Title of Project: Determining Marketable Attributes of University of Arkansas Fresh-market Muscadine Grapes

Progress Report

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Research Proposal

Name(s), mailing and email address(s) of principal investigators

Principal Investigator:
Dr. Renee Threlfall, Research Scientist, Institute of Food Science and Engineering, 2650 N. Young Ave., University of Arkansas, Fayetteville, AR 72704, rthrelf@uark.edu
Co-Principal Investigators:
Dr. John R. Clark, Distinguished Professor, Department of Horticulture, 316 Plant Science Building, University of Arkansas, Fayetteville, AR 72701, jrclark@uark.edu
Dr. Margaret Worthington, Assistant Professor, Department of Horticulture, 316 Plant Science Building, University of Arkansas, Fayetteville, AR 72701, mlworthi@uark.edu

Objectives

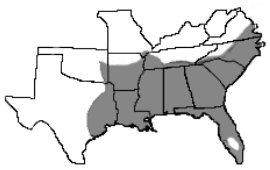
1. Identify descriptive sensory attributes of fresh-market muscadine grapes from the University of Arkansas Fruit Breeding Program
2. Determine physiochemical attributes of fresh-market muscadine grapes from the University of Arkansas Fruit Breeding Program
3. Correlate the sensory and physiochemical data to determine key relationships between the attributes

Justification

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 that have resulted in unique traits emerging with commercial, fresh-market potential. With the imminent release of new muscadine cultivars, there is an opportunity to strengthen the market presence for the muscadine industry as a southern region crop. This collaborative research from the University of Arkansas will **determine marketable attributes for fresh-market muscadine grapes** by providing information on the sensory and physiochemical attributes that drive marketability and address challenges that face the muscadine industry. This project is expected to establish a descriptive sensory lexicon and marketable attributes for fresh-market muscadine grapes and determine correlations between sensory and physiochemical attributes, leading to an economic boost for the muscadine industry, local agritourism and local food systems, as well as improving the standards for fresh-market muscadines.

Muscadine Grape Production. The genus *Vitis* is divided into *Euvitis* (bunch grapes) and *Muscadinia* (muscadine grapes). In the three species of *Muscadinia*, only *V. rotundifolia* is cultivated commercially. In the southern region, states with total grape production of over 500

acres include Arkansas (747 acres), Florida (916 acres), Georgia (1,646 acres), Mississippi (652 acres), North Carolina (3,185 acres) and Texas (3,835 acres) (USDA 2007). Although there is limited data on the percent of muscadine grapes as part of total U.S. grape production, substantial promise for expansion of muscadine production for fresh market, processing and value-added products exists.



Muscadine Grape Cultivars. Muscadines differ from bunch grapes because they have smaller clusters, the berries abscise (shatter) at maturity, the tendrils are unbranched, and they have 40 chromosomes as compared to 38 chromosomes of *Euvitis*. Muscadine clusters typically contain 6 to 24 berries. Muscadine cultivars are primarily classified by color, with bronze or black as the two prevalent color types (Carter et al. 2001, Conner 2010, Mortensen 2001).

Muscadine Grape Breeding. There are public and private muscadine breeding programs across the southern United States. Major advances in muscadine breeding have included the development of perfect-flowered and self-fruitful cultivars (Lane 1997), increased berry size and sugar content (Olien 1990), presence of dry picking scars (Conner 2010) and the introduction of a seedless muscadine grape (Gray et al. 2011). The introduction of a seedless muscadine grape will appeal to consumers more familiar with table grapes. Other important traits undergoing development include more cultivars with perfect flowers and large fruit, improved textures, thinner skins, seedlessness, a broader range of ripening dates and an expansion of the germplasm base used in muscadine breeding. The University of Arkansas Fruit Breeding Program has a focus on muscadine breeding with many cultivars with unique traits. These continued breeding efforts result in better grape quality for consumers and increased cultivar options and markets for growers.

Standards for Grades of Muscadines. The United States Standards for Grades of Muscadine Grapes were established in 2006, but were modeled after bunch grapes. In terms of quality, the muscadine grapes must "meet good soluble solids and the basic requirements for berries (similar varietal characteristics, mature, well colored, clean, not excessively soft, not dried, not excessively wet from juice or not crushed, split or leaking). Grapes must also be free from decay, mold, damage, or overripe". The quality of the fresh-market muscadines can vary greatly and impact the potential post-harvest storage and consumer expectations for repeat purchases.

