

**Title of Project:** Consumer Sensory Perception of Quality Attributes of Fresh Southern Highbush and Rabbiteye Blueberries

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**Objective**

The objective of this study is to examine consumer preferences of southern highbush and rabbiteye blueberries currently produced in Georgia using consumer sensory perception. Fresh fruit is currently being analyzed for consumer acceptability scores and these will be compared and correlated to instrumental analyses to determine relationships to various physicochemical and nutritional qualities. Knowledge of consumer preferences will benefit the breeding program, and the industry as a whole, to help provide consumers with the best quality fruit.

**Justification and Description**

Blueberry is a major specialty crop grown in Georgia and across the Southeastern US. In 2014, Georgia ranked first in the US in total blueberry production and accounted for over 55% of both total metric tons and total acreage produced in the Southeastern US (USDA-NASS, 2014). Within the state, the commercial blueberry industry consists of two main types of blueberries: southern highbush (*Vaccinium corymbosum* L.) and rabbiteye (*V. virgatum* Aiton).

There are benefits for growers in the state to grow both southern highbush and rabbiteye varieties. The southern highbush varieties ripen earlier than do the rabbiteye varieties, which provide the grower with higher prices often associated with early fruit, and extends the state's blueberry season. However, the earlier fruit ripening is preceded by earlier flowering which can be susceptible to late spring frosts often causing significant yield losses. Rabbiteyes are firm fruit, typically more suitable for mechanical harvesting than are southern highbush. Machine

harvesting can be accomplished for approximately one seventh the price of the hand harvesting typically done with southern highbush varieties. However, some negative perceptions on rabbiteye fruit quality compared to southern highbush may be detrimental in the marketing and sale of the fruit.

Much of the fruit quality debate concerning southern highbush and rabbiteye fruit is subjective, and, to some extent, rabbiteye blueberries have been perceived to be of less preferred quality. Common criticisms of rabbiteye fruit quality include tougher skin, seedier fruit, and grittier texture. However, there have been few objective studies that compare southern highbush and rabbiteye varieties for fruit quality using instrumental analyses, and even fewer studies relating these measurements to consumer acceptability.

In two such studies, variations for fruit firmness (compression test), soluble solid content, titratable acidity, sugar/acid ratio, pH, and the aromatic volatile composition, were associated with cultivar differences rather than species differences (Saftner et al., 2008; Silva et al., 2005). In a third study, Swift (2010) examined fresh and frozen highbush and rabbiteye fruit from different cultivars. Instrumental analyses were performed including puncture tests to examine skin toughness, and compression tests to examine berry firmness. Overall, toughness was not shown to increase with later season harvest intervals on a cultivar. The study concluded that the effect of cultivar (not species) has a larger significance than time, and that overall environmental variation has a large effect.

Sensory panels were also conducted for two projects (Silva et al., 2005; Blaker et al., 2014) using trained panelists to study fruit quality. Silva et al. (2005) examined two highbush and three rabbiteye cultivars and reported no differences for color, flavor, or skin toughness across varieties or species. A common perception about rabbiteye blueberries is that they are all seedier than highbush; however, Silva et al. (2005) found that this did not hold true. In fact, in their study the rabbiteye blueberry, 'Climax', rated lower for seediness in comparison with all varieties across highbush and rabbiteye. Blaker et al. (2014) evaluated a wide collection of crisp and standard texture highbush germplasm for textural attributes and found variation among the textural attributes across varieties. However, no rabbiteye varieties were examined in their study.

Saftner et al. (2008) and Swift (2010) used consumer panels to evaluate highbush and rabbiteye germplasm for texture, flavor, quality, and overall fruit acceptability. They reported that fruit size, flavor, texture and visual characteristics are good predictors of consumer acceptability. They found that highbush did not necessarily rank higher than the rabbiteye varieties for consumer acceptance. In addition, Swift (2010) reported the presence of cultivar differences throughout years.

In addition to these sensory and instrumental studies comparing southern highbush and rabbiteye blueberries, there has recently been work to identify specific traits desired in blueberry fruit by consumers. Gilbert et al. (2014) conducted an online survey of over 600 participants from various demographics (age group, ethnicity, income level) divided over two studies to examine consumer preference for 36 traits of blueberry. The traits of increased sweetness, blueberry flavor, and health benefits were positive indicators of purchasing blueberry fruit, whereas high levels of seediness and poor texture were negative indicators of purchasing blueberry fruit. Considering these major consumer preferences of blueberry fruit quality in relation to the perceived fruit quality differences between southern highbush and rabbiteye fruit, further emphasis needs to be placed on understanding the differences that may or may not exist between the two major types of blueberries grown in Georgia and in the Southeast. Providing factual information about currently grown southern highbush and rabbiteye material will help provide an information base to help to maintain and/or increase market share and profits for blueberry industry in the Southeast.

