Investigating the Effects of Novel Postharvest Treatments on the Shelf-life of Georgia-grown Blackberries

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Problem Summary

Blackberries are a high-value crop that has been increasing in Georgia with 1,858 planted acres (US Department of Agriculture, National Agricultural Statistics Service 2024) and a farmgate value of $19.9 million reported in 2022 (Georgia Farm Gate Value Report 2022). However, the fruit itself is highly perishable as it is susceptible to water loss, softening, mechanical injury, and postharvest diseases. A shelf-life of around 7 days is obtainable whenever the fruit is cooled immediately after harvest and stored at 34ºF (1°C) at 90-95% relative humidity (RH). The use of additional postharvest treatments such as controlled atmosphere (CA) to reduce the amount of oxygen (O_2) by substituting it with nitrogen (N_2) and increasing the amount of carbon dioxide (CO_2). Another treatment being the addition of gaseous ozone (O_3) molecules at a 0.5 ppm concentration to reduce the growth of pathogens during storage. The storability of commercial blackberries grown in Georgia under alternative atmospheric conditions could benefit the fresh market industry. By investigating the use of CA/ozone on the shelf-life and postharvest quality of the fruit the traditional cold storage methods could be improved to allow for a greater marketing window of Georgia-grown blackberries.

Experimental Design

Four cultivars (Caddo, Osage, Ouachita, and Ponca) (Fig.1-4) were harvested from a commercial farm at the beginning, middle, and end of the blackberry season in 2023. Sixty clamshells per cultivar were harvested. Blackberries were field packed and transported to the Vidalia Onion Research Laboratory at the UGA-Tifton Campus. The blackberries were hand-sorted to remove any damaged or diseased berries before storage. Berries were stored for up to 21 days at 34°F (1°C) at 90-95% relative humidity. Two additional treatments were used alongside the control storage conditions. Controlled atmosphere of 10% CO_2 plus 10% O_2 and 1 ppm gaseous ozone. Physiochemical attributes were analyzed at four different stages: immediately after harvest (initial evaluation), 7 days of storage, 14 days of storage, and 21 days of storage. Sample preparation occurred initially and after every seventh day of storage. Quality characteristics that were measured include berry weight loss, firmness, color, red drupelet reversion (RDR) (Fig. 5-6), respiration rate, total soluble solids, titratable acidity, and anthocyanins. Firmness measurements will be conducted using a BioWorks Firmtech firmness tester (BioWorks Inc., Wamego, KS). The color measurements will be conducted using a Chroma Meter CR-400 (Konica Minolta Sensing Americas inc., Wayne, NJ). Respiration rates were measured using a Bridge 900141 O_2/CO_2 analyzer (Bedford Heights, OH) which measures the real-time atmospheric conditions.

Results

Firmness values between cultivars under the treatments had significant differences with Ouachita having the highest firmness values in the control and controlled atmosphere storage conditions. The Ponca cultivar consistently exhibited the lowest firmness values across all three treatments. (Table 1). In the second harvest Osage had the highest firmness values across all three treatments with Caddo and Ouachita exhibiting the lowest firmness (Table 2). In the third harvest Osage had the highest firmness across all three treatments and Caddo had the lowest firmness (Table 3). Weight loss had significant differences in all three treatments. The control and ozonated storage treatments resulted in the Ponca cultivar exhibiting significantly higher firmness values than the other three cultivars. The CA treatments showed more significant results with low weight loss at only 9% in Caddo, the largest cultivar, and a weight loss of 12.8% in Ponca. The significance of RDR was seen in all three harvests. Ouachita and Ponca exhibited higher RDR after 21 days in the first and third harvest. In the second harvest Ponca exhibited the highest amount of RDR after 21 days. No significant difference was seen for the titratable acidity (TA) or total soluble solids (TSS). No significant difference was seen for the respiration rate of cultivars or treatments.

Table 1. Firmness values in Newtons (N) compared across cultivars under three treatments for the first harvest. Means with different letters for each harvest are significantly different ($P \leq 0.05$) using Tukey's significant difference test.

Firmness (N) First Harvest			
Cultivar Treatments	Control	CA	Ozone
Caddo	1.48 B	1.51 BC	1.61 A
Osage	1.43 B	1.52 B	1.64 A
Ouachita	1.61 A	1.64 A	1.65 A
Ponca	1.32 C	1.40 C	1.43 B
p-value	<.0001	<.0001	<.0001

Table 2. Firmness values in Newtons (N) compared across cultivars under three treatments for the second harvest. Means with different letters for each harvest are significantly different ($P \leq 0.05$) using Tukey's significant difference test.