Physiochemical Components of Muscadines. Muscadine berries offer a healthy fruit choice for consumers and a marketing opportunity for producers. A 10-berry serving of muscadines has 16% of the recommended daily fiber intake and 13 to 14% of vitamin C (USDA-ARS 2011). In addition, muscadine grapes contain many health bioactive compounds, including resveratrol, ellagic acid, anthocyanins and proanthocyanidin phenolic compounds (Barchenger et al. 2014a, 2014b, 2015a, 2015b, Ector et al. 1996, 2001, Pastrana-Bonilla et al. 2003, Threlfall et al. 2005). Anthocyanins are highest in muscadine skin and dark-colored berries (Striegler et al. 2005).

Consumer and Descriptive Sensory of Muscadine Grapes/Products. There are few harvest, sensory, storage and shelf-life guidelines to assist the muscadine grape industry in providing quality muscadine grapes and their products. The evaluation of factors that drive consumer acceptance is critical to the marketing of new products. A recent consumer sensory study at the University of Florida showed that consumer panelists 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 (Brown et al. 2016). For fresh-market muscadines and juice, the initial taste perception of sweetness, in particular the soluble solids/acid ratio, is a key aspect for sensory acceptability. The optimum soluble solids/acid ratio for whole muscadine grapes is 28 to 30 (Flora 1979, Walker et al. 2001). Threlfall et al. (2007) developed a sensory lexicon for muscadine juice from different cultivars with major descriptive attributes including sweet, sour, cooked muscadine, cooked grape and astringent. Other than these few sensory attributes, descriptions and characteristics of the flavor components of fresh muscadines and muscadine products need to be done.

Methodologies

Harvest

Muscadines were harvested from the University of Arkansas Fruit Research Station in Clarksville, AR. Approximately 2.2 kg of fruit of each genotype were harvested in September. The fruit was harvested prior to 10 am and then transported in coolers to the Food Science Department, Fayetteville, AR where the muscadines were randomly selected and placed into 453 g-vented clamshells. The fruit was stored at 2 °C and 90 ± 5% RH overnight for sensory analysis. The genotypes evaluated in this study included three advanced selections (AM-9, AM-74, AM-83) and three cultivars (Ison, Nesbitt and Summit).

Descriptive Sensory Analysis

Descriptive sensory analysis of the six fresh-market muscadine grape genotypes was conducted at the Sensory Research and Consumer Center, in the Food Science Department at the University of Arkansas. The descriptive panelists (n=8) developed a fresh-market muscadine lexicon of sensory terms through consensus during orientation sessions. The panelists used a modified Sensory Spectrum® method, an objective method for describing the intensity of attributes in products using references for the attributes. The panelists were served five berries per genotype. The descriptive panel identified fresh-market muscadine attributes for appearance, basic tastes, feeling factors, aromatics, texture and uniformity of sample and evaluated those attributes using a 15-point scale (0=less of an attribute, 15=more of an attribute).

Physiochemical Analysis

Approximately 250 g of berries were placed in freezer bags for each muscadine genotype in triplicate. Color, firmness, and berry attributes were measured on grapes prior to freezing. The grapes for the other physiochemical analysis were placed in plastic storage bags and stored at -20°C until analyses. Physiochemical analysis was done on three to five berries in triplicate per genotype.

Color . Exterior skin color measurements were determined on each whole berry using a Chroma Meter CR 400 series (Konica Minolta Holdings Inc., Ramsey, NJ). The Commission Internationale de I'Eclairage Laboratory transmission ''L*'' value indicates how dark or light the skin is with 0 being black and 100 being white. Hue angle describes color in angles from 0_ to 360_: 0_ =red; 90_ = yellow; 180_ = green; 270_ = blue; and 360_ = back to red. Chroma is the aspect of color by which the skin colors appear different from gray of the same lightness and corresponds to intensity of the perceived color.

