Southern Region Small Fruit Consortium

Final Report Research

Title: Characterizing Marketable Attributes of Juice from Noble and a Potential New Processing Muscadine Cultivar

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Public Abstract
Muscadine grapes (*Vitis rotundifolia* Michx.) are grown in the Southeast United States for juice and wine production. A new muscadine selection (AM-77) from the University of Arkansas System Division of Agriculture Fruit Breeding program was compared to Noble, a key processing muscadine. In 2022, grapes were harvested from a commercial vineyard for juice production, then divided into four 27 kg-lots for each genotype. After crushing/destemming, the must (seeds, juice, skin, and pulp), was cold pressed (must pressed after crushing) or hot pressed (must heated to 38 °C in a steam kettle, held for 1 min, cooled, and pressed) in duplicate per genotype. After cold settling and racking, juice was pasteurized, hot filled into glass bottles, and stored at 2 °C until composition, color, volatiles, and consumer sensory analysis. The four juices differed for all composition and color attributes. Regardless of press treatment, Noble (21%) had higher soluble solids than AM-77 (19%). AM-77 hot press had the lowest pH (2.96) and highest titratable acidity (0.83%) but had optimal soluble solids/titratable ratio (23.14). In terms of color attributes, cold press juices were pink/light red, while hot press juices were dark purple. AM-77 cold press juice had a higher red color than the other juices, while Noble cold press juice had lower red color density than the other juices and the highest brown color. Forty-eight volatile compounds were identified in these muscadine juices including 11 Esters, 10 Terpenes, 10 Alcohols, 6 Aldehydes, 4 acids, 3 Other, 2 Hydrocarbons, and 2 Ketones. AM-77 cold press juice (10.58 µ/mL) had the highest total volatiles, followed by AM-77 hot press (9.92 µ/mL), Noble cold press (7.41 µ/mL), and Noble hot press (6.90 µ/mL). Principle Component (PC) analysis explained 90.63% (PC1=57.63% and PC2=33.01%) of the variation for the 17 compounds impacted by genotype/pressing method. For AM-77, cold press juice was correlated to ester compounds, while hot press juice was correlated to terpenes. For consumer sensory evaluation, panelists (n=66) evaluated juices for overall impression, color, aroma, flavor, sweetness, and sourness using a 9-point hedonic scale and a Just-About-Right (JAR) scale, then ranked juices for preference. The four juices differed in color, flavor, sweetness, sourness, and

overall impression, but not aroma. Consumers liked the color of the hot press juice better than the cold press juice within each genotype. In terms of flavor, sourness, and overall impression, AM-77 cold and hot press juice was liked more than Noble hot and cold press juice. Consumers found the color (82%), aroma (74%), and sweetness (65%) of AM-77 hot press the highest for JAR. AM-77 hot press was the most preferred (42%), then AM-77 cold press (29%), Noble cold press (16%), and Noble hot press (13%). Regardless of press treatment, AM-77 juice had potential for commercial production as compared to Noble.

Introduction

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 for muscadine grapes used for commercial juices. The market presence for the muscadine industry as a southern region crop can be strengthened by understanding what consumers want in a muscadine juice. This research from the University of Arkansas System Division of Agriculture (UA System) will **characterize marketable attributes of juice from Noble and a potential new black-fruited processing muscadine cultivar** by evaluating physicochemical and sensory attributes that drive marketability. **This project is important because it will help establish marketability attributes that drive consumer purchasing of muscadine juice in addition to providing opportunities for a new processing muscadine cultivar for the U.S. southeastern region.**

Growing Muscadine Grapes. Muscadines differ from bunch grapes because they have smaller clusters, the berries abscise (shatter) at maturity, and the tendrils are unbranched. Muscadine clusters contain 6-24 berries and are classified by color, with bronze or black as the two prevalent color types (Conner 2010, Mortensen 2001). These native grapes have been cultivated for over 400 years and have a strong heritage in U.S. viticulture (Olien 1990). Muscadine grape production can be profitable for commercial growers (Noguera et al. 2005), but is dependent on availability of consumer markets. The top commercial muscadine-producing states are North Carolina (2,600 acres), Georgia (1,700 acres), and Florida (1,200 acres) (USDA Agricultural Census 2012).

Muscadine Juice Production. A majority of the commercial muscadine crop is used to produce juice and wine. The two most popular cultivars for processing are Noble, a black muscadine, and Carlos, a bronze muscadine. Muscadine juice and wine can have poor color, color stability, and cloudiness/sediment. Muscadine grapes and wines contain diglycosidic anthocyanins, which are unable to form stable polymeric pigment complexes (Sims and Morris, 1985). In juice production, extraction of the color from the skins of the grapes is done by applying heat to the must (seeds, skins, pulp, and juice) after the grapes are crushed but before the grapes are pressed. In contrast, cold press is when the must is pressed after the grapes are crushed, yielding lighter-colored and fruiter juice but with less juice yield (Striegler et al., 2005; Threlfall et al., 2005; 2007).

