Southern Region Small Fruit Consortium

Final Report Research

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Public Abstract

Muscadine grapes (*Vitis rotundifolia* Michx.) are a disease-resistant specialty crop native to the southeastern United States. There have been major advances in U.S. muscadine breeding efforts resulting in unique traits emerging, particularly new seedless cultivars, to expand commercial, fresh-market potential. A total of 17 muscadine genotypes (cultivars and andvanced breeding selections were evaluated at the University of Arkansas (UA) System Division Food Science Department. Seven genotypes (seeded) were harvested from the UA System Fruit Research Station and 10 genotypes (seedless and seeded) from a private grower in North Carolina. Approximately 1.8 kg of berries were harvested for each genotype, and fruit was shipped in clamshells from North Carolina to Arkansas for evaluation. The physical and composition attributes of the muscadines were evaluated at harvest and postharvest attributes were evaluated at 28 d storage at 2 °C. Most physical and all composition attributes of the muscadine from both locations were significantly impacted by genotype. For the physical attributes, there was a wide range of berry weights (1-14 g), seed number (0-5), stem scar tear (0-29%), berry firmness (5-11 N), and skin firmness (1-2 N/mm). In general, bronze genotypes had an L*. hue, and chroma of 42, 78, and 14, respectively, black genotypes had 25, 13, 5, respectively, and pink/red genotypes had 30, 33, and 10, respectively. Black/purple genotypes were 60% darker than bronze genotypes. For the composition attributes, there was a range of soluble solids (14-19%), pH (3-4), titratability acidity (0.3-1.1%), and soluble solids/titratable acidity ratio (16-70). The muscadines shipped from North Carolina to Arkansas had minimal weight loss (<2%) and splitting (<9%) upon arrival to Arkansas. Summit and RazzMaTazz® had the lowest splitting (<1%) after shipping, whereas Lane, Paulk and Supreme had the highest (8.76, 7.14, and 6.73%, respectfully). The larger, more firm berries tended to split more during

shipping. In terms of postharvest storage in clamshells for 28 d at 2 °C regardless of location, there was low weight loss (<9%) for the muscadine genotypes evaluated. Seven muscadine genotypes from Arkansas had good marketability (<10%) and five genotypes from North Carolina. Data generated from this project provided information on physical, composition, and postharvest attributes of muscadine grapes that can be used for developing recommendations for shipping and standards for grades, marketing, and supporting breeding efforts.

Introduction

Muscadine grapes (*Vitis rotundifolia* Michx.) are a disease-resistant specialty crop native to the southeastern United States with potential for increased fresh-market expansion. There have been major advances in U.S. muscadine breeding efforts resulting in unique traits emerging with commercial, fresh-market potential. With the release of new muscadine cultivars, particularly new seedless cultivars, there is an opportunity to strengthen the market presence for the muscadine industry.

Consumer Drivers of Quality. The evaluation of factors that drive consumer acceptance is critical to marketing muscadine grapes. Harvest, shipping, storage, and shelf-life guidelines to assist the muscadine grape industry in providing quality muscadine grapes are limited. Development of these guidelines and evaluation of postharvest performance of cultivars can assist public and private muscadine breeders across the southern United States. Advances in muscadine breeding include the development of perfect-flowered and self-fruitful cultivars, increased berry size and sugar content (Olien 1990), presence of dry picking scars (Conner 2010), improved skin and flesh texture (Conner 2013) and seedlessness. Breeding for improved skin texture is likely to broaden consumer acceptance of muscadine grapes (Brown et al. 2016; Conner 2013). Brown et al. (2016) showed that consumers familiar with muscadine grapes found skin thickness as a negative characteristic and concluded that breeding for thinner skins could increase appeal for muscadines as a fresh-market fruit. The development of seedless muscadine grapes may appeal to a broader base of consumers more familiar with table grapes. Jeff Bloodworth and Gardens Alive! have released two seedless muscadine cultivars (RazzMaTazz® and Oh My! ®), with more selections currently in evaluation and commercial production trials.

