Proposal Category: **_X__Research** **___Outreach**

Proposal Status: **_X_ New Proposal** **___Previously funded by SRSFC; has been previously funded for ___ years**

Title:
Evaluation of Old and New Varieties of Southern Highbush and Rabbiteye Blueberry for Postharvest Fruit Quality and Shelf-life

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Objective:

The main objective of this proposal was to examine the postharvest fruit quality and shelf-life attributes of older and newer southern highbush and rabbiteye varieties. The goal of this project was to assess postharvest fruit quality performance to help growers and packers better match varieties and their intended markets.

Justification and Description:

In Georgia and in the southeastern US, two main types of blueberries are commercially grown: southern highbush (species complex between *Vaccinium corymbosum* L. and *V. darrowii* Camp) and rabbiteye (*V. virgatum* Aiton) blueberries. Within the US in 2012, the state of Georgia accounted for over 13% of US fresh fruit production ranking number four (37 million pounds), and accounted for over 12% of US processed fruit production ranking number five (33 million pounds) (USDA-ERS, 2013). In 2014, Georgia ranked number one in total harvested blueberry acreage in the US, accounting for over 20% of US harvested acreage (16,600 acres) and over 17% of total US metric tons (283,400 metric tons) (USDA-NASS, 2014). With increasing production it becomes important to manage postharvest practices to extend the quality of berries for an extended time.

Southern highbush and rabbiteye fruit have been shown to have variations in postharvest quality depending on variety. In 2008, Saftner et al. examined instrumental fresh fruit quality measurements of ten highbush and two rabbiteye cultivars grown in New Jersey. They reported variations for firmness (compression test), soluble solid content, titratable acidity, sugar/acid ratio, pH, and the aromatic volatile concentration, associated with cultivar differences, rather than species differences. A sensory panel was also used to examine consumer acceptability of these cultivars. Panel results reported differences in highbush and rabbiteye cultivars for numerous acceptability traits. In another study, three rabbiteye and two highbush cultivars were examined for fruit characteristics including skin puncture, berry firmness (compression test), collective fruit firmness with multiple berries (Kramer shear press), carbohydrates and fiber content (Silva et al., 2005). In this study, the rabbiteye cultivars were reported to have higher

values than the highbush cultivars for all traits examined, yet no significant cultivar differences existed for sensory panelist evaluations. A confounding factor in this study was that rabbiteye cultivars were harvested in a different location/environment than the highbush fruit, with fruit collected from Mississippi and Michigan, respectively. Different preharvest environmental conditions may influence postharvest quality. Swift (2010) studied fresh and frozen highbush and rabbiteye fruit from different cultivars. The study was conducted over two years: four rabbiteye, one highbush and one highbush rabbiteye hybrid evaluated in year one; and four rabbiteye and one highbush genotype evaluated in year two. Instrumental analyses were performed including puncture tests to examine skin toughness, and compression tests to examine berry firmness. Sensory panels were also conducted. Overall, toughness was not shown to increase with later season harvest intervals on a cultivar. The study concluded that the effect of cultivar has a larger significance than time, and that overall environmental variation has a large effect.

Most recently, work at the University of Georgia (Itle and NeSmith, 2016) with detailed analyses of several southern highbush and rabbiteye varieties has shown considerable variation among varieties in several fresh fruit quality traits. These analyses were made on a one-time basis for the fruit upon harvest, but data for postharvest quality over time were not taken, so no assessment of shelf-life was made. Therefore, more information on postharvest quality over time is needed for blueberry varieties produced in the Southeastern U.S. This information is vital for growers, packers, and marketers to better understand how they should handle varieties in time and space to offer consumers the best fruit quality and shelf-life possible.