Muscadine Grape Breeding. There are public and private muscadine breeding programs across the southern United States. These continued breeding efforts result in better quality for consumers and increased cultivar options for growers. The southeastern U.S. muscadine breeding efforts are focused on improving traits for fresh-market and processing muscadine genotypes (cultivars and breeding selections), resulting in an expansion of the germplasm base used in muscadine breeding. The UA System Fruit Breeding Program began a muscadine breeding program in 2007 that includes many breeding selections with unique profiles. One of the UA

System advanced breeding selections, AM-77, shows great potential for juice and wine production and will likely be one of the first muscadine grape cultivars released from the UA System in 2022-2023. AM-77 is a black muscadine that has larger fruit size than Noble and potentially better color for juice and wine production. To determine whether AM-77 has a potential place in the market as a complement to Noble, we need to evaluate the consumer quality of the juices and wines produced from its fruit.

Physicochemical Components of Muscadines. Muscadines offer a healthy fruit choice for consumers and a marketing opportunity for producers. Muscadine grapes contain many health-promoting phenolic compounds including, resveratrol, ellagic acid, anthocyanins, and proanthocyanidins (Barchenger et al. 2014, 2015a, 2015b, Ector et al. 1996, 2001, Pastrana-Bonilla et al. 2003, Threlfall et al. 2005). Anthocyanins are highest in the skins of dark-colored muscadines (Striegler et al. 2005). Baek et al. (1997) and Baek and Cadawallader (1999) identified the predominant aroma compound in muscadine juice as furaneol (burnt sugar), *o*-aminoacetophenone ("foxy", artificial grape), 2-phenylethanol (honey, floral), diacetyl (butter), and ethyl butanoate (apple). The combination of these volatile compounds gives muscadine grapes, juices, and wines a unique aroma and flavor profile.

Sensory of Muscadine Grapes/Juice. The evaluation of factors that drive consumer acceptance is critical to the marketing of unique products. A consumer sensory study at the University of Florida showed that consumer panelists familiar with muscadine grapes had overall liking scores of fresh muscadine grapes correlated to muscadine flavor (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. Threlfall et al. (2007) evaluated the descriptive and consumer sensory attributes of juice from eight muscadine cultivars, including five black cultivars and three bronze cultivars plus two commercial juices. Consumers rated Black Beauty, Granny Val, Ison, Southern Home, and Summit juices highest for overall liking. The descriptive panel created a sensory lexicon with major attributes identified as sweet, sour, cooked muscadine, cooked grape, and astringent. Correlation between consumer and descriptive showed overall liking correlated positively to sweetness and caramelized and correlated negatively to sour and green unripe. Consumers showed a preference for juice sweetness with soluble solids ≈14% and soluble solids/acid ratios of 26 to 31. Further consumer sensory evaluations of muscadine juice is needed, especially using 100% Noble muscadine grapes, and although commercial muscadine juices are available these are typically blends of different cultivars.

Objectives

1. Evaluate the impact of cold versus hot pressing on juice from Noble and a potential new processing muscadine cultivar from the UA System

Measure physicochemical attributes and conduct consumer sensory analysis of juice produced from Noble and AM-77, a potential new processing muscadine cultivar from the UA System Fruit Breeding Program

2. Compare physicochemical and consumer sensory attributes of juice from Noble and a potential new processing muscadine cultivar from the UA System

Identify consumer-driven attributes of Noble and AM-77 muscadine grape juice by comparing the physicochemical and sensory attributes

3. Disseminate information to muscadine grape growers and juice producers on marketable quality attributes
Present results at conferences and host a field day/workshop on muscadine breeding, production, and utilization

Materials and Methods

Harvest

The genotypes were hand harvested in the morning from a commercial vineyard in Altus, AR. About 120 kg of each genotype were harvested (117 kg of AM-77 harvested on September 9, 2022 and 118 kg of Noble harvested on October 4, 2022). After harvest, the grapes were taken to the UA System Food Science Department in Fayetteville. The lugs of grapes for each genotype were randomized into eight lugs prior to processing on the day of harvest.

Grape processing

The grapes were divided into four lots (27 kg each) for each genotype. Each batch of grapes was passed twice through a crusher/destemmer, and 30 mg/L sulfur dioxide (SO2) as potassium metabisulfite (KBMS) was added at crush. After crushing the grapes for each genotype, the must (seeds, juice, skin, and pulp) for each batch was placed into food grade polyethylene containers and assigned into two treatments (Cold Press or Hot Press) in duplicate.

