POSTHARVEST TREATMENTS FOR SHELF LIFE EXTENSION AND ANTIOXIDANT PROMOTION OF CANEBERRIES

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Introduction:

Blackberries and raspberries lack a protective cuticle, so lose water rapidly after harvest. In addition, the soft epidermal layers are ideal for microbial penetration and growth, and production of sugars and softening help growth of mold spores harbored from bloom, such as Botrytis cinerea (gray mold). The introduction of improved germplasm, combined with refrigeration, has extended blackberry shelf life from 2-3 days to 7-10 days. Raspberries remain highly perishable, even with improved germplasm, and often last no more than 5 days even under low temperature storage.

The most common methods of extending shelf life of small fruits are rapid cooling (forced air), low temperature storage (0 to 5C), or modified atmosphere storage. Other treatments under investigation in blueberry and/or strawberry include use of ultraviolet light, use of essential oils as antimicrobials, and rapid, short heating of fruit. Our purpose in this grant cycle was to evaluate these more unusual systems for effectiveness in shelf life extension of blackberry and raspberry.

Approach:

Blackberry fruit were collected from field plots at the Piedmont Research Station, Salisbury NC, from June to August. Raspberries were collected from plots at Mills River and Laurel Springs, NC from August through October of 2010.

Fruit were treated with 0 to 16 kJ of UVC light, designed as a factorial design. Light was applied to fruit in clamshells with lids open using 350 nm germicidal bulbs placed in a laminar flow hood for times of 1 to 20 minutes to achieve the amount of UVC exposure needed. Control (0) fruit were placed in the same room under the laminar flow hood without light exposure for 20 minutes. Ten to 20 berries were placed in each clamshell to permit as much light exposure on fruit surfaces as possible and to simulate an overhead light system, similar to that employed in hospitals for surface sterilization. After exposure to UVC, clamshells were placed on trays, covered with plastic bags to hold in humidity, and kept at 4 C for 7 days or at 21 C for 4 days. Evaluations of individual blackberries was made by rating fruit 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 using 100-sum[%decay+%leak+%soft (rated 4 and 5)]. In raspberries, berries were rated for presence or absence of mold and leak, and determined to be soft or firm immediately when removed from the clamshell. Overall rating is 100-sum(decay, leak, soft).

Compositional analysis: Frozen samples were partially thawed and were pureed in a polytron homogenizer to get small particle size for best extraction. 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. FRAP (ferric reducing ability of plasma) was done by spectrophotometric assay using the purees extracted with methanol:water:formic acid (40:59:1).

We were unable to finish experiments with essential oils, microbial counts, or heat treatments, due to problems with setting up the equipment and under estimation of labor needs. These will be finished in 2011

Summary of results:

Blackberries could tolerate a 2 to 4 kJ exposure to UVC, demonstrated by a slight improvement in overall rating (Table 2) compared to control fruit. Exposures above 4 kJ appears to be detrimental to quality. When averaged over all cultivars, no significant changes in total phenolics, anthocyanin, or FRAP was seen. It is possible that specific components of these total assays were affected, with some increasing and some decreasing, giving a net effect of no change. This would have to be determined using more sophisticated equipment and methodology, such as GC-MS, LC-MS, and TOF.

Both blackberry and raspberry cultivars differed in response to UVC treatment (Tables 1, 3, 4). In blackberries held at 4 C, Navaho did best with 8 kJ of UVC yet Ouachita did not do well with any UVC treatment. With blackberries held at 21 C, Ouachita fruit treated with 2 kJ light did better than controls. Apache and Natchez did best with 4 kJ light at either storage temperature. Berries held at 21 C, a practice not recommended, showed more benefit from UVC treatment than those held at 4 C. The gain in overall rating appears to be from reduced decayed and leaky berries.