Our Own Preliminary Results:

Our preliminary results of evaluating a few southern highbush and rabbiteye cultivars in 2015 and 2016 suggest that there are differences in shelf-life and fruit quality attributes amongst cultivars in both southern highbush and rabbiteye (Wang, NeSmith and Nambeesan, 2016). We measured fruit firmness (compression test), skin puncture and other fruit quality attributes such as soluble solids and acidity during postharvest storage. Data for fruit firmness (using compression test) for selected cultivars analyzed for 2016 is shown in the graph below (Figure 1). Rebel and Premier displayed lower fruit firmness compared to the other cultivars. Suziblue and Miss Alice Mae showed a decline in fruit firmness after 45 days compared to other cultivars that showed a decrease in firmness at about 30 days after harvest. Differences in soluble solids and titratable acidity over the course of storage time were also observed. Future studies with more varieties are required to gather information about how fruit quality attributes change over time. Further, it is important to develop this information over the course of a few years to determine differences that exist from year to year.

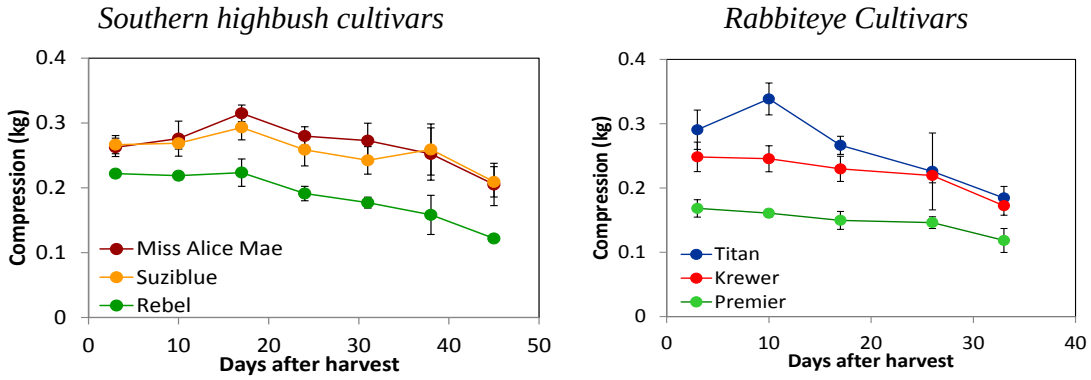


Figure 1. Change in fruit compression during postharvest storage in southern highbush and rabbiteye cultivars.

Significance:

Blueberry is an important crop in Georgia and throughout the Southeastern US, and an increased knowledge of highbush and rabbiteye postharvest fruit quality and shelf-life would benefit blueberry growers, consumers, and the industry as a whole by providing material with increased quality. Phenotypic variation within and among species for fruit quality characteristics is present as shown by previous research and our preliminary results. This project would allow for further identification of possible differences within and among older and newer varieties, as well as looking preliminarily at advanced blueberry breeding selections to be used for possible new cultivars and as parents in breeding programs.

Description of Procedures:

For the 2017 harvest season, we collected southern highbush cultivars; Emerald, Rebel, Farthing, Ms. Alice Mae, Ms. Jackie, Ms. Lily and Suziblue and rabbiteye cultivars Titan, Krewer, Alapaha and Brightwell from Cornelius farms in Manor, GA. Genotypes selected represented a range of fruit ripening times throughout the season (early, middle and late season ripening). Fruit from all varieties were harvested when plants were approximately 40 to 60% ripe. Fruit harvested from multiple plants for each genotype were placed in clamshells, packed in coolers on ice and transported back to the UGA Athens campus. Fresh fruit were held at approximately 4ºC under high humidity until all tests are completed.

Fruit quality was determined on weekly bases for about 5-7 weeks during storage. For determining fruit quality, visual assessment of fruit, weight, firmness, skin puncture, titratable acidity (TA), total soluble solids (TSS) were determined. Briefly, compression and skin puncture measurements were performed using a Fruit Texture Analyzer (Model GS-15, Güss Manufacturing (Pty) Ltd., Strand, South Africa). For measuring TA and TSS, juice from 40 g of fruit was extracted using a blender and centrifuged using a bench top micro-centrifuge. The supernatant was used to determine TSS using a digital handheld refractometer (Atago USA, Bellevue, WA). To determine TA, the supernatant was titrated using automatic mini titrator (Hanna Instruments, Woonsocket, RI). The above parameters provided valuable information on changes in critical shelf-life and fruit quality characteristics over an extended period of storage.