Firmness (N) Second Harvest			
Cultivar Treatments	Control	CA	Ozone
Caddo	1.28 B	1.38 B	1.51 A
Osage	1.49 A	1.59 A	1.62 A
Ouachita	1.28 B	1.42 B	1.39 B
Ponca	1.47 A	1.41 B	1.37 B
p-value	<.0001	<.0001	<.0001

Table 3. Firmness values in Newtons (N) compared across cultivars under three treatments for the second harvest. Means with different letters for each harvest are significantly different ($P \leq 0.05$) using Tukey's significant difference test.

Firmness (N) Third Harvest			
Cultivar Treatments	Control	CA	Ozone
Caddo	1.55 C	1.61 C	1.57 B
Osage	1.83 A	1.87 A	1.82 A
Ouachita	1.65 BC	1.73 B	1.68 B
Ponca	1.68 B	1.58 C	1.58 B
p-value	<.0001	<.0001	<.0001

Table 4. Weight loss percentage compared across cultivars under three treatments. Means with different letters for each harvest are significantly different (P ≤ 0.05) using Tukey's significant difference test.

Weight Loss %			
Cultivar Treatments	Control	CA	Ozone
Caddo	11.8% B	9% C	9.4% B
Osage	13.6% B	11.8% AB	10.7% B
Ouachita	13% B	10.7% BC	10.6% B
Ponca	16.2% A	12.8% A	14% A
p-value	<.0001	<.0001	<.0001

Table 5. Average number of berries exhibiting Red Drupelet Reversion (RDR) on severity scale of No RDR, Low RDR and High RDR (based on the number of reverted drupelets). Means with different letters for each harvest are significantly different (P ≤ 0.05) using Tukey's significant difference test.

RDR Presence First Harvest						
Cultivar	Day 0			Day 21		
	No RDR	Low	High	No RDR	Low	High
Caddo	12 a	7 a	1.6 c	10 a	8 a	2 b
Osage	11.4 a	6 a	2.4 bc	8 ab	10 a	3 b
Ponca	10.5 a	4 b	5.3 b	7 ab	4 b	8 a
Ouachita	2.5 b	6 a	11 a	6 b	8 a	6 a
P-value	<.0001	0.0070	<.0001	0.0290	0.0003	<.0001

Table 6. Average number of berries exhibiting Red Drupelet Reversion (RDR) on severity scale of No RDR, Low RDR and High RDR (based on the number of reverted drupelets). Means with different letters for each harvest are significantly different (P ≤ 0.05) using Tukey's significant difference test.

RDR Presence Second Harvest						
Cultivar	Day 0			Day 21		
	No RDR	Low	High	No RDR	Low	High
Caddo	11.7 a	6.5 a	1.6 c	5.3 b	9.2 a	5.4 a
Osage	11 a	6.1 ab	2.4 bc	6.7 b	8.6 a	4.5 ab
Ponca	10.5 a	4.1 b	5.3 b	5.6 b	6.7 b	7.5 a
Ouachita	2.8 b	6.1 ab	11 a	10.4 a	8.1 a	1.4 b
P-value	<.0001	0.0289	<.0001	0.0013	0.2019	0.0002

Table 7. Average number of berries exhibiting Red Drupelet Reversion (RDR) on severity scale of No RDR, Low RDR and High RDR (based on the number of reverted drupelets). Means with different letters for each harvest are significantly different (P ≤ 0.05) using Tukey's significant difference test.

RDR Presence Third Harvest						
Cultivar	Day 0			Day 21		
	No RDR	Low	High	No RDR	Low	High
Caddo	11.7 a	6.5 a	1.6 c	7.4 a	8.4 a	4.1 a
Osage	11.4 a	6.1 ab	2.4 bc	8.5 a	6.4 a	5 a
Ponca	10.5 a	4.1 b	5.3b	4.8 a	6.6 a	8.4 a
Ouachita	3.4 b	5.6 ab	10.8 a	6.3 a	7.7 a	5.8 a
P-value	<.0001	0.0275	<.0001	0.2430	0.2454	0.1145