## Methodologies

Both fresh and frozen fruit from southern highbush and rabbiteye cultivars were collected. Several cultivars of rabbiteye and southern highbush were obtained from commercial packers in Alma, GA from May to July, 2016. Fresh fruit were collected from southern highbush cultivars ‘Camellia’, ‘Farthing’, ‘Star’, ‘Emerald’, ‘Sweetcrisp’, and ‘Legacy’; and from rabbiteye cultivars ‘Vernon’, ‘Alapaha’, and ‘Premier’. Frozen fruit were collected from southern highbush cultivars ‘Rebel’ and ‘Legacy’; and from rabbiteye cultivars ‘Powderblue’, ‘Premier’, ‘Brightwell’, ‘Alapaha’, and ‘Austin’. All fruit were transported back to the Griffin campus. Fresh fruit were held at approximately 4°C until all initial tests were completed. Frozen fruit were transported frozen on dry ice and were held at -15°C.

Instrumental measurements of fruit quality were made on all cultivars. For measurements of fruit texture, an Instron universal testing machine (Model 1122, Instron Corp., Canton, MA) was used to estimate puncture in and out (skin toughness) and Kramer shear press (fruit firmness) as outlined in Silva et al., 2005. For fresh fruit, berries were brought to room temperature of approximately 20°C for one hour and tests were arranged in order of most to least sensitive. Punctures were run one to two days after each consumer taste panel, and Kramer shear tests were run three days after each consumer taste panel. Three reps of twelve berries of similar size per rep per cultivar were used for puncture analyses, and three samples of 50.0±1.0g of berries per each of the three reps per cultivar were used for the Kramer Shear tests. For frozen fruit, berries were thawed and brought to room temperature for approximately two hours before textural tests were conducted.

Measurements of fruit size (50 berry weights) and fruit color using CIE L\*a\*b\* color space values (MiniScan XE colorimeter, Hunter Lab, Reston, VA) were also taken on fresh or frozen fruit within three days of the consumer taste panel, with three subsamples per each of the three reps per cultivar for fruit size and color measurements. Remaining fresh fruit were frozen and were held at -15°C. Aroma and flavor profiles were measured 10-14 days after each consumer taste panel, with three reps per cultivar, as outlined in Gilbert et al., 2013. Flavor volatiles were measured using headspace solid phase microextraction (HS-SPME) was used to extract the volatiles and gas chromatography (Model 7890A, Agilent Technologies, Santa Clara, CA equipped with a HP-5MS column (30 m×250µm×0.25µm) and a MS detector (Model 5977A, Agilent Technologies, Santa Clara, CA) to separate and identify the volatiles in the blueberry samples. Frozen fruit was also examined for seed traits including total number of seed, seed weight (g), and percent seed weight/berry weight (g) within approximately three months of the consumer panel date. Flavor profile analyses and chemical quality component measurements of total titratable acids, pH, and soluble solids (°brix) are currently being conducted.

Consumer taste panels were conducted for all cultivars. Two taste panels were conducted using fresh fruit and one taste panel was conducted using frozen fruit. For fresh fruit, fruit were brought to room temperature for approximately one hour and samples of approximately 30g (1oz) were served to each panelist in 113g (4oz) Styrofoam cups in a Latin Square design. There were 98 blueberry consumers participated in all three taste panels. Consumer acceptability was scored using a nine point hedonic scale for ‘liking/acceptability’ for traits of sample color, fruit size, aroma, flavor, sweetness, acidity, texture, fruit firmness, skin toughness, grittiness/graininess, seediness, and overall liking. Additional check all that apply (CATA) questions for ‘like’ and ‘dislike’ were used as additional descriptors to aid in determining intensity levels of various traits.

For the frozen fruit consumer panel, fruit from each variety was blended with a carrier food of Dannon Lowfat (1.5% milkfat) Vanilla Yogurt (The Dannon Co., Horsham, PA) at a ratio of 1 part blueberry fruit: 0.375 part yogurt. Fruit was thawed at room temperature for approximately two hours, and blended with yogurt for approximately 20-25 minutes until a

homogenous consistency was achieved (Oster Smash Blend All, Model No. BLSTTG, Sunbeam Products, Inc., Boca Raton, FL) (Black and Decker Fusion Blade Blender, Model No. BL1111, Spectrum Brands Inc., Madison, WI). Smoothies were held overnight at 4°C and were served chilled to panelists in the same manner as the fresh fruit panels. All questions on the consumer questionnaire remained the same, except for any fruit specific traits such as fruit size, fruit firmness and skin toughness. Texture questions were replaced with a general question about the overall texture/mouthfeel of the sample. Demographic questions about blueberry purchasing, usage and consumption, and health perceptions relating to purchasing were also asked of the consumers to understand the consumer preferences. The data obtained will be correlated with the instrumental data to determine relationships between the two data sets using regression techniques.