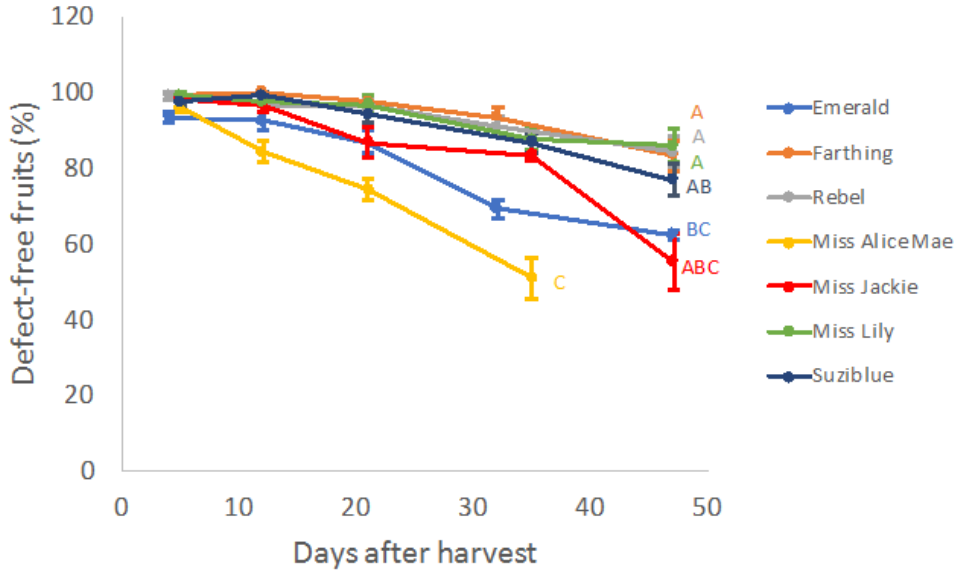
Results:

Determination of visual fruit quality in southern highbush and rabbiteye cultivars

We determined visual quality fruits by scoring for any sort of bruising, tear, leakiness and appearance of mold (Figure 1 and 2). For southern highbush cultivars, Farthing, Ms. Lily, Suziblue, and Rebel had high percentage of defect free fruit ranging from 77% to 86%, even after about 45 days of storage. In comparison, Ms. Alice Mae showed a decline in healthy fruits after about 3 weeks in storage, whereas for Emerlad it was about 4 weeks and Ms. Jackie about 4-5 weeks.

For rabbiteye cultivars, Brightwell showed good visual keeping quality for about 4-5 weeks, Alapaha and Titan for about 3-4 weeks and Krewer for about 2-3 weeks.

(A)



(B)

