among small processors, for the establishment of a market for jam, jelly, and juice from muscadine grapes. However, because processors have not been able to find a reliable supply of a high quality processing muscadine cultivar, jam and jelly production generally has been limited to small specialty packs which do not require large quantities of grapes.

Cultivar Selection and Production Considerations

Developing a sound plan for marketing crops is critical to the success of any farming operation. Marketing decisions should drive the production decisions, not vice versa. It is recommended that producers identify and research marketing opportunities prior to producing a crop (Rainey, 2002).

Arkansas is the home of two of the foremost commercial processors of muscadine products, Post Familie Vineyards and Winery and Wiederkehr Wine Cellars, Inc. Other wineries such as Mount Bethel Winery and Cowie Winery also produce muscadine wines. These processors may be willing to purchase muscadines from independent growers, provided the grapes are the appropriate varieties and are produced and handled to meet company specifications. If marketing product in this way is a desirable option, then it is important to contact the processor(s) prior to planting to ensure that the varieties and production procedures will be acceptable.

Muscadine grapes are adapted to almost any well-drained, moderately fertile soil with a pH of 5.5 to 6.5. The minimum temperature the vines can withstand depends on their vine condition, as well as weather conditions prior to low temperature exposure. Fluctuations of temperatures from high to low can be as damaging as an absolute low temperature because grape vines tend to deaclimate (lose their winter hardiness). It is best to plant muscadines in regions where the temperatures rarely go lower than 0°F.

Unlike other grape species and cultivars produced in Arkansas, the width between rows in muscadine vineyards may vary from 9 to 12 feet but is usually 12 feet (Noguera et al., 2004). The minimum spacing between vines in the row is 20 feet. This 9 x 20 foot spacing only requires 242 vines per acre, significantly fewer than the 544 to 623 plants per acre (depending on species and cultivar) required for *Vitis vinifera*, *Vitis labruscana*, and French-American Hybrid cultivars. In addition to information about the number of plants needed, Noguera et al. (2004) discuss other financial considerations for establishing a grape vineyard.

There are two types of muscadine grape cultivars planted in Arkansas: pistillate, or female flowering types; and self-fertile, or perfect flowering types (Noguera et al., 2004). The pistillate vines have flowers that produce only ovaries (fruit) and contain no anthers or pollen. Pollen for these female flowering vines must be provided by interplanting these types with self-fertile plants.

The self-fertile vines have both ovaries (fruit) and pollen and can pollinate themselves as well as the female-flowered cultivars.

Muscadine clusters are usually small, containing 6 to 24 berries (Ahmedullah and Himelrick, 1989). Unlike other grapes, mature berries generally do not adhere to the stems. Characteristics of the resulting stem scar are important in determining berry quality and storage life. A wet stem scar may develop when the cap stem or pedicel does not clearly separate from the berry. Wet stem scars provide a site for easy access of spoilage organisms and therefore may lead to premature spoilage. The percentage of berries with dry stem scars is higher for some cultivars than for others (see Table 1). Berries that are fully mature when harvested usually have a dry stem scar, whereas those harvested before they are fully ripe will tend to have a wet stem scar.

The selection of cultivars depends on the proposed use of the grapes. For example, high yields and a dry scar are important for fresh market uses, while high yield of flavorful juice is important for processing grapes into juice, jelly, and wine. In a study by Flora (1977), consumers preferred the color of juice and jelly from black cultivars to those from bronze grapes; but the flavor of products from the bronze grapes was preferred. Browning occurred more rapidly in the red juices held at room temperature than in the lighter products, suggesting that juices from dark grapes should be refrigerated to maintain juice quality.

Carlos and Noble cultivars have been commercially planted for juice and wine production in Arkansas. Carlos is a bronze cultivar of excellent quality and aromatic flavor; it ripens fairly uniformly and produces quality wine. The plant is vigorous, open, upright in growth, productive, and somewhat hardier than most other popular cultivars. It is suitable for mechanical harvesting. Noble is a dark cultivar that is relatively winter hardy and makes a quality red wine. Noble ripens uniformly and is adapted to mechanical harvesting. Both of these cultivars have perfect flowers and are self-fertile. Nesbitt, Summit, and Black Beauty are some fresh market cultivars that have been made into successful juice products. Summit and Black Beauty cultivars do not have perfect flowers.

Muscadine production guides have been developed to assist farmers in establishing and maintaining vineyards in Arkansas (Morris, 1971), Florida (Andersen and Crocker, 1994), Georgia (Krewer et al., 1999), and North Carolina (Poling et al., 2003). In studies designed to evaluate the characteristics of muscadine cultivars for growth potential in Arkansas, it was found that there are significant differences in the cultivars. Table 1 provides a summary of the characteristics of muscadine cultivars showing potential for cultivation in the state.

Table 1. Characteristics of muscadine cultivars found feasible for production in Arkansas. Performance can vary substantially in response to site, climate, and other environmental and biological factors. Cultivars marked with an * are recommended for growers in the southwestern part of the state and areas with similar climates (Adapted from Clark, 2001; Mortensen, 2001; Carter et al., 2001; Striegler et al., 2004).