Firmness. Firmness, or the maximum force to penetrate skin and flesh tissues, was determined on each whole berry. Elasticity, or distance to skin penetration, was also determined. A TA-XT2 Texture Analyzer (Stable Micro Systems, Haslemere, UK) with a 2-mm-diameter probe was used to penetrate the skin and mesocarp tissues (flesh) to a depth of 15 mm in each berry at a rate of 1 mm.s-1 with a trigger force of 0.05 N. Measurements of flesh and skin firmness were expressed as force in Newtons (N) and elasticity was expressed a distance in millimeters (mm). The data was analyzed using Texture Expert Version 1.17 (Texture Technologies Corp., Scarsdale, NY).

Berry attributes. Berry attributes (individual berry weight, berry length, and berry width) and seed attributes (number/berry and weight/berry) were measured. The berries were weighed on a digital scale and the width and height of each grape were measured with digital calipers. To determine seed attributes, seeds were extracted from the grapes and placed onto paper towels and dried at ambient temperature (21°C) for 1.5 hours. The seeds for each three-berry sample were counted, weighed, and measured.

Soluble solids, pH, and titratable acidity. The soluble solids, pH, and titratable acidity of the berries were evaluated. Samples were thawed and placed in cheesecloth to extract the juice from the berries. Titratable acidity and pH were measured with an automated titrometer 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 g/L tartaric acid. Total soluble solids (expressed as %) was measured.

Sugar and acid analysis. Organic acids and sugars were determined using HPLC. Glucose, fructose, and citric, tartaric, malic, succinic and lactic acids of the muscadine were measured using procedures described in Walker et al. 2003. The HPLC was equipped with a Bio-Rad HPLC Organic Acid Analysis Aminex HPX-87H ion exclusion column (300 x 7.8 mm) and a Bio-Rad HPLC column (150 x 7.8 mm) in series. A Bio-Rad Micro-Guard Cation-H refill cartridge (30 x 4.5 mm) was used for a guard column. The peaks were quantified using external standard calibration based on peak height estimation with baseline integration.

Correlations

Determining correlations between the sensory and physiochemical data will be critical especially with the advancement of "crispy" muscadines selections to determine if berry firmness will be correlated with descriptive sensory attributes related to texture (particularly skin thickness). Analyses will be conducted using JMP® (version 12.0; SAS Institute Inc., Cary, NC). Tukey's HSD (Honestly Significant Difference) will be used for mean separation. Pearson's correlation will be used to test the relationship between/within attributes. The correlations of the data and other statistical analysis are in progress and will be completed by April 2018.

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Results

Table. 1. Descriptive sensory lexicon for fresh-market muscadine grapes.

TERM	DEFINITION	TECHNIQUE	REFERENCE
AROMA (5 WHOLE BERRIES)			
GRAPE-OVERALL	Smell associated with fresh grapes	Fresh grapes	Intensities based on Universal Scale: Saltine 3.0 Applesauce 7.0 Orange Juice 10.0 Grape Juice 14.0 Big Red Gum 15.0
GRAPE-MUSCADINE	Smell associated with fresh muscadine	Ripe muscadine	Intensities based on Universal Scale
GRAPE-OTHER	Smell associated with other grape species	Any grape aroma other than muscadine i.e. concord	Intensities based on Universal Scale
FRUITY	Smell associated with fruits other than grapes		Intensities based on Universal Scale
FLORAL	Smell associated with floral aromas		Intensities based on Universal Scale
EARTHY/DIRTY	Smell associated with damp soil or wet foliage	Damp potting soil	Intensities based on Universal Scale
GREEN/UNRIPE	Smell associated with freshly cut green vegetation; unripe	Unripe banana	Intensities based on Universal Scale
MOLD/MILDEW	Smell associated with moldy or mildew aromas	Old mildewed clothes	Intensities based on Universal Scale
OVERRIPE	Smell associated with overripe aromas		Intensities based on Universal Scale
APPEARANCE (EXTERIOR OF WHOLE BERRY)			
UNIFORMITY OF COLOR	The ratio of uniformity of color on the exterior of the muscadines Place stems down.	Observe the five berries and rate the degree to which the sample in uniform in color. **(Un-uniform---Uniform)**	Ratio of color uniformity 0%=0, 50%=7.5, 100%=15
COLOR- PURPLE	The intensity of purple of the sample	Observe the sample and rate the degree to which the sample is purple in appearance. **(Light---Dark)**	187A=8.0 Greyed-Purple Group Royal Horticultural Society Colour Chart
COLOR- BRONZE	The intensity of bronze of the sample	Observe the five berries and rate the degree to which the sample is bronze in appearance. **(Light---Dark)**	161 A=8.0 Greyed-Yellow Group Royal Horticultural Society Colour Chart
GLOSSINESS	The degree to which the surface of the berry shines.	Observe the sample and determine the degree to which the surface shines.	Copy paper 3.0 Photo Paper 15.0