Muscadine Grape Standards. The United States Department of Agriculture Muscadine Grape Standards for Grades were established in 2006, but were modeled after bunch grapes (USDA 2020). In addition to the standards, there are shipping point and market inspection instructions and an unofficial muscadine grape visual aid. The visual aid shows a surface discoloration, a pulled stem, and spotted berries of a bronze, muscadine cultivar. Commercial growers that supply fresh-market muscadines to retail markets, have expressed concern over the outdated and limited materials available for standards, especially with the continued release of new and unique muscadine cultivars. **For fresh-market muscadines, there are not any standards specific to seedless muscadines, and the existing standards for muscadines need to be revised with more inspection instructions and expanded visual aids.**

Objectives

Extreme Temperatures and Pandemic Impact on the Project: In February 2021, extreme freezing temperatures (-15 to -25 °F) in Arkansas destroyed muscadine plants to the ground or damaged the plants for many genotypes in the UA System breeding program. In addition, a late freeze in April caused additional damage to muscadines in Arkansas. Thus, muscadine fruit from Arkansas was limited, and we were not able to ship any fruit to North

Carolina for the shipping evaluation as part of this study. The Covid-19 pandemic impacted the objectives for this project in terms of attending in-person conferences and meetings for the dissemination of content.

1. Evaluate postharvest attributes of fresh-market muscadine grapes
Measure postharvest attributes (shipping potential and marketability) of fresh-market muscadines grown in Arkansas and North Carolina
2. Evaluate physical and composition attributes of fresh-market muscadine grapes
Measure physical (berry size, color, and firmness and seed number and size) and composition (soluble solids, pH, titratable acidity, organic acids, and sugars attributes) of fresh-market muscadines grown in Arkansas and North Carolina
3. Develop recommendations for shipping and standards of fresh-market muscadine grapes
Develop recommendations for the shipping and standards of both seedless and seeded fresh-market muscadine grapes based on data and materials generated from Objectives 1 and 2.

Materials and Methods

The physical, composition, and postharvest attributes of seedless and seeded fresh-market muscadines were evaluated. Fruit from genotypes (named cultivars and advanced breeding selections) were harvested from the UA System Fruit Research Station, Clarksville on September 20, 2021 and harvested August 23, 2021 from a private commercial grower in North Carolina (Table 1). The muscadines from North Carolina were shipped to Arkansas on August 25, 2021 and arrived August 26, 2021. The seven Arkansas muscadine genotypes evaluated were AM-26 (bronze), AM-70 (pink/red), AM-77 (dark/black), AM-135 (bronze), AM-148 (dark/black), AM-154 (dark/black), and AM-240 (dark/black). The 10 North Carolina muscadine genotypes evaluated were the seedless cultivars, JB-06-30-2-20 (bronze), JB 08-38-1-10 (dark/black), JB 09-15-3-9 (pink/red), Oh My!® (bronze), and RazzMatazz® (pink/red), and the seeded cultivars, Hall (bronze), Lane (bronze), Paulk (dark/black), Summit (bronze) and Supreme (dark/black). Approximately 1.8 kg of berries (four 1-quart clamshells) were harvested for each genotype at each site. The physical, composition, and postharvest attributes of fresh-market muscadines from Arkansas and North Carolina were evaluated at the UA System Department of Food Science, Fayetteville. Photos of the grapes or clamshells of grapes were taken to document the variation in cultivars and changes during storage.

Objective 1. Evaluate postharvest attributes of fresh-market muscadine grapes

The postharvest attributes (shipping potential and marketability) of the fresh-market muscadine genotypes were evaluated. The shipping potential of the clamshells of muscadines were evaluated with shipments from North Carolina to Arkansas. For the marketability attributes, the fruit from each genotype was randomized and placed into three 1-pint containers organized as a completely randomized design with three replicates per genotype with attributes measured at harvest (day 0 or upon arrival after shipping) and after 28 days at 2°C.