For the cold press treatments, the must was pressed after crushing. For the hot press treatments, the must was placed in a 76-L (20-gal) steam kettle, heated to 38 °C, held for one minute, placed back into the polyethylene container, allowed to cool, and then pressed. The musts were pressed with a 70-L Eno Agricola Rossi Hydropress (Calzolaro, Italy). The juice was collected in 11.4-L glass carboys, cold (2°C) settled overnight, then racked. The juice was placed in a steam kettle, pasteurized (88 °C for 1 minute), and hot filled into 125-mL, 375-mL and 750-mL glass bottles. After sealing the bottles with the caps, the bottles were placed on their sides to cool. The pasteurized juice was stored at 2 °C until physicochemical and sensory analysis.

Statistical design and analysis

There were four treatments (AM-77 Cold Press, AM-77 Hot Press, Noble Cold Press, and Noble Hot Press) in duplicate. Statistical analyses will be conducted using JMP® (version 16.0; 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.

Methods for physiochemical analysis

The physiochemical attributes (color, composition, and volatile profile) of each juice sample (2 genotypes x 2 press treatments x 2 replications) were evaluated at the UA System Food Science Department.

Color analysis

L*, a*, b*, hue angle, and chroma. Juice color analysis was conducted using a ColorFlex system (HunterLab, Reston, VA). The ColorFlex system uses a ring and disk set (to control liquid levels and light interactions) for measuring translucent liquids in a 63.5-mm glass sample cup with an opaque cover to determine CIELab transmission values of L*=100, a*=0, and b*=0 (CIE, 1986).

Red color and color density. Red color of juice was measured spectrophotometrically as absorbance at 520 nm, and color density was measured as red color + yellow/brown color (420 nm) (Iland et al. 1993). Absorbance values were measured using a Hewlett-Packard 8452A Diode Array spectrophotometer equipped with UV-Visible ChemStation software (Agilent Technologies, Inc., Santa Clara, CA). Samples were diluted with deionized water as needed prior to analysis and measured against a blank sample of deionized water. A 1-cm cell was used for all spectrophotometer measurements.

Composition analysis

Soluble solids, pH, and titratable acidity. Juice was used to determine soluble solids, pH, and titratable acidity. Total soluble solids (expressed as %) was measured using a refractometer. Titratable acidity and pH was measured with an automated titrimeter. 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. Soluble solids/titratable acid ratio was calculated.

Sugar and acid analysis. Organic acids and sugars (expressed as %) were determined using HPLC. Glucose, fructose, and citric, tartaric, malic, acids of the muscadine juices 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 as guard column. The peaks were quantified using external standard calibration based on peak height estimation with baseline integration.

Volatile profile analysis

Volatile compounds analysis. For sample preparation, 0.4 g of NaCl was placed in a 10 mL amber screw cap vial, then 1 mL of juice was added to the vial. Volatile detection was performed using a Shimadzu Nexis GC-2030 (Shimadzu, Japan) system equipped with a triple-quadruple mass selective detector and an AOC-6000 Autosampler (Shimadzu, Japan). The volatiles were absorbed on a 1-cm long SPME fiber coated with Divinylbenzene/Carboxen/Polydimethylsiloxane (DVB/CAR/PDMS) (Supelco, PA). The capillary column used was ZB-5MSplus (30 m x 0.25 mm x 0.25 μm) (Zebron, CA. The injection was performed on splitless mode at an inlet temperature of 230 °C. The fiber was preconditioned for 5 minutes at 240 °C, samples were incubated at 50 °C for 10 minutes, then extracted and desorbed for 10 minutes and 3 minutes, respectively. Helium was used as the carrier gas at a flow rate of 1 mL/min. The inlet pressure was 46.7 kPa. The initial oven temperature was set to 35 °C, held for 5 min, then raised to 150 °C at a rate of 5 °C/min, then raised to 280 °C at a rate of 8 °C/min and held for 5 min. The total run time was 49.25 min. The MS was operated in full scan mode (40-400 m/z) at interface and ion source temperatures of 290 and 240 °C, respectively. Compounds were identified (match rates of ≥90%) on Shimadzu LabSolution software based on mass spectral libraries using NIST2020 (National Institute of Standards and Technology, Gaithersburg, MD, USA). A linear retention index was created using an alkane standard mix solution (C7–C20) to further confirm the molecule identifications. Ten μL of hexanal-d12 (1 μg/μL) was added to each vial as an internal standard (IS). Volatile concentrations (as μg/g) were calculated based on IS and identified molecule peak areas, IS concentration and volume injected, and mass of berries into the vial, as shown in the following equation: Molecule concentration (μg/g)=((Peak area of compound)/(Peak area of IS) x IS concentration (µg/µL) x IS Volume (µL))/(Muscadine juice (mL))

Methods for consumer sensory analysis

The sensory attributes of the juices were evaluated during the NCCC212 meeting on October 26, 2022 in Fayetteville, AR and at the UA System Food Science Department on October 31, 2022. For sensory analysis, the replications of each treatment were combined (2 genotypes x 2 press treatments) for a total of four juice samples.