		(Dull--Wet/Shiny)	
UNIFORMITY OF SIZE	The ratio of uniformity of size	Observe the five berries and rate the degree to which the sample in uniform in size. **(Un-uniform---Uniform)**	Ratio of size uniformity 0%=0, 50%=7.5, 100%=15
SIZE OF MUSCADINE	The visual size of the sample	Observe the five berries and determine the overall size of the sample. **(Small---Large)**	Photo reference of size of circles A=15.0 (1.5 inches) B=11.0 (1.25 inches) C=7.5 (1.0 inches) D-4.0 (0.75 inches) E=1.0 (0.5 inches)
SHAPE OF MUSCADINE	The visual shape of the sample	Observe the five berries and determine the overall shape of the sample. **(Oval---Round)**	Egg/oval=5.0 2.5-inch ball =15.0
AMOUNT OF BLEMISHES/ DEFORMITIES	The visual ratio of blemishes/deformities on the sample	Observe the five berries and determine the amount of blemishes/deformities on the surface **(None---Much)**	Ratio of blemishes and deformities 0%=0, 50%=7.5, 100%=15
STEM SCAR TEAR	The visual presence of tear of the stem scar	Observe the five berries and determine the numbers of berries with a tear at the scar bigger than the scar	Number of berries with tears
USING A KNIFE, CUT ONE MUSCADINE IN HALF, LEAVING THE REMAINING FOUR BERRIES INTACT. EXTRACT THE SEEDS WITH THE TIP OF THE KNIFE.			
APPEARANCE (PULP OF BERRY HALF)			
VISUAL SEPARATION	Detachability of pulp from skin of berry	Squeeze half of berry and observe the extent of which the pulp detaches from the skin **(None---Much)**	None=0 Much-15.0
AMOUNT OF SEEDS	The number of seeds in the whole berry	Count the number of seeds in the whole berry	Number of seeds
SEED SIZE	The visual size of the seeds	Observe the seeds and determine the overall size. **(Small---Large)**	Photo reference of size A=12 (5.3 x 8.5 mm) B=7 (4.9 x 7.1 mm) C=3 (3.9 x 6.1 mm)
BASIC TASTES (FOUR BERRIES, INITIAL IMPACT DOES NOT INCLUDE SKINS OR SEEDS)			
SWEET	The basic taste, perceived on the tongue, stimulated by sugars and high potency sweeteners.	Solutions of sucrose in spring water.	2% 2.0 5% 5.0 10% 10.0 16% 15.0
SOUR	The basic taste, perceived on the tongue, stimulated by acids, such as citric acid	Solutions of citric acid in spring water.	0.05% 2.0 0.08% 5.0 0.15% 10.0 0.20% 15.0

BITTER	The basic taste, perceived on the tongue, stimulated by sugars and high potency sweeteners.	Solutions of caffeine in spring water.	0.05% 2.0 0.08% 5.0 0.15% 10.0 0.20% 15.0
AROMATICS			
OVERALL AROMATIC IMPACT	The overall impact of all aromatics in the muscadine grape		Intensities based on Universal Scale
GRAPE OVERALL	Aromatic associated with fresh grapes	Fresh grapes	Intensities based on Universal Scale
GRAPE-MUSCADINE	Aromatic associated with fresh muscadine	Ripe muscadine	Intensities based on Universal Scale
GRAPE-OTHER	Aromatic associated with other grape species	Any grape aroma other than muscadine i.e. concord	Intensities based on Universal Scale
FRUITY	Aromatic associated with fruity aromas		Intensities based on Universal Scale
FLORAL	Aromatic associated with floral aromas		Intensities based on Universal Scale
GREEN/UNRIPE	Aromatic associated with damp soil or wet foliage	Damp potting soil	Intensities based on Universal Scale
EARTHY/DIRTY	Aromatic associated with freshly cut green vegetation; unripe	Unripe banana	Intensities based on Universal Scale
MOLD/MILDEW	Aromatic associated with moldy or mildew aromas	Old mildewed clothes	Intensities based on Universal Scale
OVERRIPE	Aromatic associated with overripe fruit.	Over ripened fruit	Intensities based on Universal Scale
UNIFORMITY OF FLAVOR	The ratio of uniformity of flavor	Taste the four berries and rate the degree to which the sample in uniform in flavor. **(Un-uniform----- Uniform)**	Ratio of flavor uniformity 0%=0, 50%=7.5, 100%=15
FEELING FACTORS			
ASTRINGENT	The feeling factor on the tongue or other skin surfaces of the mouth described as puckering or drying.	Chew sample to point of swallow, expectorate and feel surfaces of the mouth. Swish references in mouth, swallow or expectorate and wait 5 seconds.	A-9= 6.0 (0.53 g alum/500mL water) **Swish, expectorate wait 5 seconds.**
METALLIC	Aromatic associated with metals, tinny or iron or a flat chemical feeling stimulated on the tongue by metal coins	Tin foil to bite on	Intensities based on Universal Scale
TEXTURE (WHOLE BERRY)			