Shipping potential

Muscadine grapes grown in North Carolina were shipped to Arkansas. The shipping was scheduled as overnight delivery. A shipping container with appropriate packaging to minimize muscadine fruit bruising and keep temperatures below 10 °C was used. Each genotype had two to four clamshells for small and large fruited genotypes, respectively. The clamshells of muscadines were packed in carboard/Styrofoam shipping containers with ice packs. Each clamshell was secured with a rubber band and placed in carboard trays. A non-moisture foam or

bubble wrap was used inside the container to protect the fruit during shipping. The temperature of the container was monitored with DeltaTrak FlashLink® In-Transit BLE Temperature and Humidity Logger (Model 40910, Pleasanton, CA). Evaluation of shipping potential included weight loss and splitting of the berries upon arrival.

Weight loss. The weight loss was calculated as the weight decrease of the total grapes in the clamshell prior to shipping and after shipping expressed as percent.

Splitting. The splitting (visible splitting or rupture) of the berries in the clamshell was calculated as (number of decayed or torn berries/total berries) × 100 and expressed as percent.

Marketability attributes

The marketability attributes of the grapes grown in Arkansas and North Carolina were evaluated at the UA System and included unmarketable and weight loss. Unmarketable berries and weight loss were evaluated after 28 d at 2 °C for each genotype. Photos of the grapes was be taken at harvest and during storage.

Unmarketable. The unmarketability (visible mold or rot) of the berries was calculated as (number of decayed or torn berries/total berries) × 100 and expressed as percent.

Weight loss. The weight loss of the clamshell was calculated as the weight decrease of the total grapes in the clamshell expressed as percent.

Objective 2. Evaluate physical and composition attributes of fresh-market muscadine grapes

The physical (berry size, stem scar tear, color, firmness, and seed number and seed size) and composition (soluble solids, pH, and titratable acidity) attributes of each of the fresh-market muscadines grown in Arkansas and North Carolina were evaluated at the UA System. The experiment was organized as a completely randomized design with three replicates per genotype. The physical and composition attributes were measured at harvest (day 0 or upon arrival after shipping). For muscadines that shipped from North Carolina, fruit without any shipping damage was used for this study. Samples for composition were placed in zip-type bags and stored at -10°C until analysis.

Physical attributes

Five berries per genotype and replication were evaluated for physical attributes.

Berry size. Size attributes evaluated included individual berry weight, length, and width. Each berry was weighed (g) on a digital scale, and the width (mm) and length (mm) of each berry was measured with digital calipers.

Stem scar tear. The stem scar tear (tear > 2x diameter of stem scar) of the berries was calculated as (number of torn berries/total berries) × 100 and expressed as percent.

Color. The color of the grape skins was analyzed using a Konica Minolta CR-400 Chroma Meter (Konica Minolta, Inc., Ramsey, NJ). The L*, chroma, and hue angle were evaluated using Commission Internationale de l'Eclairage (CIE) Laboratory transmission values of L* = 100, a* = 0, and b* = 0 (CIE, 1986).

Firmness. Firmness of each berry was measured using a Stable Micro Systems TA.XT.plus texture analyzer (Texture Technologies Corporation, Hamilton, MA). The berries were placed on the texture unit vertically, stem scar down. Using the 2-mm diameter probe, at a rate of 2 mm/s with a trigger force of 0.02 N, the flesh firmness and skin firmness was measured. Skin

firmness is the force required to puncture the skin of the berry divided by the distance traveled before the berry skin is ruptured and was measured in N/mm. Flesh firmness was measured consecutively as the probe enters the flesh and was measured as force in N.

Seed number and size. For genotypes with seeds or trace seeds, the seeds of each berry were removed, weighed, and counted. Total seed weight (g) was measured on a digital scale (PA224 Analytic Balance; Ohaus Corporation, Parsippany, NJ). Individual seed weight was calculated (total seed weight/number of seeds).

Composition attributes

Five to twenty-five berries (depending on the size of the berries) per genotype and replication were evaluated for composition attributes. Berries were placed in cheesecloth to extract the juice from the berries. The juice from the berry samples was used to determine composition attributes.