Data are currently being analyzed using two-way Analysis of Variance model performed in SAS 9.4 (SAS Institute, Cary NC, USA). Results presented below are consumer scores of 'liking/acceptability' for fresh fruit consumer panels.

### **Current Results**

Cultivars were compared for 'liking/acceptability' of twelve traits (Table 1). For fruit color, there was no significant difference in the acceptability scores of all cultivars. For fruit size, larger fruited cultivars had higher acceptability scores, while smaller fruited cultivars had lower scores. No particular variety was well liked or disliked for aroma, as the range for all cultivars ranged from 5.8 to 6.4 (5 = 'neither like nor dislike' to 7 = 'like moderately'). For overall flavor, 'Sweetcrisp' and 'Vernon' ranked the highest for acceptability (7.2 and 6.8, respectively), and 'Star', 'Alapaha' and 'Emerald' ranked the lowest for acceptability (5.8, 5.8, and 5.6, respectively). For sweetness, 'Sweetcrisp' ranked significantly higher ( $P \leq 0.05$ ) than all other cultivars. 'Legacy', 'Camellia', 'Farthing', and 'Vernon' ranked similarly, with acceptability scores ranging from 6.1 – 6.5 (6 = 'like slightly', 7 = 'like moderately'). 'Star', 'Premier', 'Emerald', and 'Alapaha' also ranked similarly for sweetness, with acceptability scores ranging from 5.4-5.9 (5 = 'neither like nor dislike' to 6 = 'like slightly'). For acidity, the range for all cultivars examined was from 5.3-6.5.

For overall texture, 'Sweetcrisp' ranked the highest for acceptability (7.6) (7 = 'like moderately', 8 = 'like very much'); 'Legacy', 'Camellia', 'Farthing', and 'Vernon' ranked in the middle of the cultivars examined with scores ranging from 6.6-6.9 (6 = 'like slightly', 7 = 'like moderately'); and 'Premier' and 'Emerald' ranking among the lowest for texture acceptability (5.4 for both) (5 = 'neither like nor dislike', 6 = 'like slightly'). 'Alapaha' had the lowest acceptability score for overall texture (5.0). Textural traits of fruit firmness and skin toughness ranked similarly to scores for overall fruit texture. Cultivar scores for 'grittiness' and 'seediness' also ranked similarly. 'Sweetcrisp' had the highest acceptability scores across cultivars for both grittiness and 'seediness' (6.9 and 7.0, respectively). 'Alapaha' had the lowest consumer acceptability for 'grittiness' (5.1), and 'Premier' and 'Alapaha' had the lowest scores for seediness (5.2 for both). For overall liking, 'Sweetcrisp' had the highest acceptability score (7.3); 'Legacy', 'Camellia', 'Farthing', and 'Vernon' ranked in the middle of the cultivars examined with scores ranging from 6.4-6.8; and 'Star', 'Premier', 'Emerald' and 'Alapaha' ranked the lowest with scores ranging from 5.3-5.7.

Traits were examined for relationships to one another (Table 2). Traits of fruit color, fruit size and fruit aroma were not related to overall liking ( $P > 0.05$ ). All other traits evaluated were related to overall liking, with strong correlations for all remaining traits, ranging from  $r = 0.81$  for seediness, to  $r = 0.99$  for overall texture. Many other additional strong correlations were identified between the various traits examined. All consumer acceptability scores will be

compared with objective instrumental measures of fruit quality to further understand and these relationships.

Data for the frozen consumer panel will be compared in a similar manner, and comparisons will also be made between cultivars evaluated as both fresh and frozen fruit. Additionally, all data will be compared with demographic and questionnaire data to identify consumer acceptability trends among these traits, and the potential influence of selected traits on future purchases.