Consumers panelists (66) assessed the color, aroma, and taste of the four muscadine juices evaluated for physiochemical attributes. The sample presentation order was randomized. Sample cups were labeled with three-digit codes, and each panelist was served 30 mL of juice. Unsalted crackers and water were provided for palate cleansing between samples. Each consumer evaluated overall impression, color, aroma, flavor, sweetness and sourness on a 9-point verbal hedonic scale (1 = dislike extremely; 9 = like extremely) and a 5-point Just About Right (JAR) scale (1 = not nearly enough 3 = just about right; 5 = much too much). Consumers were also asked a preference question about the samples. Consumers were asked demographic questions. Data was acquired using paper ballots.

Methods for outreach dissemination

Present results at conferences and host a field day/workshop on muscadine breeding, production, and utilization

Results and Discussion

Physiochemical analysis

Juice genotype/pressing method significantly impacted composition and color attributes (Tables 1, 2 and 3). Regardless of press treatment, 'Noble' (21%) had higher soluble solids than AM-77 (19%). AM-77 hot press had the lowest pH (2.96) and highest titratable acidity (0.83%), as well as optimal soluble solids/titratable ratio (23.14). Total sugars of AM-77 cold press juice (21.79%) were higher than the other juices, while AM-77 hot press juice was higher in total organic acids than the other juices.

In terms of color attributes, cold press juices were pink/light red, while hot press juices were dark purple. In terms of L*, AM-77 and Noble hot press juices (3.44 and 1.29, respectively) were darker than cold press juices (39.91 and 27.97, respectively). AM-77 juice had a higher red color than the other juices. Noble cold pressed juice had lower red color density than the other juices and had the highest brown color.

There were 48 volatile compounds identified in these muscadine juices, 17 of the compounds impacted by genotype/pressing method (Table 4). Analysis of volatile compounds in these four juices showed 11 Esters (23%), 10 Terpenes (20%), 10 Alcohols (21%), 6 Aldehydes (12%), 4 acids (8%), 3 Other (6%), 2 Hydrocarbons (4%), and 2 Ketones (4%). The Esters (fruity/ethereal), Alcohols (fruity), Terpenes (floral), and Aldehydes (green/vegetable) were the top classes of volatiles, followed by Aromatic hydrocarbons (spicy/clove) and Ketones (fruity/berry). AM-77 cold press juice (10.58 µ/mL) had the highest total volatiles, followed by AM-77 hot press juice (9.92 µ/mL), Noble cold press juice (7.41 µ/mL), and Noble hot press juice (6.90 µ/mL). Principle Component (PC) analysis of PC1 and PC2 explained 90.63% (PC1=57.63% and PC2=33.01%) of the variation for all significant data collected for the volatile compounds of these muscadine juices with different press treatments. AM-77 cold press juice was correlated to many ester compounds, while AM 77 hot press juice was correlated to several terpenes.

Consumer sensory analysis

Overall, 59% of panelists for the consumer sensory study were female and 41% were male. In terms of age, 20% were 21 years of age or younger, 39% were 22-34, 16% were 35-44, 3% were 45-54, 12% were 55-64, and 10% were 65 or older. Over half (51%) of panelists had a graduate degree, 16% had a four-year degree, 28% had some college education, and 5% indicated "other" for education. Fifty-nine percent of panelists had previously consumed muscadine juice while 41% had not. Twenty-one percent had purchased muscadine juice, while 79% had not. When asked how often they consumed muscadine juice, 49% indicated "never", 28% indicated once per year, 20% indicated 2-3 times per year, and 3% indicated 4-10 times per year.

Consumers panelists (66) evaluated color, aroma, flavor, sweetness, sourness, and overall impression of the juice on a 9-point verbal hedonic scale and a JAR scale (Tables 5 and 6). The liking for all the attributes ranged from 4.53 (dislike slightly to neither like nor dislike) to 7.30 (like moderately). For the hedonically rated attributes, the panelists found significant differences in the attributes except aroma which was rated 5.93 (neither like nor dislike to like slightly). The Noble hot press juice (7.30) was scaled the highest for color and was higher than the AM-77 cold press and Noble cold press. In general, the cold press juices were pink/light red, whereas the hot press juices were dark purple. **AM-77 cold or hot press juice was higher in liking for flavor, sourness, and overall impression than Noble cold or hot press**. AM-77 hot press was scaled highest for sweetness and was scaled higher than Noble cold press.