Soluble solids. Soluble solids (expressed as percent) of the fruit was measured using an Abbe Mark II refractometer (Bausch and Lomb, Scientific Instrument, Keene, NH).

Titratable acidity and pH. Titratable acidity and pH were measured with an automated titrimeter and electrode standardized to pH 2.0, 4.0, 7.0, and 10.0 buffers. Titratable acidity was determined using 6 mL of juice diluted with 50 mL of deionized, degassed water by titration with 0.1 N sodium hydroxide (NaOH) to an endpoint of pH 8.2; results were expressed as % tartaric acid.

3. Develop recommendations for shipping and standards of fresh-market muscadine grapes

Develop recommendations for the shipping and standards of both seedless and seeded fresh-market muscadine grapes based on data and materials generated from Objectives 1 and 2.

Statistical analysis

Analysis of physical, composition, and postharvest attributes were conducted Statistical analysis was conducted using JMP® Pro Statistical Software (version 16.0; SAS Institute Inc., Cary, NC). The study was analyzed as a completely randomized design with three replicates per genotype. A univariate analysis of variance (ANOVA) was used to determine the significance of the main factors. Tukey's Honest Significant Difference test or Student's T test were used to detect differences among means ($p<0.05$).

Results and Discussion

Objective 1. Evaluate postharvest attributes of fresh-market muscadine grapes

Shipping potential

The muscadines shipped from North Carolina to Arkansas had minimal weight loss (<2%) (data not shown). The muscadines shipped from North Carolina had <9% splitting upon arrival to Arkansas (Fig. 1). Summit and RazzMaTazz® had the lowest percent (<1%) of berries splitting after shipping from North Carolina to Arkansas, whereas Lane, Paulk and Supreme had the highest (8.76, 7.14, and 6.73%, respectfully). Supreme was the largest (about 14 g) and firmest (11 N) which probably resulted in higher tendency to split.

Marketability attributes

The weight loss and unmarketability attributes for muscadines from both locations were significantly impacted by genotype (Table 2). Regardless of location, there was low weight loss

(<9%) for the muscadine genotypes evaluated. In terms of marketability, only one genotype from Arkansas (AM-70) and two from North Carolina (Hall and JB-08-38-1-10) had high unmarketable berries (22-37%). Seven muscadine genotypes from Arkansas had good marketability (<10%) and five genotypes from North Carolina. For Arkansas muscadines, weight loss was < 9% and unmarketability < 23%. AM-26 (5.06%) had the lowest weight loss. AM-70 the highest unmarketability (22.54%) and weight loss (8.66%). AM-148 and AM-154 had no unmarketable berries. For North Carolina muscadines, weight loss < 9% and unmarketability < 37%. JB-09-15-3-9 (8.55%) had the highest weight loss and Hall (3.97%) had the lowest. Hall (34.80%) had the highest unmarketability and RazzMatazz® (1.70%) had the lowest.

Objective 2. Evaluate physical and composition attributes of fresh-market muscadine grapes

Physical attributes

The berry size, stem scar tear, and berry firmness attributes of the muscadine skins from both locations were significantly impacted by the genotype, but seed number and weight of muscadines from North Carolina were not significantly impacted by genotype (Table 3). For the muscadines from Arkansas, AM-135 had the highest berry weight (13.88 g) and length (29.88) and lowest berry firmness (7.90 N). AM-77 had the lowest berry weight (5.67 g), length (20.83 mm), berry width (20.76 mm) and skin firmness (1.21 N/mm), but the highest berry firmness (10.78 N). AM-148 had no stem scar tear. The genotypes had 2-5 seeds with seed weights of 0.2-0.4 g). For the North Carolina muscadines, Supreme had the highest berry weight (14.41 g), length (27.59 mm), width (28.10 mm), stem scar tear (29.42%), berry firmness (11.03 N), and skin firmness (1.67 N/mm). RazzMatazz® had the lowest berry weight (1.12 g), length (11.17 mm), width (10.56 mm), stem scar tear (1.88%), berry firmness (4.98 N), and skin firmness (0.77 N/mm). The genotypes JB-06-30-2-20, JB-09-15-3-9. Oh My!® and RazzMatazz® had no seeds present.