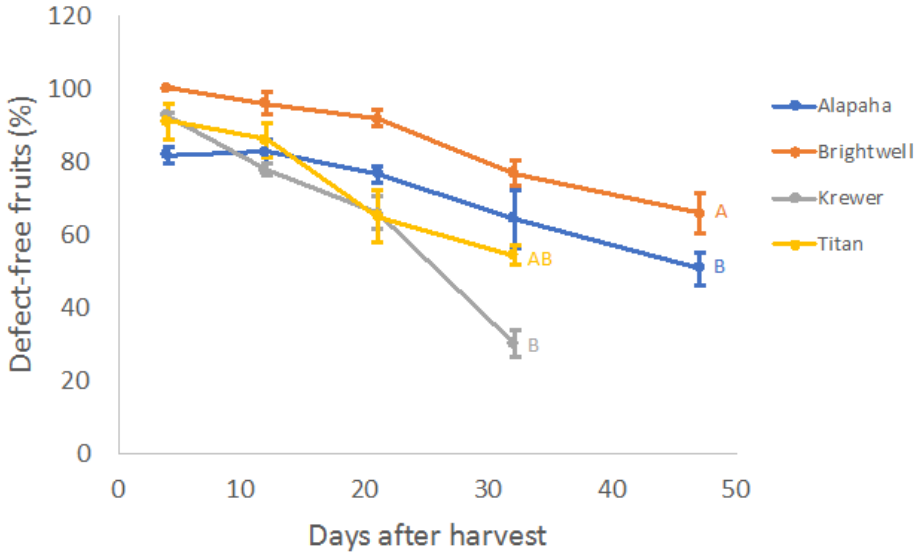


Figure 1. Percentage of defect-free fruits determined at various times after harvest in southern highbush blueberries (A) and rabbiteye blueberries (B). Error bars represent standard errors. Significance is set at $P < 0.05$ amongst all cultivars. A different letter indicates significant differences between values.

Compression and Puncture

We determined compression as a measure of fruit firmness and puncture as a measure of skin toughness (Table 1 and Table 2). Farthing and Suziblue had higher firmness, whereas Emerald and Rebel had lower firmness. In comparison, Ms. Alice Mae, Ms. Jackie and Ms. Lily were of intermediate firmness. Interestingly compression did not change over time during postharvest storage in all cultivars except Ms. Alice Mae where fruit softening occurred around 5 weeks.

Skin toughness was higher in Farthing, Jackie and Suziblue with Emerald and Rebel having lower puncture values. The skin toughness was in general, intermediate for Ms. Alice Mae and Ms. Lily. Similar to compression, skin toughness did not change for upto 5 weeks during postharvest storage.

For rabbiteye cultivars, Titan and Brightwell had higher firmness compared to Alapaha and Krewer. However fruit softening occurred around 5 weeks for all cultivars except Alapaha. For skin toughness, in general there was no difference among cultivars, except 1 week after harvest, Brightwell and Titan had higher puncture values compared to Alapaha and Krewer. Similar to compression, puncture values were lower around 5 weeks for all cultivars except Alapaha.

To conclude, in southern highbush cultivars, Farthing and Suziblue had good shelf-life, higher firmness and skin toughness. Although in our study Ms. Lily and Rebel had good shelf-life, these cultivars had lower compression and skin toughness. For rabbiteye cultivars, Brightwell had good shelf-life with higher firmness and skin toughness. For the other cultivars, shelf-life characteristic did completely correlate with compression and puncture.

Fruit Weight

For southern highbush cultivars, Ms. Lily had the highest weight and Emerald fruit had the least weight (Table 1). For rabbiteye the fruit weight was highest in Titan followed by Krewer, followed by Brightwell and Alapaha had the least weight (Table 2)**.**

Total soluble solids and titratable acidity

We also determined total soluble solid content and titratable acidity (Table 1 and 2). Among southern highbush cultivars, Emerald, Rebel and Ms. Alice Mae had higher soluble solid content whereas Suziblue and Ms. Lily had lower content of soluble solids. Farthing and Ms. Jackie were intermediate. Although not statistically significant, Krewer had higher total soluble solids compared to other rabbiteye cultivars. The content of soluble solids did not change during postharvest storage in both southern highbush and rabbiteye cultivars.

Titratable acidity is the only attribute that decreases during postharvest storage. Among southern highbush cultivars, Rebel, Emerald and Ms. Alice Mae had high titratable acidity followed by Farthing and Jackie, Suziblue and Ms. Lily had the lowest titratable acidity. For rabbiteye cultivars, Alapaha had higher titratable acidity and Krewer had low titratable acidity. In general total soluble solids and titratable acidity did not correlate with shelf-life; however for some cultivars a negative correlation between total soluble solids and shelf-life was observed (Suziblue, Ms. Lily, Emerald, Ms. Alice Mae, Krewer)

Table 1: Fruit quality attributes determined at various times during storage in southern highbush blueberries.