Total phenolics, anthocyanin, and FRAP increased significantly with 4 and 2 kJ light for Apache and Arapaho, respectively (Table 1). Among raspberry cultivars, NC344 showed the biggest gain in overall rating with 2 kJ UVC (Table 4). NC548 and Latham, which are soft raspberry selections, showed no positive effect with UVC treatment. Exposure to 4 kJ UVC increased fruit darkening and shrivel.

Conclusions

Use of ultraviolet light (UVC) did not consistently improve antioxidant content in blackberry fruit, as measured by the total antioxidant tests of anthocyanin, phenolic, and FRAP. Slight improvements in overall quality were seen with 2-4 kJ, and occasionally 8 kJ.

Use of UVC in a pass-over system to act as a prophylactic in case of cold chain issues may prove to be useful if the extra costs and handling become minimal.

This is the first report on the tolerance of blackberry and raspberry to ultraviolet light treatment, and effects on total antioxidants.

Table 1. Comparison of cultivar x treatment effect on blackberry quality and composition after 7 days storage at 4C, 90% RH.

Cultivar	Tmt (kJ UVC)	LEAK	DECAY	SOFT	RED	OVERALL	% SSC	PH	total phenolics (mg/kg)	total anthocyanin (mg/kg)	FRAP (umol/g)
	fresh	-	-	-	-	-	10.2	3.31	2840	1638	20.5
Apache	0	19	18	16	8	39	9.6	3.5	3960	2036	24.6
	1	33	25	27	14	0.9	9.8	3.49	3973	2294	24.8
	2	22	25	19	9	26	9.5	3.52	3762	2211	23.6
	4	10	21	11	14	44	9.7	3.51	4281	2522	25.3
	8	33	21	15	21	9	9.4	3.58	3837	2136	23.9
	16	33	45	6	42	-27	8.8	3.57	3744	1915	23.1
	fresh	-	-	-	-	-	10.7	3.29	2719	1120	19.2
Arapaho	0	82	36	26	0	-44	11.6	3.73	3325	1088	18.9
	1	68	18	14	0	0	11.6	3.72	3989	1738	24.9
	2	66	14	10	0	10	10.1	3.68	3333	1155	20.5
	4	56	28	14	0	2	10.5	3.7	3387	1219	20.6
	8	78	28	25	0	-30	11.6	3.94	3579	1427	20.1
	16	-	-	-	-	-	-	-	-	-	-
	fresh	-	-	-	-	-	10.1	3.42	2719	734	17.0
NC430	0	7	6	21	30	36	10.6	3.83	3784	1319	22.7
	1	13	10	15	21	42	10.7	3.85	3649	879	21.1
	2	13	10	14	25	38	10.9	3.77	3482	1042	19.9
	4	16	8	15	26	35	10.6	3.77	3493	929	20.3
	8	12	7	10	25	47	10.5	3.85	3661	817	20.8
	16	15	9	23	51	2	9.4	3.76	3474	695	20.5
	fresh	-	-	-	-	-	11.2	3.22	2540	1176	18.3
Navaho	0	12	11	17	10	50	11.4	3.34	3537	1598	20.3
	1	15	6	9	21	49	11.3	3.43	3352	1503	19.9
	2	18	6	20	12	44	11	3.48	3440	1548	20.5
	4	22	6	23	14	35	11.2	3.48	3546	1651	20.6
	8	9	2	10	7	72	10.8	3.48	3569	1619	21.5
	16	20	0	14	0	66	10.9	3.4	3487	1604	20.8
	fresh	-	-	-	-	-	10.3	3.22	2359	927	14.3
Ouachita	0	12	7	7	2	72	10.7	3.51	3248	1197	18.9
	1	24	9	12	3	51	10.6	3.52	3163	1081	19.6
	2	27	7	7	4	55	11	3.55	2984	1043	17.1
	4	24	14	7	2	52	11	3.62	3235	1136	18.5
	8	31	17	10	10	32	10.5	3.54	3197	1137	18.5
	16	30	10	20	0	40	10.8	3.54	3073	1333	16.1

Highlighted areas indicate significant differences among treatments within a cultivar ($P<0.05$), LSD. Fresh berries are those frozen right after harvest.