### **Current Conclusions**

1. Variation exists for consumer acceptability scores for the 12 traits examined.
2. Across all fruit quality traits, ‘Sweetcrisp’ ranked the highest for consumer acceptability for nine of the traits examined. This suggests that this cultivar may be needed for removal from the data set to more clearly identify similarities and differences amount the other eight varieties examined.
3. Aroma had the smallest acceptability range out of all of the traits examined, ranging across all cultivars from 5.8 to 6.4 (5 = ‘neither like nor dislike’ to 7= ‘like moderately’), whereas traits relating to flavor characteristics (overall flavor, sweetness, acidity) and textural characteristics (overall texture, fruit firmness, skin toughness, and seediness) had wider ranges present across all cultivars examined.
4. Traits of color, aroma, and fruit size were not correlated to overall liking. This suggests that these traits are not major influencers of overall consumer acceptability of a blueberry cultivar.
5. Many other additional strong correlations were identified between the various traits examined. All consumer acceptability scores will be compared with objective instrumental measures of fruit quality to further understand and these relationships.

### **Impact Statement**

This project is a vital starting point in helping the Southeast to maintain and potentially increase their overall share in the blueberry market. Consumer acceptance is of utmost importance as it drives the growth and the sustainability of an industry. Understanding the overall fruit quality attributes as they relate to consumer perception and overall health/nutrition will allow producers and retailers a better knowledge of fruit quality of Southeastern blueberries. Currently there is limited knowledge available concerning physical, chemical and nutritional characteristics for blueberries for the Southeast. We need to improve our fundamental understanding of consumer preferences as they relate to fruit physicochemical qualities of fresh fruit from germplasm in the state. This project overall can help the growers and producers to enhance, and prevent lowered, sale price point of varieties. The information provided by this study may also help blueberry producers target specific markets depending on market preferences of various quality parameters.

### **Citation(s) for any publications arising from this project:**

#### **Literature Cited**

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Table 1. Consumer panel<sup>a</sup> acceptability scores<sup>b</sup> for fresh fruit from southern highbush (*Vaccinium corymbosum* L.)<sup>c</sup> and rabbiteye (*V. virgatum* Aiton)<sup>d</sup> cultivars grown in Georgia during the 2016 season<sup>e</sup>.

Cultivar	Color	Fruit size	Aroma	Overall Flavor	Sweetness	Acidity	Overall Texture	Fruit Firmness	Skin Toughness	Grittiness	Seediness	Overall Liking
'Sweetcrisp'	7.4a <sup>f</sup>	6.9 c	5.8 b	7.2 a	7.1 a	6.5 a	7.6 a	7.7 a	7.1 a	6.9 a	7.0 a	7.3 a
'Legacy'	7.5a	7.5 ab	5.7 b	6.6 b	6.4 b	6.1 ab	6.7 b	6.7 b	6.8 ab	6.4 bc	6.7 a	6.7 b
'Camellia'	7.3a	7.9 a	6.4 a	6.5 b	6.1 bc	5.7 bcd	6.9 b	7.1 b	6.9 ab	6.5 ab	6.7 a	6.6 b
'Farthing'	7.7a	7.7 ab	6.0 ab	6.5 bc	6.2 bc	6.0 b	6.6 b	7.0 b	6.8 ab	6.1 cd	6.2 b	6.6 b
'Vernon'	7.6a	7.7 ab	6.4 a	6.8 ab	6.5 b	6.0 b	6.6 b	6.9 b	6.5 b	5.7 def	5.6 cd	6.4 b
'Star'	7.3a	6.6 cd	6.0 ab	5.8 d	5.7 cd	5.7 bcd	5.8 c	5.8 c	6.0 c	5.8 de	6.3 b	5.7 c
'Premier'	7.5a	7.4 b	6.3 a	6.1 cd	5.9 c	5.7 bcd	5.4 c	5.4 c	5.8 c	5.3 fg	5.2 d	5.7 c
'Emerald'	7.5a	7.7 ab	6.2 a	5.6 d	5.4 d	5.3 d	5.4 c	5.6 c	6.0 c	5.5 efg	5.8 c	5.4 c
'Alapaha'	7.1a	6.3 d	6.2 a	5.8 d	5.8 cd	5.6cd	5.0 d	4.5 d	5.3 d	5.1 g	5.2 d	5.3 c

<sup>a</sup> Consumers (n=98) evaluated fruit over two panel sessions. 'Camellia', 'Farthing', 'Star', 'Emerald', and 'Sweetcrisp' evaluated at first panel session; 'Legacy', 'Vernon', 'Alapaha', and 'Premier' evaluated at second panel session.

<sup>b</sup> Traits evaluated on nine point hedonic scale for 'liking/acceptability', with 1= 'dislike extremely', 5= 'neither like nor dislike', and 9= 'like extremely'.

<sup>c</sup> Southern highbush cultivars: 'Camellia', 'Farthing', 'Star', 'Emerald', 'Sweetcrisp' and 'Legacy'.

<sup>d</sup> Rabbiteye cultivars: 'Vernon', 'Alapaha', and 'Premier'.