Weeks after harvest	Cultivar	Compression (kg)	Puncture (kg)	Weight (g)	TSS[a] (^{o}Brix)	TA[b] (%)	pH
	Emerald	0.23 cd	0.13 c	1.95 b	14.40 a	0.77 a	3.30 d
	Farthing	0.29 a	0.15 abc	1.95 b	12.75 b	0.46 b	3.43 cd
	Rebel	0.23 cd	0.14 bc	1.80 b	14.58 a	0.30 cd	3.75 ab
~1	Miss Alice Mae	0.26 b	0.16 ab	1.88 b	14.88 a	0.26 d	3.85 a
	Miss Jackie	0.21 d	0.17 a	1.72 b	13.05 b	0.65 a	3.50 cd
	Miss Lily	0.25 bc	0.14 bc	2.38 a	11.10 c	0.38 bcd	3.60 bc
	Suziblue	0.26 b	0.18 a	2.02 ab	10.88 c	0.45 bc	3.53 c
	Prob>F	<0.0001	<0.0001	0.0022	<0.0001	<0.0001	<0.0001
	Emerald	0.21 c	0.14 b	1.46 c	14.40 a	0.59 a	3.45 d
	Farthing	0.29 a	0.18 a	1.97 b	12.70 b	0.35 b	3.55 cd
	Rebel	0.22 bc	0.14 b	1.92 b	14.45 a	0.19 c	4.00 a
~2	Miss Alice Mae	0.24 bc	0.14 b	1.69 bc	14.50 a	0.26 bc	3.85 ab
	Miss Jackie	0.23 bc	0.18 a	1.70 bc	12.50 b	0.70 a	3.50 d
	Miss Lily	0.25 b	0.16 ab	2.51 a	11.23 c	0.33 bc	3.83 abc
	Suziblue	0.30 a	0.18 a	1.82 b	10.65 c	0.39 b	3.65 bcd
	Prob>F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Emerald	0.20 c	0.12 b	1.45 c	13.88 ab	0.52 a	3.65
	Farthing	0.30 a	0.15 ab	2.00 b	12.60 b	0.36 b	3.88
	Rebel	0.22 bc	0.12 b	1.83 bc	13.93 a	0.22 c	4.05
~3	Miss Alice Mae	0.29 a	0.13 b	1.63 bc	14.05 a	0.25 bc	3.93
	Miss Jackie	0.25 b	0.17 a	1.67 bc	12.90 ab	0.54 a	3.60
	Miss Lily	0.25 b	0.15 ab	2.47 a	10.88 c	0.32 bc	3.88
	Suziblue	0.30 a	0.17 a	1.81 bc	11.03 c	0.37 b	3.70
	Prob>F	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	ns
	Emerald	0.20 bc	0.14	1.47 d	13.83 a	0.49 a	3.78 ab
	Farthing	0.30 a	0.17	1.94 b	12.50 ab	0.34 b	3.70 ab
	Rebel	0.20 bc	0.13	1.62 cd	14.05 a	0.15 d	4.15 a
~5	Miss Alice Mae	0.18 c	0.17	1.71 bcd	13.48 a	0.20 cd	4.08 a
	Miss Jackie	0.22 b	0.17	1.67 bcd	12.58 ab	0.59 a	3.48 b
	Miss Lily	0.21 bc	0.13	2.53 a	11.13 bc	0.29 bc	3.98 ab
	Suziblue	0.28 a	0.19	1.84 bc	10.60 c	0.34 b	3.93 ab
	Prob>F	<0.0001	ns	<0.0001	<0.0001	<0.0001	0.0041
	Emerald	0.18 b	0.12 bc	1.55 d	13.60 a	0.41 a	3.67 c
	Farthing	0.27 a	0.17 a	1.97 b	12.55 a	0.30 b	3.63 c
	Rebel	0.16 b	0.10 c	1.98 b	13.75 a	0.11 c	4.43 a
~7	Miss Alice Mae	-	-	-	-	-	-
	Miss Jackie	0.17 b	0.13 bc	1.70 cd	12.70 a	0.48 a	3.78 bc
	Miss Lily	0.20 b	0.13 bc	2.39 a	10.85 b	0.29 b	4.03 b
	Suziblue	0.29 a	0.16 ab	1.81 bc	11.05 b	0.28 b	3.88 bc
	Prob>F	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001

Significance is set at $P < 0.05$ among all cultivars for a given storage time. A different letter indicates significant differences between values. Non-significant values are denoted by ns.