BERRY HARDNESS	The force required to compress the sample.	Place the sample in the mouth. Compress or bite through the sample one time with molars or incisors. **(Soft-----Hard)**	Cream Cheese 1.0 Egg White 2.5 Am Cheese 4.5 Beef Frank 5.5 Olive 7.0 Peanut 9.5 Almond 11.0
MOISTURE RELEASE	The amount of wetness or moistness felt in the mouth after one bite or chew.	Compress the sample with molars one time only. **(Dry-----Wet)**	Banana 1.0 Carrot 2.0 Mushroom 4.0 Snap Beans 7.0 Cucumber 8.0 Apple 10.0 Honeydew 12.0 Orange 15.0 **(Chew refs 5 times)**
AWARNESS OF SKINS	How aware are you of the skins during mastication of the sample.	Place sample in mouth and chew 3-5 times. Can also be evaluated in first bite stage. **(None-----Much)**	Baked Beans 4.0 Medium Lima Beans 8.0
PULP CRISPNESS	Unique, strong, clean, and acute sound produced in first bite of the food with incisors and open lips.	Place the sample in the mouth. Compress or bite through the sample one time with molars or incisors. Evaluate the sound intensity produced at the first bite. **(None-----Much)**	Ripe Banana 0.0 Granny Smith Apple 7.5 Carrot 15.0
DETACHABILITY	The ease with which the pulp separates from the skin of the berries	Place the sample in the mouth. Compress or bite through the sample one time with molars or incisors. Evaluate the ease that the pulp separates from the skin. **(None-----Much)**	None=0.0 Much=15.0
FIBROUSNESS BETWEEN TEETH	The amount of grinding of fibers required to chew through the sample. (Not including skins)	Place sample between molars and chew 3-5 times. **Evaluate during chewing, but ignore the skin.** **(None-----Much)**	Apple 2.0 Apricot 5.0 Salami 7.0 Celery 9.0 Toasted Oats (4-5) 10.0 Bacon 12.0 Beef Jerky 20.0
SEED SEPARATION	The ease with which the seeds separate from the pulp of the berry	Manipulate the pulp in the mouth for ease to separate seeds from pulp.	None=0.0 Much=15.0
UNIFORMITY OF BERRY HARDNESS	The ratio of uniformity of hardness	Observe the four berries and rate the degree to which the sample in uniform in hardness. **(Un-uniform----- Uniform)**	Ratio of size uniformity 0%=0, 50%=7.5, 100%=15

Table 2. Descriptive sensory aroma attributes for muscadine genotypes evaluated on a 15-point scale (0=less of the attribute and 15=more of the attribute in terms of intensity), Clarksville, AR 2017.