<sup>e</sup> Fruit was collected from commercial packers in Alma, GA.

<sup>f</sup> Differences examined using LS-Means ( $P \leq 0.05$ ).

Table 2. Pearson correlation coefficients (r) for consumer panel<sup>a</sup> acceptability scores<sup>b</sup> for fresh fruit from southern highbush (*Vaccinium corymbosum* L.)<sup>c</sup> and rabbiteye (*V. virgatum* Aiton)<sup>d</sup> cultivars grown in Georgia during the 2016 season<sup>e</sup>.

Traits	Color	Fruit Size	Aroma	Overall Flavor	Sweetness	Acidity	Overall Texture	Fruit Firmness	Skin Toughness	Grittiness	Seediness	Overall Liking
Color	<b>1.00<sup>f</sup></b>	<b>0.76</b>	-0.03	0.26	0.12	0.19	0.28	0.43	0.39	0.11	0.03	0.27
Fruit Size	<b>0.76</b>	<b>1.00</b>	0.23	0.26	0.03	0.00	0.35	0.49	0.50	0.25	0.18	0.31
Aroma	-0.03	0.23	<b>1.00</b>	-0.33	-0.47	-0.55	-0.44	-0.33	-0.42	-0.57	-0.63	-0.49
Overall Flavor	0.26	0.26	-0.33	<b>1.00</b>	<b>0.96</b>	<b>0.93</b>	<b>0.92</b>	<b>0.88</b>	<b>0.85</b>	<b>0.77</b>	0.59	<b>0.94</b>
Sweetness	0.12	0.03	-0.47	<b>0.96</b>	<b>1.00</b>	<b>0.98</b>	<b>0.86</b>	<b>0.78</b>	<b>0.75</b>	<b>0.75</b>	0.58	<b>0.90</b>
Acidity	0.19	0.00	-0.55	<b>0.93</b>	<b>0.98</b>	<b>1.00</b>	<b>0.84</b>	<b>0.77</b>	<b>0.74</b>	<b>0.74</b>	0.59	<b>0.89</b>
Overall Texture	0.28	0.35	-0.44	<b>0.92</b>	<b>0.86</b>	<b>0.84</b>	<b>1.00</b>	<b>0.98</b>	<b>0.98</b>	<b>0.94</b>	<b>0.84</b>	<b>0.99</b>
Fruit Firmness	0.43	0.49	-0.33	<b>0.88</b>	<b>0.78</b>	<b>0.77</b>	<b>0.98</b>	<b>1.00</b>	<b>0.98</b>	<b>0.89</b>	<b>0.79</b>	<b>0.95</b>
Skin Toughness	0.39	0.50	-0.42	<b>0.85</b>	<b>0.75</b>	<b>0.74</b>	<b>0.98</b>	<b>0.98</b>	<b>1.00</b>	<b>0.94</b>	<b>0.86</b>	<b>0.96</b>
Grittiness	0.11	0.25	-0.57	<b>0.77</b>	<b>0.75</b>	<b>0.74</b>	<b>0.94</b>	<b>0.89</b>	<b>0.94</b>	<b>1.00</b>	<b>0.96</b>	<b>0.93</b>
Seediness	0.03	0.18	-0.63	0.59	0.58	0.59	<b>0.84</b>	<b>0.79</b>	<b>0.86</b>	<b>0.96</b>	<b>1.00</b>	<b>0.81</b>
Overall Liking	0.27	0.31	-0.49	<b>0.94</b>	<b>0.90</b>	<b>0.89</b>	<b>0.99</b>	<b>0.95</b>	<b>0.96</b>	<b>0.93</b>	<b>0.81</b>	<b>1.00</b>

<sup>a</sup> Consumers (n=98) evaluated fruit over two panel sessions. 'Camellia', 'Farthing', 'Star', 'Emerald', and 'Sweetcrisp' evaluated at first panel session; 'Legacy', 'Vernon', 'Alapaha', and 'Premier' evaluated at second panel session.

<sup>b</sup> Traits evaluated on nine point hedonic scale for 'liking/acceptability', with 1= 'dislike extremely', 5= 'neither like nor dislike', and 9= 'like extremely'.

<sup>c</sup> Southern highbush cultivars: 'Camellia', 'Farthing', 'Star', 'Emerald', 'Sweetcrisp' and 'Legacy'.

<sup>d</sup> Rabbiteye cultivars: 'Vernon', 'Alapaha', and 'Premier'.

<sup>e</sup> Fruit was collected from commercial packers in Alma, GA.

<sup>f</sup> Values in bold are significant at ( $P \leq 0.05$ ).