Seventy-six percent of the panelists found AM-77 too light in color, but 82% found AM-77 hot press JAR for color. The panelists A majority (76%) of the panelists found AM-77 cold press juice JAR for aroma. In terms of flavor, panelists found the AM-77 cold and hold press juice (62-70%) more JAR than the Noble cold and hot juice (42-44%). AM-77 hot press juice (65%) had the highest rating for JAR sweetness. In terms of sourness, panelists found the AM-77 cold and hold press juice (55-56%) more JAR than the Noble cold and hot press juice (32%).

In terms of preference, 42% preferred AM-77 hot press juice, followed by 29% for AM-77 cold press juice, 16% Noble cold press juice, and 13% Noble hot press juice.

Outreach dissemination

Juice Tasting Events

NCCC-212 2022 Meeting. University of Arkansas System Division of Agriculture, Don Tyson Center for Agricultural Sciences, Fayetteville, AR, October 26-27, 2022 **(45 attendees)**.

Sensory Science class. University of Arkansas System Division of Agriculture Food Science Department, Fayetteville, AR October 31, 2022 **(25 attendees)**.

Published Abstract

Threlfall*, R., M. Worthington, and J. Chenier. 2023. Characterizing marketable attributes of juice from Noble and a potential new processing muscadine cultivar. HortScience 59(9) (Supplement 2) – 2023 SR-ASHS Annual Meeting. In press

Oral Presentations

Threlfall*, R., M. Worthington, and J. Chenier. 2023. Characterizing marketable attributes of juice from Noble and a potential new processing muscadine cultivar. Southern Region-American Society for Horticulture Science Annual Meeting. February 3-5, Oklahoma City, OK.

Chenier, J., M. Worthington, and R. Threlfall*. Consumer acceptability of new fresh-market muscadine grapes from the University of Arkansas System Division of Agriculture Fruit Breeding Program. American Society for Enology and Viticulture-Eastern Section 47th Annual Conference. June 7-9, 2023, Austin, TX.

Conclusions

The four juices (AM-77 and Noble hot and cold press) differed for all composition and color attributes. Regardless of press treatment, Noble had higher soluble solids than AM-77, but AM-77 hot press had the lowest pH, highest titratable acidity, and an optimal soluble solids/titratable ratio. In general, cold press juices were pink/light red, while hot press juices were dark purple. However, AM-77 cold press juice had a higher red color than the other juices, while Noble cold press juice had lower red color density and the highest brown color. Forty-eight volatile compounds were identified in these muscadine juices, primarily Esters, Terpenes, and Alcohols. AM-77 cold press juice had the highest total volatiles, followed by AM-77 hot press, Noble cold press, and Noble hot press. Principle Component (PC) analysis explained 90.63% (PC1=57.63% and PC2=33.01%) of the variation for the 17 compounds impacted by genotype/pressing method. For AM-77, cold press juice was correlated to ester compounds, while hot press juice was correlated to terpenes. For consumer sensory evaluation, the four juices differed in color, flavor, sweetness, sourness, and overall impression, but not aroma. Consumers liked the color of the hot press juice better than the cold press juice within each genotype. In terms of flavor, sourness, and overall impression, AM-77 cold and hot press juice was liked more than Noble hot and cold press juice. Consumers found the color, aroma, and sweetness of AM-77 hot press the highest for JAR. AM-77 hot press was the most preferred, followed by AM-77 cold press, Noble cold press, and Noble hot press. Regardless of press treatment, AM-77 juice had potential for commercial production as compared to Noble.

Impact Statement

A new muscadine grape (*Vitis rotundifolia* Michx.) breeding selection (AM-77) from the University of Arkansas System Division of Agriculture Fruit Breeding program was compared to Noble, a key juice and wine processing muscadine in the southern United States. The muscadine grapes were used for juice production using two methods (hot and cold pressing). The four juices differed for all composition and color attributes, some volatile attributes, and most sensory attributes. In terms of the composition, color, volatiles, and consumer sensory attributes, AM-77 muscadine grapes showed potential, especially in the sensory evaluation, for commercial juice production as compared to Noble.

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Table 1. Composition of cold and hot pressed juice made from muscadine grapes grown in Arkansas and evaluated at the University of Arkansas System Division of Agriculture (2022).

