cultivars and Selections Grown under Tunnels or Field Systems in the North Carolina Piedmont. ASHS (abstract).

Table 1. Ratings of raspberries held 6 days at 4 C, 90% RH in 4 and 6 oz clamshells, 2010.

			Ratings						
Source	CV	ave berry wt (g)	Berry dark ness	Berry srhivel	weight loss (%)	Moldy berries (%)	Leaky (%)	Soft (%)	OVER ALL rating
Field									
MR	HimboTop	2.9	1.9	1.2	1.7	27.5	53.4	63.5	-44.3
LS	A. Britten	4.0	2.4	1.4	2.5	37.5	44.3	51.6	-33.5
LS	HimboTop	4.2	1.9	1.4	2.3	26.7	47.9	57.9	-32.5
LS	Caroline	3.4	2.3	1.1	2.3	12.4	21.6	56.1	9.9
LS	Joan J	4.4	2.9	1.1	1.9	22.0	27.6	37.8	12.7
LS	Nantahala	3.4	1.9	1.2	1.7	16.8	21.2	35.9	26.1
LS	Nova	4.2	1.9	0.7	1.9	10.0	9.6	27.7	52.7
SALS	HimboTop	2.7	1.8	1.1	1.8	19.1	44.6	62.8	-26.5
SALS	Lauren	4.0	1.5	1.4	2.5	24.3	40.4	53.4	-18.1
SALS	NC605	2.9	2.4	1	2.4	23.6	28.7	49.3	-1.6
SALS	Moutere	2.9	1.7	2.3	2.3	10.2	30.0	39.4	20.5
SALS	NC621	3.1	0.6	2.8	4.5	2.6	21.9	52.1	23.5
SALS	NC638	3.0	1.3	0.9	3.0	16.8	18.0	32.0	33.2
SALS	NC548	3.3	1.7	1.1	2.2	18.3	12.2	30.2	39.3
Tunnel									
LS	HimboTop	4.1	1.5	1.1	2.2	14.6	46.5	55.7	-16.8
LS	A.Britten	3.8	2.5	1.3	2.0	12.7	49.1	45.9	-7.8
LS	Caroline	2.8	2.8	1.2	1.1	23.4	25.9	53.2	-2.5
LS	Nantahala	4.0	1.9	1	0.9	30.7	13.1	51.4	4.8
LS	Joan J	4.5	2.4	1.3	1.9	10.2	33.5	46.4	10.0
MR	HimboTop	2.7	1.5	2.9	1.7	9.9	46.0	72.9	-28.7
MR	NC452	3.8	2.1	0.9	2.2	0.0	43.8	59.6	-3.4
MR	Nantahala	3.3	1.4	1	1.5	0.0	35.8	39.0	25.2
SALS	HimboTop	1.9	1.9	1.3	3.5	13.1	52.1	70.3	-35.5
SALS	Joan J	1.8	3	2.3	3.7	14.4	27.3	56.3	2.0
SALS	Latham	2.8	2.1	1.5	2.7	9.8	29.4	53.2	7.7
SALS	NC612	2.0	2.5	2	4.4	15.7	21.7	51.4	11.2
SALS	NC344	3.1	1.9	2.8	2.6	19.1	23.9	31.9	25.0

LS=laurel springs (upper mountain); SALS=Salisbury (piedmont); MR=Mills River (lower mountain). Overall score >0 is good; berry darkness, shrivel <2 is acceptable

Table 2. Comparison of ratings for 2009 and 2010 in field and tunnel raspberries.