Genotype [z]	Grape overall	Grape muscadine	Grape other	Fruity	Floral	Earthy/ dirty	Green/ unripe	Mold/ mildew
AM-9	4.6 b	5.2 ab	0.2 a	1.0 a	0.6 a	0.8 a	0.2 a	0.8 a
AM-74	6.1 a	6.4 a	0.2 a	0.7 ab	0.7 a	0.2 a	0.6 a	0.4 a
AM-83	0.7 d	0.5 d	0.2 a	0.0 c	0.2 a	0.8 a	0.0 a	0.6 a
Ison	3.5 c	3.4 c	0.0 a	0.4 abc	0.4 a	0.2 a	0.6 a	0.6 a
Nesbitt	4.1 bc	4.1 bc	0.2 a	0.3 bc	0.6 a	0.6 a	0.6 a	0.6 a
Summit	5.8 a	5.9 a	0.4 a	0.7 ab	0.8 a	0.4 a	0.5 a	0.6 a
P value	<0.0001	<0.0001	0.8550	0.0330	0.3880	0.1440	0.1620	0.873

[z] Trained descriptive panel (n=8) evaluated five berries per genotypes in duplicate. Means with different letter(s) for each attribute are significantly different ($p < 0.05$) using LSD.

Table 3. Descriptive sensory appearance attributes for muscadine genotypes evaluated on a 15-point scale (0=less of the attribute and 15=more of the attribute in terms of intensity), Clarksville, AR 2017.

Genotype [z]	Color purple	Color bronze	Glossiness	Size	Shape	Amount of blemishes	Stem scar tear	Visual separation	Number of seeds	Seed size
AM-9	11.5 a	0.0 b	7.1 b	7.8 ab	12.9 a	3.2 a	0.0 c	12.1 a	3.3 ab	6.9 a
AM-74	3.1 c	8.7 a	6.6 b	8.4 a	12.7 a	4.3 a	0.9 a	11.7 a	2.6 c	6.9 a
AM-83	12.1 a	0.0 b	8.3 a	7.4 bc	8.5 b	4.5 a	0.2 bc	9.2 b	3.6 a	6.3 a
Ison	10.1 b	0.5 b	7.9 a	7.3 bc	12.6 a	3.3 a	0.4 b	12.2 a	3.5 a	7.4 a
Nesbitt	9.5 b	0.6 b	8.0 a	7.2 c	12.7 a	4.0 a	0.8 a	12.1 a	3.0 bc	6.7 a
Summit	3.5 c	7.9 a	6.5 b	7.2 c	12.5 a	3.9 a	0.2 bc	11.8 a	3.4 ab	7.0 a
P value	<0.0001	<0.0001	<0.0001	0.0010	<0.0001	0.1820	<0.0001	<0.0001	0.0040	0.5080

[z] Trained descriptive panel (n=8) evaluated five berries per genotypes in duplicate. Means with different letter(s) for each attribute are significantly different ($p < 0.05$) using LSD.

Table 4. Descriptive sensory attributes (basic tastes and feeling factors) for muscadine genotypes evaluated on a 15-point scale (0=less of the attribute and 15=more of the attribute in terms of intensity), Clarksville, AR 2017.

Genotype [z]	Sweet	Sour	Bitter	Astringent feeling factor	Metallic feeling factor
AM-9	7.4 abc	3.2 bcd	1.4 a	6.9 a	1.4 abc
AM-74	7.9 a	2.9 cd	0.7 a	6.5 a	1.2 d
AM-83	6.3 d	3.3 bc	1.1 a	6.8 a	1.4 bc
Ison	6.7 cd	3.9 a	1.1 a	7.0 a	1.6 a
Nesbitt	7.0 bcd	3.7 ab	1.0 a	6.8 a	1.5 ab
Summit	7.6 ab	2.7 d	0.7 a	6.4 a	1.3 cd
P value	0.0020	0.0010	0.0960	0.0940	0.0010

[z] Trained descriptive panel (n=8) evaluated five berries per genotypes in duplicate. Means with different letter(s) for each attribute are significantly different ($p < 0.05$) using LSD.

Table 5. Descriptive sensory aromatic attributes for muscadine genotypes evaluated on a 15-point scale (0=less of the attribute and 15=more of the attribute in terms of intensity), Clarksville, AR 2017.

Genotype [z]	Overall Aromatic impact	Grape overall	Grape muscadine	Fruity	Floral	Green/ unripe	Earthy/ dirty
AM-9	8.1 abc	6.7 ab	7.3 a	0.4 a	0.7 a	0.5 a	0.9 a
AM-74	8.3 ab	6.9 a	7.2 a	0.2 a	1.2 a	1.0 a	0.7 a
AM-83	7.1 d	5.9 d	9.8 a	0.5 a	0.8 a	0.5 a	0.9 a
Ison	7.7 c	6.2 cd	6.6 a	0.6 a	0.8 a	0.6 a	1.4 a
Nesbitt	7.9 bc	6.4 bc	6.7 a	0.6 a	0.9 a	0.7 a	1.5 a
Summit	8.4 a	6.8 ab	7.3 a	0.0 a	1.2 a	0.6 a	0.8 a
P value	<0.0001	<0.0001	0.6560	0.5840	0.2870	0.1260	0.728

[z] Trained descriptive panel (n=8) evaluated five berries per genotypes in duplicate. Means with different letter(s) for each attribute are significantly different ($p < 0.05$) using LSD.