Table 2. Comparison of UVC treatments averaged over cultivars. Fruit stored 7 days at 4C, 90% RH.

UVC Treatment (kJ)	LEAK	DECAY	SOFT	RED	OVERALL	% SSC	PH	total phenolics (mg/kg)	total anthocyanin (mg/kg)	FRAP (umol/g)
fresh	-	-	-	-	-	10.5	3.29	2635	1119	17.9
0	26.4	15.6	17.4	10.0	30.6	10.8	3.58	3571	1448	21.1
1	28.4	13.6	13.8	10.8	33.6	10.7	3.61	3583	1482	21.8
2	30.5	10.1	13.0	10.4	36.1	10.7	3.62	3364	1254	20.0
4	25.6	15.4	14.0	11.2	33.6	10.6	3.62	3588	1491	21.1
8	32.6	15.0	12.6	12.6	26.0	10.6	3.67	3568	1427	21.0
16	24.5	16.0	15.8	23.3	20.2	10.0	3.57	3444	1387	20.1

Highlighted value indicates significance within column, P<0.05, LSD.

Table 3. Effects of UVC treatment on blackberry fruit quality and composition when held 4 days at 21C, 80% RH after treatment.

Selection	Tmt (kJ UVC)	%mold	%leak	%soft	overall rating	SSC	PH	total anthocyanin (mg/kg)	total phenolics (mg/kg)	FRAP (umol/g)
Natchez	0	23	38	20	18	9.4	3.8	1743	3695	34.3
	4	12	28	10	50	9.3	3.7	1661	3298	32.5
Navaho	0	48	60	40	-48	10.3	3.45*	1570*	2872*	27.8*
	2	43	67	33	-43	10	3.66	1868	3313	32.6
	4	22	37	31	10	10.6	3.69	1960	3472	32.8
	8	77	80	80	-137	na	na	na	na	na
NC430	0	64	69	54	-100	9.1	4.1	928	2912	24.3
	4	50	54	49	-53	9.9	4.2	1017	3290*	26.9
	8	63	80	73	-116	na	na	na	na	na
Ouachita	0	73	70	55	-98	na	na	na	na	na
	2	27	23	3	47	11.4	3.77	893	2741	22.7
	4	67	57	42	-65	12.3*	3.75	981	2666	22
	8	83	83	77	-143	na	na	na	na	na

Highlighted value indicates significance within column, P<0.05, LSD. An overall score >40 is considered good.

Table 4. Effects of UVC treatment (kJ) on postharvest quality of raspberries held 4 days at 21C after treatment.

Cultivar	tmt	DARKNESS	Shrivel	%leak	%mold	%soft	overall

Lauren	0	2	1.5	67	73	53	-93
	2	1.8	1	37	43	73	-53
Latham	0	1.7	1.2	41	62	64	-68
	2	1.7	1.4	47	66	59	-71
	4	2.4	2	33	50	78	-62
Moutere	0	2.2	2	40	72	67	-78
	2	2.2	2.4	17	58	60	-35
	4	2.3	2.5	23.3	73	60	-57
NC344	0	2.5	1	47	97	43	-87
	2	2.2	2	23	27	33	17
	4	2.3	2.5	10	67	17	7
NC548	0	2.3	2	27	50	45	-22
	2	2.2	1.2	50	53	68	-72
	4	2.8	1.8	30	17	77	-23

Highlighted areas indicate significant differences within cultivar, P<0.05, LSD.
Darkness and shrivel are subjective rankings where 0=none and 3=severe. Percent rankings indicate the percent berries considered leaky, moldy, or soft. Overall score is 100-sum(leak, decay, soft), with values ranging from +100 (perfect) to -300 (worst). Scores over 0 are good.