[a] Total soluble solids (TSS)

[b] Titratable acidity (TA)

Table 2: Fruit quality attributes determined at various times during storage in rabbiteye blueberries.

Weeks after harvest	Cultivar	Compression (kg)	Puncture (kg)	Weight (g)	TSS[a] (^{o}Brix)	TA[b] (%)	pH
~1	Alapaha	0.19 b	0.12 b	1.02 e	14.10	0.34 a	3.43 b
	Brightwell	0.26 a	0.16 a	1.43 c	14.73	0.28 ab	3.53 b
	Krewer	0.21 b	0.13 b	2.92 b	15.55	0.24 b	3.80 a
	Titan	0.26 a	0.14 a	3.22 a	14.80	0.29 ab	3.58 ab
	Prob>F	<0.0001	0.0002	<0.0001	ns	0.069	0.0045
~2	Alapaha	0.21 b	0.14	1.03 d	14.10 b	0.29 a	3.55 c
	Brightwell	0.23 ab	0.15	1.54 c	15.43 a	0.24 bc	3.73 b
	Krewer	0.20 b	0.13	2.79 b	14.90 ab	0.21 c	3.93 a
	Titan	0.25 a	0.15	3.18 a	13.95 b	0.27 ab	3.63 bc
	Prob>F	0.0025	ns	<0.0001	0.0118	0.0008	0.0001
~3	Alapaha	0.21 b	0.13	1.01 d	13.58	0.24	3.58 b
	Brightwell	0.23 ab	0.13	1.48 c	14.48	0.24	3.70 b
	Krewer	0.20 b	0.14	2.65 b	14.78	0.19	4.00 a
	Titan	0.25 a	0.13	3.09 a	13.60	0.23	3.73 b
	Prob>F	0.0096	ns	<0.0001	ns	ns	0.0004
~5	Alapaha	0.19	0.12 b	0.99 d	13.58 ab	0.24 a	3.73 b
	Brightwell	0.22	0.14 a	1.50 c	14.78 a	0.21 ab	3.70 b
	Krewer	0.17	0.11 b	2.49 b	13.80 ab	0.21 ab	3.93 ab
	Titan	0.20	0.12 ab	3.25 a	12.98 b	0.17 b	4.00 a
	Prob>F	ns	0.0148	<0.0001	0.0102	0.0132	0.0097
~7	Alapaha	0.18	0.14	0.96 b	13.68	0.23	3.63
	Brightwell	0.21	0.16	1.42 a	14.38	0.21	3.68
	Krewer	-	-	-	-	-	-
	Titan	-	-	-	-	-	-
	Prob>F	ns	ns	<0.0001	ns	ns	ns

Significance is set at $P < 0.05$ among all cultivars for a given storage time. A different letter indicates significant differences between values. Non-significant values are denoted by ns.

[a] Total soluble solids (TSS)

[b] Titratable acidity (TA)

Conclusions

In general shelf-life varies among cultivars between three to atleast seven weeks. Among southern highbush cultivars, Suziblue, Ms. Lily, Farthing has good shelf-life. These data are in agreement with variety trial conducted in 2016. Incase of Rebel, we found it had good shelf-life however in the past years Rebel had a poor shelf-life; therefore the results are slightly contrasting. In case of rabbiteye, Brightwell had good shelf-life, Titan and Alapaha were slightly lower. In 2016, Titan had good shelf-life. Even though some yearly variations occur, this information along with fruit firmness will be useful to make decisions on handling and postharvest storage of fruit.

Impact Statement

This research evaluated shelf-life and fruit quality attributes during postharvest storage for several southern highbush and rabbiteye cultivars. Data from this study will provide valuable information to growers, packers and distributors to make decisions on how to handle cultivars that differ in postharvest storage to be able to deliver higher quality fruit to consumers.

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