The color attributes of the muscadine skins from both locations were significantly impacted by the genotype (Table 4). Among the genotypes grown in Arkansas and North Carolina there was a range values for L* (24.38-52.15 and 23.59-47.13, respectively), chroma (2.47-17.59 and 2.69-17.22, respectively), and hue (8.28-88.91 and 6.67-102.86, respectively). For Arkansas-grown grapes, AM-77 had the lowest L* and chroma, AM-135 had the highest L* and chroma, AM-26 had the highest hue. In general, bronze genotypes had an L*, hue, and chroma of 42, 78, and 14, respectively, black genotypes had 25, 13, 5, respectively, and pink/red genotypes had 30, 33, and 10, respectively. So, black genotypes were about 60% darker than bronze genotypes in terms of the L* value.

Composition attributes

The composition of the muscadines from both locations were significantly impacted by genotype (Table 4). For the muscadines from Arkansas, AM-135 had the highest soluble solids (19.47%) and soluble solids/titratable acidity ratio (70.31). AM-240 had the highest pH (3.98). AM-77 had the highest titratable acidity (0.88%) and lowest pH (3.04) and soluble solids/titratable acidity ratio (16.06). For the muscadines from North Carolina, Summit had the highest soluble solids (18.60%) and soluble solids/titratable acidity ratio (37.66). Lane had the highest pH (3.55) and lowest titratable acidity (0.47%). RazzMatazz® had the highest titratable acidity (1.13%) and lowest soluble solids/titratable acidity ratio (16.16).

Objective 3. Develop recommendations for shipping and standards of fresh-market muscadine grapes

These seeded and seedless muscadine genotypes from Arkansas and North Carolina had high diversity in the physical and composition attributes, but showed great potential for postharvest storage after 28 d at 2 °C. The minimal weight loss and splitting of these muscadine genotypes harvested in North Carolina and shipped to Arkansas showed the potential for shipping as a fresh-market industry. Further work with this data is needed to expand recommendations for the shipping and standards of muscadine grapes.

Conclusions

The physical and composition attributes of 17 muscadine genotypes from Arkansas and North Carolina were evaluated at harvest and postharvest attributes were evaluated after 28 d storage at 2 °C. The muscadines shipped from North Carolina to Arkansas had minimal weight loss (<2%) and splitting (<9%) upon arrival to Arkansas with a tendency of the larger, more firm berries to split. These seeded and seedless muscadine genotypes from Arkansas and North Carolina had high diversity in the physical and composition attributes, but showed potential for postharvest storage. In terms of postharvest storage of the muscadines from both locations, there was low weight loss (<9%), and good marketability (<10%) for seven genotypes from Arkansas and five genotypes from North Carolina. The minimal weight loss and splitting of these muscadine genotypes harvested in North Carolina and shipped to Arkansas showed the potential for shipping as a fresh-market industry. Data generated from this project provided information on physical, composition, and postharvest attributes of muscadine grapes that can be used for developing recommendations for shipping and standards for grades, marketing, and supporting breeding efforts.

Impact Statement

This collaborative research from the University of Arkansas System Division of Agriculture (UA System) and North Carolina State University (NCSU) generated data that can be used to **develop recommendations for the shipping and standards for grades of fresh-market seedless and seeded muscadine grapes** by evaluating the physical, composition, and postharvest attributes. Ten muscadine genotypes from North Carolina and seven from Arkansas were evaluated. The data on fresh-market muscadines from this study will be used for presentations at regional and national conferences in 2022, a UA System Food Science Department Master's student thesis, and a journal publication. The outcomes from this research can provide an economic boost for the muscadine industry, as well as increase local agritourism and local food systems.

