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Development of New Muscadine Wine Grapes

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Three white and five red wine muscadine grapes were selected from 6650 seedlings of FAMU's muscadine breeding program. Horticultural characteristics, wine evaluation scores, and wine browning data indicate that these selections have advanced horticultural and/or wine characteristics over premium wine cultivars Carlos and Noble, making these the new premium wine grapes in the future.

In the hot and humid environment of southeastern United States, where bunch grapes are challenged by the lethal Pierce's disease, muscadine (*Vitis rotundifolia* Michx.) industries have been important. According to the Florida Grape Grower Association (FGGA), there are about 1000 acres of muscadine grape growing in Florida. The products are aimed at both fresh and value adding markets, while wine is the most important industry. Muscadine wine production started several hundred years ago (Adams, 1985), and because of the unique taste and distinct flavor, high concentration in antioxidants such as resveratrol (Lamikanra et al., 1996), muscadine wine has been gaining popularity in recent years. Muscadine wine has become the major product of 17 Florida wineries today, according to FGGA. This growing market has been demanding the expansion of muscadine wine cultivars for the diversities of consumers. Virtually every muscadine grape could be made into wines as in old times, while only a few are commercially used to produce high quality wine products today. Good muscadine wine grapes are not only able to produce marketable or fine wines, they also need to be acceptable, or preferable by grape industries in many other aspects such as good yield, easier vineyard management, better tolerance or resistance to prevailing disease/insects, even ripening, low fruit rot rate, and stable pigments in wines (Bates et al., 1981; Mortensen and Andrew, 1981). For these reasons, only a few muscadines are eligible as wine cultivars in Florida, 'Noble' and 'Carlos' being the commercial premium wine cultivars. It is unusual for the expanding market to depend only on two wine cultivars. Therefore, improvements in yield, better growing performance, disease and insect resistance, wine quality, and stable wine color of muscadine wine grapes through breeding are necessary for the diversities in muscadine wine markets.

Materials and Methods

Wine muscadine breeding at FAMU started in the early 1990s; extensive efforts were made in developing new wine cultivars for the demanding industries in the past 17 years. The wine breeding work consists of more than 50 crosses and total 6550 selection populations.

The seedlings were first discriminated by flower sex; only confirmed self-fertile or perfect plants were selected. Their vigor, productivities, disease, even ripening, and sugar and acid contents were compared with 'Carlos' or 'Noble'. Shoot vigor was used to evaluate the vine's vigor, which is the averages of shoot length, node length, and shoot diameter of 10 random fruiting shoots from upper/outside vine canopies. Vine yield was evaluated with spur fruit weight instead of vine yield; it was expressed by the average fruit weight from 10 random spurs, which eliminated the effects of vine size and spur numbers on yield caused by age. When most of these parameters were superior to 'Carlos' or 'Noble', wines were subject to further evaluation of wine quality, otherwise the selection was rejected. Immediately after harvest, fruit rot rates, sugar and acid contents were checked; then fruits were processed. Fruit rot rates were recorded by counting the total rot fruit numbers of 100 randomly harvested fruits. Standard wine-making procedures in our laboratory were followed to ensure all wines were uniformly made and comparable. Wines were judged by a 20-person taste panel, with the standard 20-point commercial wine evaluation system. The 20 points are divided into appearance (1–3), aroma/bouquet (1–6), taste/texture (1–6), aftertaste (1–3), and overall impression (1–2). If a wine was considered a poor wine, it was discarded; similar discard was made if a wine's evaluation score was significantly lower than 'Carlos' or 'Noble'. We selected about 15 wines each year because of the above discarding procedures; only the following 8 are believed to be worthy of continuing studies and hence are reported here.

Oxidation-related browning was evaluated by keeping 500 mL of 8-month-old wines for 20 d at room temperature in 750-mL dark green wine bottles with loosely covered cork that allowed air to penetrate into the bottles. The absorbance at 420 nm was recorded with a Genesys 10-uv spectrophotometer (Rochester, NY), at 5-d intervals. Red wine was diluted 10 times with distilled water.

Results and discussion

Flowers. All selections have perfect flowers; this is a necessary characteristic for the wine industry.