Genotype [z]	Press treatment [y]	Soluble solids (%)	pH	Titratable acidity (%)[y]	Soluble solids/titratable acidity ratio
AM-77	Cold press	19.3 b	3.22 a	0.52 b	37.43 b
AM-77	Hot press	19.2 b	2.96 b	0.83 a	23.14 c
Noble	Cold press	21.0 a	3.26 a	0.39 c	53.21 a
Noble	Hot press	20.5 a	3.20 a	0.56 b	36.58 b
P-value		*0.0023*	*0.0023*	*0.0004*	*0.0021*

[z] Genotypes were evaluated in duplicate. Means with different letters for each attribute within location are significantly different ($p<0.05$) using Tukey's Honestly Significant Difference test.
[y] For cold press treatments, must was pressed after crushing. For hot press treatments, must was placed in a 76-L (20-gal) steam kettle, heated to 38 °C, held for one minute, placed back into the polyethylene container, allowed to cool, and then pressed.

Table 2. Sugars and organic acids of cold and hot pressed juice made from muscadine grapes grown in Arkansas and evaluated at the University of Arkansas System Division of Agriculture (2022).

Genotype [z]	**Press treatment** [y]	**Glucose (%)**	**Fructose (%)**	**Total sugars (%)**	**Tartaric acid (%)**	**Malic acid (%)**	**Citric acid (%)**	**Total organic acids (%)**
AM-77	Cold press	10.08 b	11.71 a	21.79 a	0.45 c	0.59 b	0.15 b	1.19 c
AM-77	Hot press	9.64 c	11.31 b	20.95 b	0.65 a	0.64 a	0.47 a	1.75 a
Noble	Cold press	11.13 a	9.38 d	20.50 b	0.44 c	0.39 d	0.21 b	1.03 d
Noble	Hot press	10.87 a	9.77 c	20.64 b	0.57 b	0.43 c	0.52 a	1.52 b
P-value		*<0.0001*	*<0.0001*	0.0005	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*

[z] Genotypes were evaluated in duplicate. Means with different letters for each attribute within location are significantly different ($p<0.05$) using Tukey's Honestly Significant Difference test.
[y] For cold press treatments, must was pressed after crushing. For hot press treatments, must was placed in a 76-L (20-gal) steam kettle, heated to 38 °C, held for one minute, placed back into the polyethylene container, allowed to cool, and then pressed.

Table 3. **Color and phenolic attributes of cold and hot pressed juice made from muscadine grapes grown in Arkansas and evaluated at the University of Arkansas System Division of Agriculture (2022).**

Genotype [z]	Press treatment [y]	L*	Hue angle (°)[x]	Chroma	Red color[w]	Brown color[w]	Color density[w]
AM-77	Cold press	39.91 a	25.82 a	39.06 b	3.98 a	2.68 b	6.65 a
AM-77	Hot press	3.44 c	4.46 b	14.48 b	2.97 b	3.65 ab	6.62 a
Noble	Cold press	27.97 b	30.38 a	53.61 a	1.56 c	1.32 c	2.88 b
Noble	Hot press	1.29 c	10.01 b	3.72 d	2.87 b	4.70 a	7.57 a
P-value		*< 0.0001*	*< 0.0001*	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*

[z] Genotypes were evaluated in duplicate. Means with different letters for each attribute within location are significantly different ($p<0.05$) using Tukey's Honestly Significant Difference test.
[y] For cold press treatments, must was pressed after crushing. For hot press treatments, must was placed in a 76-L (20-gal) steam kettle, heated to 38 °C, held for one minute, placed back into the polyethylene container, allowed to cool, and then pressed.
[x] Hue angles <90° were subjected to a 360° compensation to account for discrepancies between red samples near 0° and those near 360°.
[w] Red color calculated as absorbance of wine at 520 nm, Brown color at 420 nm, Color density at 520 nm + absorbance 420 nm.

Table 4. **Volatile compounds (µg/mL) of cold and hot pressed juice made from muscadine grapes grown in Arkansas and evaluated at the University of Arkansas System Division of Agriculture (2022).**