Table 6. Descriptive sensory texture attributes for muscadine genotypes evaluated on a 15-point scale (0=less of the attribute and 15=more of the attribute in terms of intensity), Clarksville, AR 2017.

Genotype [z]	Hardness	Moisture release	Awareness of skins	Pulp crispness	Detachability	Fibrousness between teeth	Seed separation
AM-9	8.6 a	9.8 a	13.1 a	3.7 a	12.4 a	3.9 a	10.7 a
AM-74	8.0 a	10.3 a	12.8 a	3.5 a	11.6 a	4.0 a	10.2 a
AM-83	8.5 a	9.6 a	12.8 a	3.9 a	11.0 a	4.2 a	10.2 a
Ison	8.1 a	9.9 a	13.0 a	3.4 a	12.2 a	4.1 a	10.4 a
Nesbitt	8.3 a	9.8 a	13.1 a	3.6 a	12.3 a	4.2 a	10.3 a
Summit	8.3 a	9.9 a	12.9 a	3.5 a	12.1 a	4.3 a	10.1 a
P value	0.5250	0.0710	0.6180	0.4310	0.0500	0.7120	0.7220

[z] Trained descriptive panel (n=8) evaluated five berries per genotypes in duplicate. Means with different letter(s) for each attribute are significantly different ($p < 0.05$) using LSD.

Table 7. Physical attributes for muscadine grape genotypes at harvest, Clarksville, AR 2017.

Genotype [z]	Weight (g)	Length (mm)	Width (mm)	L*	a*	b*	Chroma	Hue	Seeds (#)	Seed weight (g)	Stem scar tear (%)[y]
AM-9	10.68	25.29	26.28	23.85	3.61	0.88	3.72	13.89	3	0.11	1.11
AM-77	14.38[y]	28.49	27.89	47.94	-1.11	16.94	17.23	92.93	2	0.12	11.01
AM-83	9.92	28.40	24.23	25.06	2.42	0.39	2.47	34.67	4	0.09	1.08
Ison	10.01	26.36	24.61	24.86	4.48	0.89	4.58	12.39	4	0.12	8.01
Nesbitt	10.10	25.20	25.56	26.62	7.19	0.70	7.24	30.31	3	0.12	10.17
Summit	9.25	24.75	24.31	47.62	-1.40	18.14	18.36	93.39	3	0.10	2.47
P value	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0017	<0.0001	0.0003	0.0441

[z] Genotypes were evaluated using three to five berries in triplicate. Means with different letter(s) for each attribute are significantly different ($p < 0.05$) using Tukey's Honestly Significant Difference.
[y] Stem Scar Tear defined as a tear twice the size of the stem diameter.

Table 8. Physicochemical attributes for muscadine grape genotypes at harvest, Clarksville, AR 2017.

Genotype [z]	Skin force (N)	Flesh force (N)	Elasticity (mm)	Soluble solids (%)	pH	Titratable acidity (%)[y]	Soluble Solids/ titratable acidity ratio
AM-9	5.69	1.18	6.73	14.23	3.27	0.57	24.93
AM-77	7.50[y]	1.13	5.52	13.63	3.08	0.57	24.36
AM-83	5.93	2.14	4.20	13.27	3.33	0.64	20.73
Ison	5.32	1.34	6.08	13.20	2.88	1.01	13.12
Nesbitt	7.43	0.89	5.34	12.73	3.03	0.76	16.91
Summit	6.47	1.72	5.54	15.40	3.19	0.54	28.49
P value	0.0003	0.0149	0.0324	0.0002	<0.0001	<0.0001	<0.0001

[z] Genotypes were evaluated using three to five berries triplicate. Means with different letter(s) for each attribute are significantly different ($p < 0.05$) using Tukey's Honestly Significant Difference.
[y] Calculated as percent tartaric acid.