Vine vigor. Vigor is an important horticultural parameter; vigorous plants are generally preferred, but it is not always obligatory. Under Florida's hot and plenty rainfall environments, excessive vegetative growth in muscadine grapes could result in poor light exposure inside the vine canopy and increasing difficulties in vine

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management are often observed. Too much vine vigor also results in poor air ventilation inside and under the vine canopy, easier spreading of disease, and eventually less accumulation in sugar and skin color pigments. Avoiding excessive vigor in plant selection is necessary, with all selections showing less vine vigor than that of 'Carlos' or 'Noble' judged by fruiting shoot length and node length (Table 1). Plant vigor is generally defined as "vigorous," "moderate," and "weak," while most muscadine grapes growing in Florida are "vigorous." This general definition is difficult to distinguish individual vines; with shoot vigor, the plant's vigor may be easily quantified and evaluated. The longer shoot length and node length of 'Carlos' and 'Noble' indicated that 'Carlos' and 'Noble' are more vigorous than most of these selections. Too much vigor in a vine means more vegetative growth and deteriorated light condition inside the vine canopy, while less vigor in a vine means better light exposure inside its canopy. Therefore, we could expect better light environments inside their vine canopies and subsequent vine performance improvements among these selections than their counterparts 'Carlos' and 'Noble'.

Spur yield ranged from 117 to 192 g per spur (Table 1). Except for FAA1-13-7, most of them were close to 'Carlos' or 'Noble'. 'Carlos' and 'Noble' are the two most productive muscadines; therefore, these selections' yields may be considered as high-yield vines.

The harvest date of these selections were later than 'Carlos' and 'Noble'; the latest, FAA27-10-9 and FAO28-7, were almost 1 month later than 'Carlos' and 'Noble' (Table 1). Later ripening enables grapes to accumulate more sugar and color pigments, enhancing wine quality, and would be preferred by wine industries.

Wine fruit parameters. Fruit size ranged from 3.5 to 6.6 g, compared with 3.5 and 5.7 g of 'Carlos' and 'Noble' fruits (Table 2), and are well within the good size ranges desired for wine grapes. Smaller fruits have more skin area than larger fruits, so do the pigment contents among red grapes. Study also indicated that skin contributed about 70% of the total resveratrol in muscadine grapes (Ector et al., 1996). The size effect on both wine pigment and antioxidants suggests good fruit size is important for wine muscadines.

The rot fruit rates of red grapes were 1% to 4%, whereas white grapes were 7% to 8%. When red selections were compared with 'Noble' and white selections compared with 'Carlos', there were no differences in fruit rot rates (Table 2).

Wine grapes grown in Florida generally contain lower sugar levels than expected, and higher sugar content is always preferred. Therefore, the sugar content of any selection must not be lower than that of 'Carlos' or 'Noble'. The average sugar contents of the white selections were 15.2% to 17.0%, while that of 'Carlos' was 15.0%, meaning that sugar contents of these white grape selections were 1% to 13% higher than those of 'Carlos'. The sugar contents were more significant between red selections and 'Noble'.The former ranged from 16.2% to 20.0% and the latter was 15.2%, which equaled 6% to 32% more sugar in these red selections (Table 2). These higher sugar contents are no doubt beneficial to wine making. Tritable acid and pH of the selections were close to 'Carlos' and/or 'Noble', within the ranges of wine grapes.

The panel evaluation scores of 1-year-old wines were close to or higher than that of 'Carlos' and 'Noble', especially the red selections FAA1-13-7, FAO19-19-8, FA0-28-7, and FAO28-22-5 (Table 2). A few wine selections showed lower evaluation scores than that of 'Carlos' and 'Noble', while several parameters of the selections such as high sugar content and relative lower shoot

Table 1. Pedigree and major horticultural characteristics of the selections.