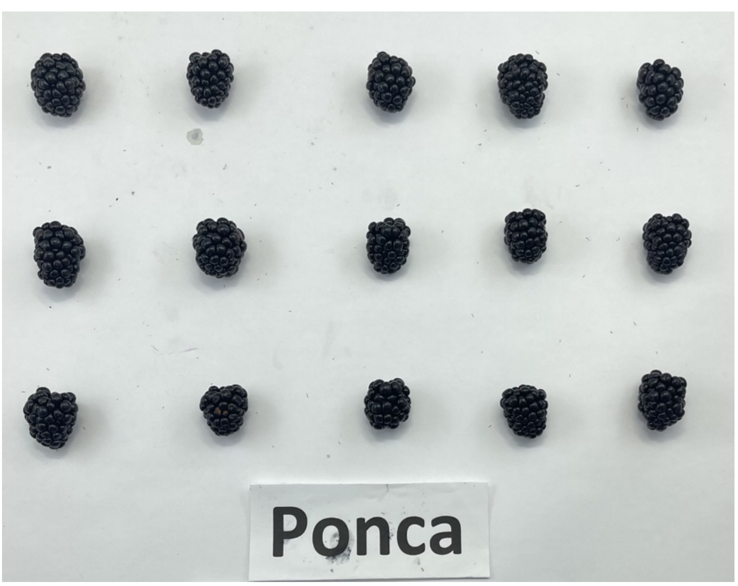

Figure 1. Typical phenology of Ponca cultivar berries grown in South Georgia.

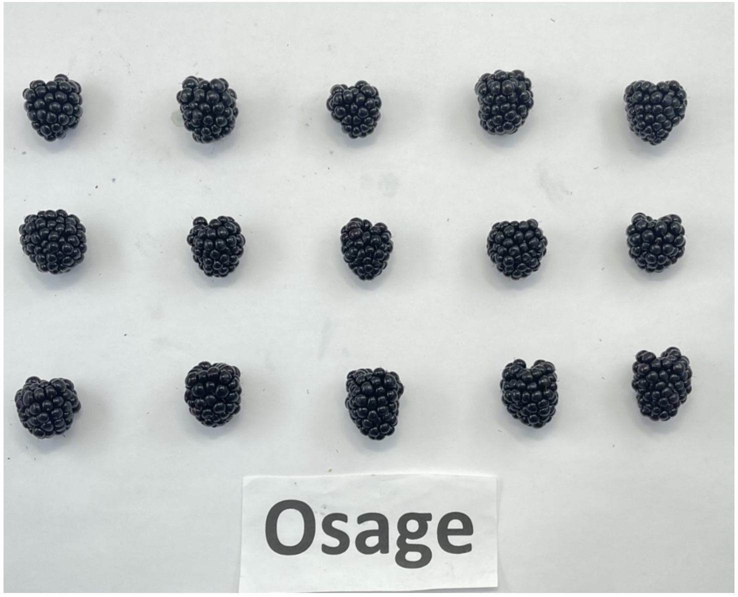

Figure 2. Typical phenology Osage cultivar berries grown in South Georgia.

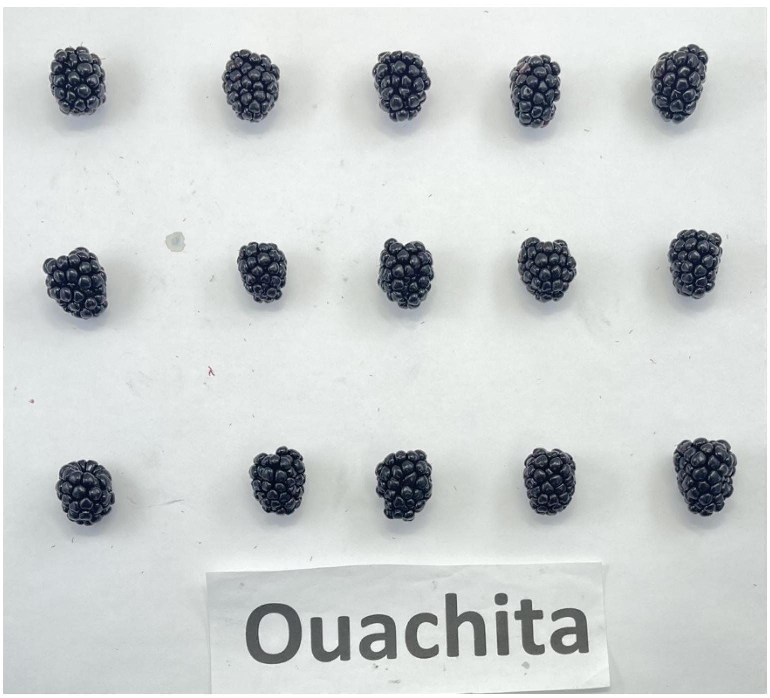

Figure 3. Typical phenology of Ouachita cultivar berries grown in South Georgia.

Figure 4. Typical phenology of Caddo cultivar berries grown in South Georgia.

Figure 5. Red Drupelet Reversion in varying severity.

Figure 6. Red Drupelet Reversion affecting individual drupelets on a blackberry.