Field		**color**	**shrivel**	**Decay**	**Leak**	**Soft**	**Overall**
Himbo							
Top	2009	1.8	1.7	29	69	77	-76
	2010	1.8	1.1	19	45	63	-26*
Lauren	2009	2.4	1.4	24	22	49	-24
	2010	1.5*	1.4	21	40	39	-18
Moutere	2009	2	1.4	21	22	39	7
	2010	1.7	2.3*	10	30	45	20
NC548	2009	2	0.9	11	17	20	27
	2010	1.7	1.1	18	12	27	39
Tunnel							
Himbo							
Top	2009	1.2	1	4	48	61	-14
	2010	1.9	1.3	13	52	70	-36
Joan J	2009	2.2	1.8	4	39	50	7
	2010	3	2.3	14	27	56	2
Latham	2009	2.4	0.8	11	43	77	-31
	2010	2.1	1.5*	10	29	53*	8*
NC344	2009	1.2	0.1	10	15	44	30
	2010	1.9	2.8*	19	24	32	25

Table 3. Composition of raspberries before (D0) and after 6 days (D6) storage at 4 C, 2009 and 2010 from Salisbury NC.

Selection	Year	Total phenolic content (mg/kg)		Total anthocyanin content (mg/kg)		FRAP (umol/g trolox equiv)		% SSC	
		d0	D6	d0	D6	d0	D6	d0	D6
NC644 (yellow)	2009	2216	2440	34	30.6	13.0	15.2	8.4	8.4
A. Bliss	2009	2664	2410	724	896	17.5	17.6	10.5	10.8
Mandarin	2009	3016	2495	928	709	20.1	16.9	11.4	10.7
NC612	2009	2731	3541	359	443	16.7	19.1	10.7	10.5
DormanRed	2009	1770	2294	315	356	9.8	13.2	7.7	7.7
Heritage	2009	2359	2685	598	676	16.6	16.6	10.7	11.8
Nantahala	2010	2758	2932	254	549	20.4	26.9	11.4	10.9
Himbotop	2009	2925	2924	472	485	19.4	17.8	10.3	11.4
	2010	3087	3196	449	491	29.2	30.0	10.5	10.1
Lauren	2009	2639	2837	502	440	16.4	17.4	10.5	9.1
	2010	2224	2595	297	376	18.9	21.7	10.8	10.1
Joan J	2009	2934	2682	675	712	19.6	16.9	10.9	10.9
	2010	3096	3367	668	799	29.2	32.8	10.3	10.8
A. Britten	2009	2629	2288	675	662	17.3	14.9	10.1	11.0
	2010	2768	2755	610	862	23.4	27.7	10.5	9.5
Latham	2009	2225	2720	374	515	14.0	18.0	9.9	9.7
	2010	2181	2710	195	358	17.6	23.5	10.2	9.9
NC344	2009	2195	2425	306	345	13.2	14.2	11.1	11.2
	2010	2050	2408	223	326	17.2	21.1	10.1	10.1
Caroline	2009	2479	2837	479	582	16.7	18.9	11.0	11.7
	2010	2799	2822	568	694	24.8	26.0	10.6	10.2
Moutere	2009	2802	3256	469	414	18.0	19.6	10.8	10.8
	2010	3052	3333	293	362	27.5	31.5	10.8	9.7
NC548	2009	2787	3092	373	352	16.8	15.5	9.9	9.8
	2010	2420	2760	246	353	21.1	24.9	10.4	10.9

Yellow highlights indicate significant differences in values ($P<0.05$) by year .

Table 4. Ratings of blackberries harvested at Salisbury, NC in 2010 and held 7 days at 4 C, 90% RH in pint clamshells.

	percent berries			Rating		
Cultivar	Moldy	Leaky	Soft (4,5)	Red drupe	Overall	Marketable
Carolina Chester Thornless	8.1	44.1	24.8	11.6	23	74.3
Apache	5.7	37.9	23.6	7.9	32.8	77.6
Black Diamond	1.9	31.3	13.4	14.5	53.4	84.5
Tupy	4.7	24.8	11.4	10.5	59	86.4
Navaho	2	13.8	15.4	5.7	68.8	89.6
NC430	3.1	12.8	12.4	12.1	71.7	90.6
Ouachita	4.1	15	7.4	7.7	73.4	91.2
Natchez	0.8	7.3	4.4	17.2	87.5	95.8
Arapaho	0.5	10	0	4.1	89.5	96.5

Overall rating is 100-sum(moldy+leaky+soft)
Marketable rating is 100-(sum(moldy+leaky+soft)/3)

Table 5. Comparison of blackberries, 2009 and 2010, field only.