				Fruiting shoot vigor (cm)			Fruit wt	Harvest
Selections	Pedigree	Color	Flower	Shoot length	Node length	Diam	per spur (g)	date
FAA2-1	Summit × Noble	white	perfect	103	4.0	0.42	169	21 Sept.
FAA27-10-9	Pam open 2nd generation	white	perfect	95	3.9	0.47	132	5 Oct.
FAO26-3-1	Supreme × Triumph	white	perfect	83	3.3	0.39	192	22 Sept.
Carlos				126	4.4	0.44	191	8 Sept.
FAA8-14-2	Noble × ARX#1	red	perfect	102	4.0	0.44	135	10 Sept.
FAA1-13-7	JT × S21	red	perfect	92	3.9	0.34	117	15 Sept.
FAO19-19-8	Fry open	red	perfect	88	3.6	0.42	189	21 Sept.
FAO28-7	Supreme × Tara	red	perfect	108	4.1	0.40	141	5 Oct.
FAO28-22-5	Supreme × Pineapple	red	perfect	95	3.8	0.36	153	15 Sept.
Noble		red	perfect	117	4.6	0.49	158	8 Sept.

Table 2. Fruit wines of the selections.

			SSC				
Selections	Rot fruit	Size (g)	Avg	% C/N[z]	TA	PH	Wine score
FAA2-1	4	5.0	15.2	101	0.50	3.41	9.8
FAA27-10-9	5	4.3	17.0	113	0.67	2.96	11.0
FAO26-3-1	7	6.6	15.3	102	0.74	2.89	11.8
Carlos	8	5.7	15.0	100	0.56	3.08	12.9
FAA1-13-7	2	3.5	17.2	113	0.69	3.13	14.7
FAA8-14-2	1	3.8	19.0	125	0.57	3.56	12.3
FAO19-19-8	3	4.1	16.1	106	0.63	3.00	14.2
FAO28-7	4	4.2	20.0	132	0.70	3.03	14.0
FAO28-22-5	3	5.4	16.2	107	0.72	2.85	14.0
Noble	2	3.5	15.2	100	0.60	3.00	12.9

[z]C/N: 'Carlos'/'Noble'. The SSC of white selections were compared with 'Carlos' (100); red selections were compared with 'Noble' (100).

Table 3. 420-nm absorbance of selections vs. 'Carlos' and 'Noble'.

Selections	Days					D20/D1[z]
	1	5	10	15	20	
FAA2-1	269	337	447	616	674	2.506
FAA27-10	199	243	381	485	548	2.754
FAO26-3-1	202	288	376	495	579	2.866
Carlos	196	212	353	483	556	2.837
FAA1-13-7	239	274	304	473	520	2.076
FAA8-14	277	286	339	484	534	1.928
FAB1-1-1	295	305	315	497	556	1.885
FAO19-19	236	273	304	433	483	2.047
FAO28-7	289	318	353	585	635	2.197
FAO28-22	242	301	351	474	566	2.334
Noble	240	284	329	502	537	2.238

[z]Rate of 420-nm absorbance on Day 20 to Day1.

vigor, make these selections better in corresponding traits, and worthy of continuing study. It seems these `selections could be good candidates for premium wine cultivars in the future.

There were notable increases of 420-nm absorbance with all wines during the 20-d evaluation period. The 420-nm absorbances from day 1 to day 20 of three white selections wine were 2.506 to 2.866, similar to 'Carlos's increment of 2.837. The 420-nm absorbance increments of red selections during the 20 d ranged from 1.885 to 2.334, which were also close to 'Noble's increment of 2.238 (Table 3).

The 5-d intervals data on 420-nm absorbance showed similar absorbance increase patterns among the selections 'Carlos' and 'Noble', which suggest that the browning speeds of these selections are similar to 'Carlos' and 'Noble'. These indicate there is no significant difference in oxygen-related wine browning between selections 'Carlos' and 'Noble'.

Color stability is a major concern in muscadine red wines. Among the wine grapes, 'Noble' is the only one proven to be color stable in Florida. Our red selections did not differ significantly from 'Noble' in the browning evaluation, indicating that these wines may be as stable as 'Noble' on red color fading or browning. Browning of wine is a complex process; only long-term work in the future can finally discover browning-related red color stabilities of these wine selections.

Conclusion

Developing a new wine grape is an elaborate process; high yield and high wine quality under certain growing environments must be combined. It is almost impossible to have a perfect combination; compromise on major horticultural characteristics and wine quality would be necessary. The wine evaluation scores or vine growth habits in the selections we reported here were better than those of premium wine cultivars Carlos or Noble. These selections are worthy of further study. 'Noble' is the only one to produce color-stable wine. The browning similarity between 'Noble' and red selections of different pedigrees indicated stable red color could be obtained with various sources by gene combination.

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