Literature Cited

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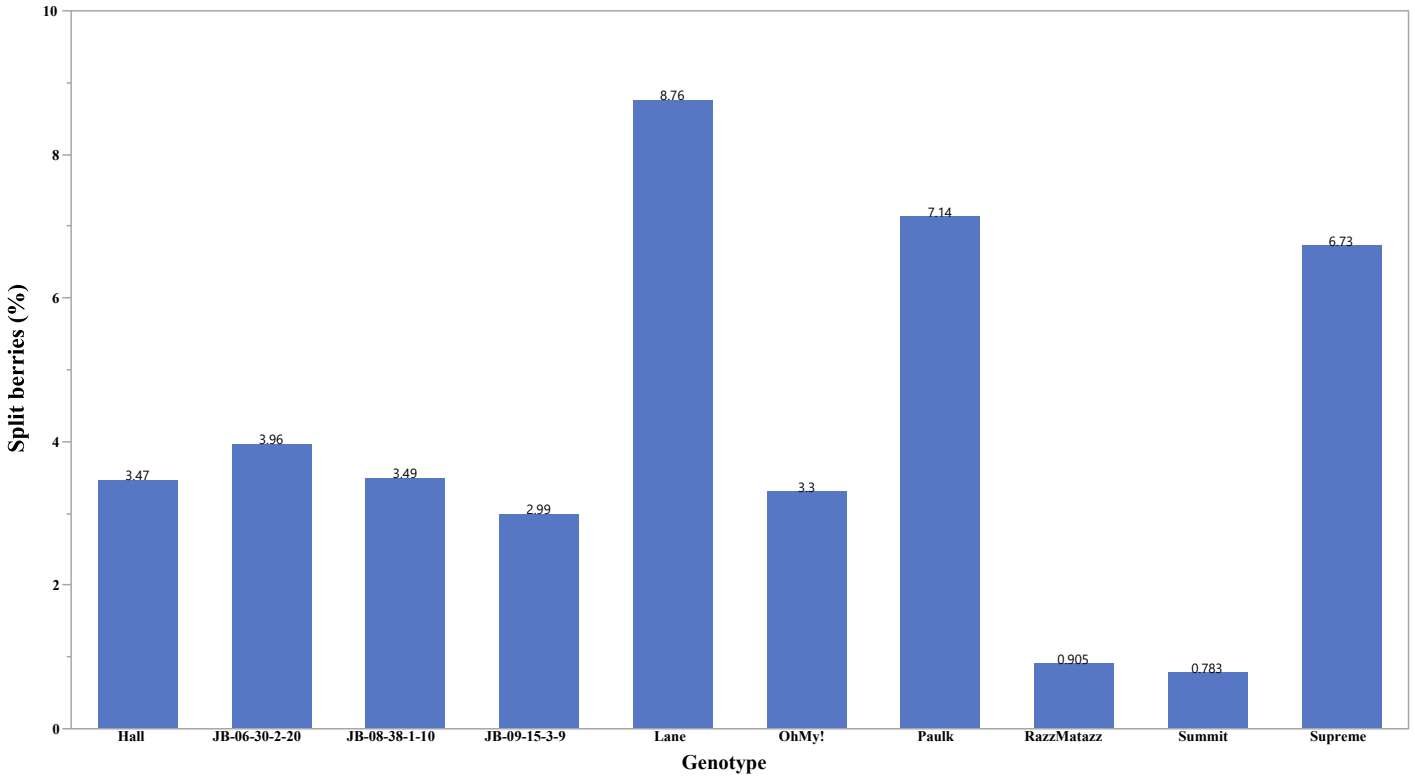

Figure 1. Percent of split berries after shipping muscadine genotypes harvested from Kings Mountain, NC to Fayetteville, AR (2021).

Table 1. Muscadine grapes grown in Arkansas and North Carolina and evaluated at the University of Arkansas System Division of Agriculture (2021).