Selection	Year	% leak	% decay	% red	% soft (3,4,5)	Overall score
Apache	2009	27.5	4.5	0.4	10.8	56.8
	2010	37.9	5.7	7.9	23.6	32.8
Arapaho	2009	29.7	6.6	0.7	13.4	49.7
	2010	10.0	0.5	0.0	4.1	89.6
NC430	2009	9.6	2.1	2.4	6.8	79.2
	2010	12.8	3.1	12.1	12.4	71.7
Navaho	2009	38.6	3.5	1.2	16.2	40.5
	2010	13.8	2.0	5.7	15.4	68.8
Ouachita	2009	16.8	3.7	1.8	4.1	73.7
	2010	15.0	4.1	7.7	7.4	73.4
Chester	2009	36.5	5	1	9.9	57.7
Thornless	2010	44.1	8.1	11.6	24.8	6.4
Natchez	2009	13.4	3.1	2.5	4.3	76.8
	2010	7.3	0.8	17.2	4.4	89.5

Table 6. Composition of blackberries grown in Salisbury NC 2010 before and after storage at 4 C for 7 days.

Cultivar	storage day	SSC (%)	pH	Total phenolics (mg/kg)	Total anthocyanin (mg/kg)	FRAP (umol/g trolox)
Apache	0	10.5	3.45	2857.7	1427.0	25.5
Apache	7	10	3.47	2809.0	1475.0	25.7
Arapaho	0	9.7	3.10	2609.1	898.8	23.5
Arapaho	7	9.8	3.40	2696.0	1038.0	23.8
Black Diamond	0	8.9	3.16	2546.7	1069.9	21.3
Black Diamond	7	8.7	3.33	2534.0	1052.0	22.3
Carolina	0	5.6	3.31	3757.3	1964.3	36.9
Carolina	7	6.4	3.44	3494.0	1759.0	35.8
Chester	0	9.8	3.09	2653.1	1392.0	24.9
Chester	7	9.8	3.32	2903.0	1536.0	29.5
Natchez	0	9.1	3.12	2999.8	1028.6	27.5
Natchez	7	8.6	3.28	3360.0	1289.0	32.1
Navaho	0	10.2	3.15	2708.7	984.7	24.2
Navaho	7	10.1	3.30	2740.0	1196.0	23.6
NC430	0	9.4	3.28	2762.0	563.4	23.3
NC430	7	9.4	3.57	2673.0	593.0	22.6
Ouachita	0	10.1	3.20	2425.0	783.0	20.0
Ouachita	7	9.9	3.40	2602.0	814.0	21.1
Tupy	0	8.7	3.17	2305.7	987.5	20.1
Tupy	7	8.6	3.39	2499.0	1040.0	21.7

Total phenolics as gallic acid equivalents; total anthocyanin as cyanidin-3-glucoside equiv. Highlighted numbers represent significantly different values, $P<0.05$, between days storage.

Table 7. Comparison of field and tunnel within a blackberry cultivar, 2009
Note: no replicate plots for tunnels.

Selection	Field/ Tunnel	No. clamshells	% leak	% decay	% red	% soft (3,4,5)	Overall score
Apache	F	20	27.5	4.5	0.4	10.8	56.8
Apache	T	23	53.4	9.5	0	16.7	20.4
Arapaho	F	25	29.7	6.6	0.7	13.4	49.7
Arapaho	T	24	47.7	10.2	0.7	24.8	16.7
NC430	F	18	9.6	2.1	2.4	6.8	79.2
NC430	T	30	29.1	5.2	3.1	14.1	48.5
Navaho	F	45	38.6	3.5	1.2	16.2	40.5
Navaho	T	36	26.8	7.9	0.6	16.7	48.1
Ouchita	F	35	16.8	3.7	1.8	4.1	73.7
Ouchita	T	36	23.4	6.4	4.3	6.9	58.9

In each case,tunnel fruit had more leak and a poorer score.
If difference between field, tunnel is >10%, is highlighted.
Note that Navaho and Ouchita were not as different in T, F as the others.