Compound[z]	Class	**AM-77 Cold Press**[y]	**AM-77 Hot Press**	**Noble Cold Press**	**Noble Hot Press**	***P-value***
Nonanoic acid	Acid (Organic acid)	0.346 a	0.218 a	0.409 a	0.295 a	*0.882*
Heptanoic acid	Acid (Organic acid)	0.000 b	0.073 a	0.000 b	0.000 b	***<0.0001***
Octanoic acid	Acid (Organic acid)	0.676 a	0.579 ab	0.442 ab	0.236 b	*0.561*
Nonanoic acid	Acid (Organic acid)	0.346 a	0.218 a	0.409 a	0.295 a	*0.882*
1-Butanol	Alcohol	0.024 a	0.029 a	0.000 b	0.000 b	*0.382*
3-Hexen-1-ol	Alcohol	0.089 c	0.103 bc	0.153 ab	0.158 a	*0.730*
(E)-2-Hexen-1-ol	Alcohol	0.204 b	0.237 b	0.501 a	0.530 a	*0.963*
1-Hexanol	Alcohol	1.868 a	1.832 a	1.121 b	0.975 b	*0.730*
1-Heptanol	Alcohol	0.321 a	0.267 ab	0.277 ab	0.198 b	*0.567*
1-Octen-3-ol	Alcohol	0.053 b	0.072 a	0.060 ab	0.059 ab	***0.013***
Benzyl alcohol	Alcohol	0.000 b	0.000 b	0.018 a	0.017 a	*0.498*
1-Octanol	Alcohol	1.098 a	1.195 a	0.590 b	0.588 b	*0.227*
Phenylethyl Alcohol	Alcohol	0.691 a	0.722 a	0.113 b	0.120 b	*0.770*
(Z)-5-Decen-1-ol	Alcohol	0.063 a	0.076 a	0.000 b	0.010 b	*0.765*
Hexanal	Aldehyde	0.146 a	0.095 a	0.151 a	0.125 a	*0.780*
2-Hexenal	Aldehyde	0.008 b	0.017 a	0.012 ab	0.015 a	*0.124*
Heptanal	Aldehyde	0.083 a	0.037 b	0.091 a	0.055 b	*0.416*
Octanal	Aldehyde	0.174 a	0.054 b	0.160 a	0.091 b	***0.044***
Phenylacetaldehyde	Aldehyde	0.035 c	0.024 c	0.114 a	0.087 b	*0.201*
Nonanal	Aldehyde	0.138 a	0.044 d	0.098 b	0.077 c	***<0.0001***
Ethyl Acetate	Ester	2.271 a	1.687 ab	1.196 bc	0.724 c	*0.699*
Isopropyl acetate	Ester	0.006 bc	0.000 c	0.024 a	0.013 ab	*0.431*
Butyl acetate	Ester	0.312 a	0.167 b	0.040 c	0.020 c	***0.005***
Ethyl 2-butenoate	Ester	0.106 a	0.080 b	0.022 c	0.000 d	*0.628*
Ethyl 3-hydroxybutanoate	Ester	0.123 a	0.107 a	0.021 b	0.018 b	*0.505*
Ethyl hexanoate	Ester	0.017 a	0.015 a	0.000 b	0.000 b	*0.245*
(Z)-3-Hexen-1-ol acetate	Ester	0.032 a	0.014 b	0.005 b	0.005 b	***0.039***
Hexyl acetate	Ester	0.045 a	0.025 b	0.000 c	0.000 c	***0.007***
2-Phenylethyl acetate	Ester	0.282 a	0.177 b	0.000 c	0.000 c	***0.002***
Propanoic acid, 2-methyl-, 2,2-dimethyl-1-(2-hydroxy-1-methylethyl)propyl ester	Ester	0.254 a	0.278 a	0.280 a	0.155 a	*0.332*
Propanoic acid, 2-methyl-, 3-hydroxy-2,2,4-trimethylpentyl ester	Ester	0.481 a	0.381 a	0.552 a	0.291 a	*0.575*
(Z)-3-Dodecene	Hydrocarbon	0.051 a	0.026 a	0.017 a	0.037 a	*0.097*
1-Tetradecene	Hydrocarbon	0.034 a	0.025 a	0.032 a	0.034 a	*0.150*
4-Hydroxy-3-methylacetophenone	Ketone	0.000 c	0.000 c	0.220 b	0.354 a	***<0.0001***
(2E)-1-(2,6,6-Trimethyl-1,3-cyclohexadien-1-yl)-2-buten-1-one	Ketone	0.039 a	0.046 a	0.003 b	0.000 b	***0.044***

2(3H)-Furanone, dihydro-5-pentyl-	Other-Furanone	0.022 a	0.025 a	0.017 a	0.026 a	*0.302*
Chavicol	Other-Phenol	0.060 a	0.052 a	0.000 b	0.000 b	*0.219*
2,2,6-Trimethyl-6-vinyltetrahydropyran	Other-Pyran	0.008 b	0.058 a	0.000 c	0.000 c	***<0.0001***
beta-Myrcene	Terpene	0.060 a	0.117 a	0.087 a	0.127 a	*0.688*
.alpha.-Terpinene	Terpene	0.000 a	0.006 a	0.000 a	0.008 a	*0.801*
p-Cymene	Terpene	0.000 b	0.015 a	0.000 b	0.013 a	*0.097*
Linalool	Terpene (Oxygenated Terpene)	0.000 c	0.290 a	0.000 c	0.117 b	***<0.0001***
Myrcenol	Terpene (Oxygenated Terpene)	0.000 a	0.006 a	0.000 a	0.000 a	*0.099*
cis-β-Terpineol	Terpene (Oxygenated Terpene)	0.000 b	0.000 b	0.000 b	0.043 a	***<0.0001***
cis-Ocimenol	Terpene (Oxygenated Terpene)	0.003 b	0.072 a	0.000 b	0.000 b	***<0.0001***
trans-Ocimenol	Terpene (Oxygenated Terpene)	0.013 b	0.070 a	0.000 b	0.000 b	***<0.0001***
Terpinen-4-ol	Terpene (Oxygenated Terpene)	0.000 b	0.000 b	0.000 b	0.199 a	***0.015***
alpha-Terpineol	Terpene (Oxygenated Terpene)	0.000 d	0.287 b	0.175 c	0.788 a	***<0.0001***
Total		**10.5818**	**9.9172**	**7.4086**	**6.9032**	