Location and genotype	Skin color	Seeds
Arkansas		
AM-26	Bronze	Seeded
AM-70	Pink/red	Seeded
AM-77	Dark/black	Seeded
AM-135	Bronze	Seeded
AM-148	Dark/black	Seeded
AM-154	Dark/black	Seeded
AM-240	Dark/black	Seeded
North Carolina		
Hall	Bronze	Seeded
JB-06-30-2-20	Bronze	Seedless
JB 08-38-1-10	Dark/black	Seedless
JB-09-15-3-09	Pink/red	Seedless
Lane	Bronze	Seeded
Oh My!®	Bronze	Seedless
Paulk	Dark/black	Seeded
RazzMaTazz®	Pink/red	Seedless
Summit	Bronze	Seeded
Supreme	Dark/black	Seeded

Table 2. Marketability attributes for muscadine genotypes stored at 2°C at 28 days, Clarksville, AR and Kings Mountain, NC (2021)

Location and genotype [z]	Weight loss (%)	Unmarketable (%)
Arkansas		
AM-26	5.06 d	1.75 b
AM-70	8.66 a	22.54 a
AM-77	7.10 b	2.35 b
AM-135	6.26 bc	1.85 b
AM-148	5.30 bc	0.00 b
AM-154	8.08 a	0.00 b
AM-240	5.82 cd	9.18 ab
P-value	*<0.0001*	*0.0008*
North Carolina		
Hall	3.97 c	37.09 a
JB-06-30-2-20	6.71 ab	9.91 bcd
JB-08-38-1-10	6.59 ab	34.80 a
JB-09-15-3-9	8.55 a	15.18 bc
Lane	5.09 bc	8.28 bcd
Oh My!®	6.75 ab	2.63 cd
Paulk	7.06 ab	16.32 b
RazzMatazz®	6.04 bc	1.70 d
Summit	6.76 ab	16.36 b
Supreme	5.28 bc	6.02 bcd
P-value	*0.0323*	*<0.0001*

[z] Genotypes were evaluated in triplicate. Means highlighted are highest value and means underlined are lowest. Means with different letters for each attribute within location are significantly different ($p<0.05$) using Tukey's Honestly Significant Difference test.

Table 3. Physical attributes of muscadine genotypes at harvest, Clarksville, AR and Kings Mountain, NC (2021)

Location and genotype [z]	Berry weight (g)	Berry length (mm)	Berry width (mm)	Seed number	Seed weight (g)	Stem scar tear (%)	Berry firmness (N)	Skin firmness (N/mm)
Arkansas								
AM-26	11.08 bc	27.49 b	25.57 ab	2.33 a	0.24 a	3.03 bc	9.68 ab	1.53 ab
AM-70	13.50 ab	27.62 b	27.86 a	2.00 a	0.22 a	11.55 abc	10.04 ab	1.51 ab
AM-77	5.67 d	20.83 c	20.76 c	4.00 a	0.41 a	10.83 abc	10.78 a	1.21 c
AM-135	13.88 a	29.88 a	27.49 a	4.67 a	0.32 a	8.77 abc	7.90 c	1.31 bc
AM-148	11.86 abc	28.16 ab	26.30 a	2.33 a	0.33 a	0.00 c	8.65 bc	1.42 abc
AM-154	9.61 c	27.38 b	23.74 b	2.00 a	0.18 a	22.60 a	8.74 bc	1.65 a
AM-240	13.49 ab	29.14 ab	27.69 a	3.00 a	0.26 a	16.84 ab	10.21 a	1.55 ab
P-value	*<0.0001*	*<0.0001*	*<0.0001*	*0.0307*	*0.1048*	*0.0038*	*<0.0001*	*0.0003*
North Carolina								
Hall	10.07 b	24.02 b	24.52 b	1.33 bcd	0.09 bc	28.05 ab	9.17 b	1.12 bc
JB-06-30-2-20	3.55 de	17.54 cd	16.51 cd	0.00 d	0.00 c	24.33 abc	6.62 c	0.78 d
JB-08-38-1-10	2.72 de	15.25 d	15.24 d	2.33 abc	0.03 bc	6.39 cd	8.59 b	1.12 bc
JB-09-15-3-9	4.29 de	18.24 cd	17.46 cd	0.00 d	0.00 c	9.26 bcd	8.89 b	1.31 bc
Lane	9.35 b	23.90 b	23.79 b	3.00 ab	0.22 a	19.86 abcd	8.94 b	1.27 bc
Oh My!®	5.87 cd	19.46 c	19.75 c	0.00 d	0.00 c	13.72 abcd	9.59ab	1.36 b
Paulk	8.96 bc	23.02 b	23.35 b	3.67 a	0.06 bc	15.84 abcd	8.90 b	1.03 cd
RazzMatazz®	1.12 e	11.17 e	10.56 e	0.00 d	0.00 c	1.88 d	4.98 c	0.77 d
Summit	9.85 b	23.54 b	24.42 b	1.33 bcd	0.13 ab	13.14 abcd	9.89 ab	1.34 b
Supreme	14.41 a	27.59 a	28.10 a	1.00 cd	0.09 bc	29.42 a	11.03 a	1.67 a
P-value	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*0.0005*	*<0.0001*	*<0.0001*