Conclusions

Descriptive Sensory Analysis

The lexicon developed by the descriptive panel included references used by the panelists to evaluate the appearance, basic tastes, feeling factors, aromatics and texture of fresh muscadines (Table 1). This lexicon can be used by other programs to evaluate the attributes of fresh muscadines or modified for use with other fresh fruit.

Aroma attributes. The panelist evaluated the aroma attributes of the muscadines including grape-overall, grape-muscadine, grape-other, fruity, floral, earthy/dirty, green/unripe, and mold/mildew. (Table 2). Grape-overall and grape-muscadine aroma were more prevalent than the other aromas with AM-74 with the highest and AM-83 the least.

Appearance attributes. The appearance attributes of muscadines are an important attribute for fresh market because consumers can purchase muscadines based on appearance in a clamshell container. The appearance attributes of the muscadines evaluated included color-purple, color-bronze, glossiness, size, amount of blemishes, stem scar tear, visual separations, number of seeds and size of seeds (Table 3). AM-74 and Summit were the only bronze cultivars. AM-74 was the biggest berry. AM-83 was the hardest to detach the pulp from skin of berry. There were about three seeds per berry.

Basic tastes. The panelists evaluated the basic tastes (sweet, sour, and bitter) of the muscadines (Table 4). The panelists found the sweetness of the muscadines ranged from 6.3 to 7.9 with a 5=5% sucrose solution and 10=10% sucrose solution. In terms of sourness, the berries ranged from 2.7 to 3.9 with 2=0.05% citric acid solution and 5=0.08% citric acid solution. There was not a difference for the genotypes for bitterness. AM-74 was the sweetest, while 'Ison' was the sourest.

Feeling factors. The panelists evaluated the feeling factors (astringent and metallic) of the muscadines. There was not difference in the astringent feeling factor for these genotypes. The metallic feeling factors (biting into tin foil as a reference) of the muscadines were low (<1.6)

Aromatic attributes. The aromatic attributes (volatiles perceived by the olfactory system while chewing a sample in the mouth) of the muscadines included overall aromatic impact, grape-overall, grape-muscadine, fruity, floral, and green/unripe (Table 5). The intensity of overall aromatic impact ranged from 7.1 to 8.4 with 'Summit' having the highest intensity. AM-83 had the highest grape-muscadine aromatic. There was no difference in the genotypes for grape-muscadine fruity, floral, and green/unripe aromatics. The aromatic attributes play a key role in the "taste" of the muscadines, and overall, grape-overall, and grape-muscadine were the highest scored intensities in the mid-range of the 15-point scale.

Texture attributes. The texture attributes included hardness, moisture release, awareness of skins, pulp crispness, detachability, fibrousness between the teeth and seed separation (Table 6). There was not difference in the genotypes for any of the texture attributes.

Physiochemical Analysis

In terms of physiochemical data of the fruit, the color, firmness, berry attribute, basic composition (soluble solids, pH, and titratable acidy) and the organic acid (isocitric, isocitric lactone and malic acid) and sugar (glucose and fructose) content were measured (Tables 7 and 8). This data will be statistically analyzed by January 2018.

Color . The darkest berry was the black genotypes, AM-9, AM-83, Ison, and Nesbitt, while the lightest were AM-74 and Summit, the bronze genotypes.

Firmness. The firmness in terms of force to break the skin was AM-74, while the least firm was AM-9.

Berry attributes. AM-77 was the largest berry (14.38g), while 'Summit' was the smallest (9.24 g). The number of seeds in a berry ranged from 2-4.

Basic composition. At harvest, the fruit had 12.73-14.23% soluble solids, 0.54-1.01% titratable acidity, and soluble solids/titratable acidity ratio of 16.91-28.49. 'Summit' was the sweetest berry with the highest soluble solids/titratable acidy ratio and the lowest titratable acidity.

Sugar and acid analysis. This data is in progress.

Impact Statement

The data collected from this study will help characterize muscadine fruit quality for future U.S. breeding objectives. More specifically, the results will identify attributes for muscadines from the University of Arkansas fruit breeding program.

Citation(s) for any publications arising from the project

The data is being analyzed and a journal publication will be done. Data from this project will be used to present oral and poster presentations at regional and national meetings.