[z] Compounds were identified on Shimadzu LabSolution (Japan) software based on mass spectral libraries using NIST2020 (National Institute of Standards and Technology, Gaithersburg, MD). A linear retention index was created using an alkane standard mix solution (C7–C20) to further confirm the molecule identifications. Ten µL of hexanal-d12 (1 µg/µL) was added to each vial as an internal standard (IS). Volatile concentrations (as µg/mL) were calculated based on IS and identified molecule peak areas, IS concentration and volume injected, and mass of berries into the vial

[y] For cold press treatments, must was pressed after crushing. For hot press treatments, must was placed in a 76-L (20-gal) steam kettle, heated to 38 °C, held for one minute, placed back into the polyethylene container, allowed to cool, and then pressed.

Table 5. Attributes evaluated by a consumer sensory panel using a nine-point hedonic scale[z] for cold and hot pressed juice made from muscadine grapes grown in Arkansas and evaluated at the University of Arkansas System Division of Agriculture (2022).

Genotype [y]	Press treatment [x]	Color	Aroma	Flavor	Sweetness	Sourness	Overall impression
AM-77	Cold press	5.06 c	5.71 a	6.09 a	5.83 ab	5.61 a	6.03 a
AM-77	Hot press	7.02 ab	6.14 a	6.05 a	6.05 a	5.61 a	6.17 a
Noble	Cold press	6.20 b	5.76 a	5.02 b	5.08 b	4.53 b	4.92 b
Noble	Hot press	7.30 a	6.11 a	4.66 b	5.29 ab	4.59 b	4.97 b
P value		***<0.0001***	*0.2842*	***<0.0001***	*0.0043*	***<0.0001***	***<0.0001***

[z] Wines were evaluated by 66 consumer panelists using a nine-point hedonic scale (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, and 9=like extremely).

[y] Means with different letters for each attribute within location are significantly different ($p<0.05$) using Tukey's Honestly Significant Difference test.

[x] For cold press treatments, must was pressed after crushing. For hot press treatments, must was placed in a 76-L (20-gal) steam kettle, heated to 38 °C, held for one minute, placed back into the polyethylene container, allowed to cool, and then pressed.

Table 6. **Percent (%) of responses for consumer sensory analysis using a collapsed five-point just-about-right (JAR) [z] scale for cold and hot pressed juice made from muscadine grapes grown in Arkansas and evaluated at the University of Arkansas System Division of Agriculture (2022).**

Genotype	Press treatment [y]	Color			Aroma			Flavor			Sweetness			Sourness		
		Not enough	JAR	Too much	Not enough	JAR	Too much	Not enough	JAR	Too much	Not enough	JAR	Too much	Not enough	JAR	Too much
AM-77	Cold press	76	23	1	35	56	9	18	70	12	11	45	44	36	56	8
AM-77	Hot press	4	82	14	15	74	11	15	62	23	24	65	11	8	55	37
Noble	Cold press	48	49	3	46	49	5	23	44	33	11	46	43	42	32	26
Noble	Hot press	2	63	35	36	55	9	11	42	47	27	38	35	32	32	36

[z] Wines were evaluated by 66 consumer panelist using a five-point JAR scale (1 = much to low; 2 = too low; 3 = JAR; 4 = too much; 5 = much too much) collapsed to Too low, JAR, and Too much.

[y] For cold press treatments, must was pressed after crushing. For hot press treatments, must was placed in a 76-L (20-gal) steam kettle, heated to 38 °C, held for one minute, placed back into the polyethylene container, allowed to cool, and then pressed.

Figure 1. **Biplot of Principle Component (PC) PC1 and PC2 explaining 91% of the variation for all significant data collected for the volatile compounds (µg/mL) for cold and hot pressed juice made from muscadine grapes grown in Arkansas and evaluated at the University of Arkansas System Division of Agriculture (2022).**