[z] Genotypes were evaluated in triplicate. Means highlighted are highest value and means underlined are lowest. Means with different letters for each attribute within location are significantly different ($p<0.05$) using Tukey's Honestly Significant Difference test.

Table 4. Composition and color attributes of muscadine genotypes at harvest, Clarksville, AR and Kings Mountain, NC (2021)

Location and genotype [z]	Soluble solids (%)	pH	Titratable acidity (%)[y]	Soluble solids/titratable acidity ratio	L*	Hue	Chroma
Arkansas							
AM-26	16.23 b	3.62 b	0.50 b	32.65 b	42.17 b	88.91 a	13.97 b
AM-70	18.90 a	3.89 a	0.29 c	66.06 a	25.62 cd	8.28 c	3.89 cd
AM-77	14.00 c	3.04 c	0.88 a	16.06 b	24.38 d	19.65 b	2.47 d
AM-135	19.47 a	3.89 a	0.28 c	70.31 a	52.15 a	81.17 a	17.59 a
AM-148	16.30 b	3.67 b	0.54 b	30.53 b	25.59 cd	15.06 bc	3.81 cd
AM-154	16.93 b	3.58 b	0.25 c	68.92 a	27.53 c	14.07 bc	13.19 b
AM-240	16.87 b	3.98 a	0.26 c	64.93 a	24.60 d	15.06 bc	5.13 c
P-value	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
North Carolina							
Hall	15.23 c	3.40 ab	0.48 bc	31.67 ab	47.13 a	93.51 b	17.22 a
JB-06-30-2-20	17.63 a	2.95 d	0.56 bc	31.50 ab	45.99 a	102.86 a	17.04 a
JB-08-38-1-10	14.40 c	3.01 d	0.56 bc	25.76 bc	23.59 c	10.61 e	2.69 d
JB-09-15-3-9	17.30 ab	3.24 bc	0.61 bc	28.53 b	38.05 b	70.58 c	10.28 bc
Lane	14.87 c	3.55 a	0.47 c	32.12 ab	24.62 c	10.03 e	3.55 d
Oh My!®	15.77 bc	3.09 cd	0.78 b	20.18 cd	44.21 a	97.34 ab	13.61 ab
Paulk	15.00 c	3.32 b	0.58 bc	25.94 bc	25.01 c	6.67 e	5.47 cd
RazzMatazz®	17.40 ab	2.98 d	1.13 a	16.16 d	25.58 c	20.95 d	16.12 ab
Summit	18.60 a	3.29 b	0.50 bc	37.66 a	40.76 b	72.51c	16.23 ab
Supreme	15.47 c	3.27 b	0.56 bc	27.77 bc	24.60 c	12.83 e	3.26 d
P-value	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*

[z] Genotypes were evaluated in triplicate. Means highlighted are highest value and means underlined are lowest. Means with different letters for each attribute within location are significantly different ($p<0.05$) using Tukey's Honestly Significant Difference test.
[y] Titratable acidity expressed as % tartaric acid.