-)	
	Flower		% Dry		Disease	Cold		Sugar	
Cultivar	Туре	Berry Wt.	S tem S car	Yield	Resist.	Hardiness*	Flavor	Content	Uses
Black Cultivars									
Black Beauty*	д	ΛΓ	Μ	Н	1 44	G-VG	ы	M	F, F
Cowart	v	M	Μ	H-M	Œ	F-G	ტ	M	면
Lon	v	П	Μ	н	ы	ტ	ტ	M	F.
Jumbo	д	ΛΓ	Μ	M	ტ	ᄄ	ტ	ᆸ	F.
NC67AD15-17*	v	v	ΔΛ	Н	No data	No data	ഥ	M	F,P
NC67A015-26*	v	Δ	ΔΛ	н	No data	No data	ы	н	F.
Nesbitt*	v	П	Ω	M	ΔV	ᄕ	ΔS	M	면
Southern Home*	v	M	Ω	ᆸ	ഥ	Œ	ტ	H	д
Sugargate	д	ΛΓ	Μ	ΛΓ	Ę.	Д	ы	ΛH	ഥ
Supreme*	д	ΛΓ	Μ	NΗ	ΔV	ტ	FI	M	F, F
Bronze Cultivars									
Carlos*	v	i/s	ΔΛ	н	ტ	ㅂ	ტ	ᆸ	д
Doreen	w	iv:	Μ	н	ტ	ტ	ტ	ΛH	д
Early Fry	д	П	Μ	NΗ	ტ	ტ	ტ	н	ᄕ
Fry	д	ΛΓ	MΛ	M	124	P.F	ы	M	Ē
Granny Val*	v	ı	Д	ΝН	P.G	면	ტ	ΛΓ	ᅜ
Late Fry	v	ı	ΔΛ	н	ы	떠	ტ	ΛH	ഥ
Scarlet	д	П	Ω	Н	ΔV	ტ	ΔV	н	F, E
Sterling	v	v	W	M	ΔC	ㅂ	Ŀ	M	Д
Summit*	д	u	Д	н	9A-9	Ŀı	اب ئ	Ħ	ᅜ
Tara	v	ΛΓ	ΔΛ	M	ტ	Ŀ	ტ	Ħ	다 다
Triamph	v	M	ΔV	M	F.G	Д,	ტ	н	F.

Flower type: S= self-finited or perfect flowered. P= pixiliste or female-flowered. If pixiliste cultivars are planted, one or more self-finited cultivars must also be planted to provide polber.

^{&#}x27;Berry weight (giberry); VS = 2.8.40; S = 4.160; M = 6.1-7.9; L = 8.0.94; VL > 9.4

[&]quot;Yield (bahine): VH > 80; H = 61-80; M = 46-60; L = 31-45; VL < 30 " "Day Stem Scor: VD > \$5; D = 71.85; W = 51.70; VW < 50

Disease Resistance, Cold Hardness, and Flavor: $P=\mathbf{poor}$; $F=\mathbf{fair}$; $G=\mathbf{good}$; $VG=\mathbf{very}$ good: $E=\mathbf{excellent}$

Sugar Content (74): VH > 18.5; H = 17.4-18.5; M = 16.1-173; L = 14.6-160; VL < 14.6

^{&#}x27; Uses: F = fresh market; P = processing

Harvest and Postharvest Factors Influencing Quality

With muscadines, as with all grapes, flavor is dependent on the chemical composition at harvest (Lanier and Morris, 1978a). It is crucial that the grapes be harvested at their optimum maturity to produce a high quality product. While much is known about the ripening process for other species of grapes, little attention has been given to the changes muscadine grapes undergo during ripening.

Muscadines are usually harvested when the pH reaches 3.2 and soluble solids (sugar levels) range from 15 to 19% (Ahmedullah and Himelrick, 1989). However, many cultivars of muscadines do not ripen uniformly, and a range of ripeness is present during the entire harvest period. Cultivar selection helps lessen this problem, but it is not a total solution.

In a study designed to define the changes that occur in muscadines as they ripen, Lanier and Morris (1978a) evaluated the composition of Carlos and Noble grapes harvested at one week intervals throughout the harvest season. Results of this study indicated that maturation of both cultivars was marked by an increase in soluble solids, a decrease in titratable acidity, a disappearance of green color in Carlos, and an increase in red color in Noble.

The concept of vineyard mechanization is gaining acceptance as a means of combating rising labor costs and helping assure the long-term prosperity of the U.S. grape industry (Morris, 2004). Mechanization of muscadine vineyards is a challenge because of the abscission layer that forms as the berries mature (Morris and Striegler, 1996). With some cultivars, this layer is so complete that the ripe fruit drops in advance of the mechanical harvester's collecting mechanism. University of Arkansas researchers have adapted grape mechanical harvesters to make them suitable for use with muscadines. A collecting unit that adapts to the front of any conventional commercial grape harvester prevents the loss of highly mature fruit. Since the fruit of most muscadine cultivars is easily removed, one set of beater rods is adequate to remove all fruit. Elimination of the front, or first set, of beater rods on a mechanical harvester prevents loss of mature fruit in advance of the harvester.

Muscadines generally ripen unevenly. This is a desirable characteristic when growing fruit for fresh markets since there is ripe fruit on the vine for up to five weeks (Striegler et al., 2004). The lack of uniform ripening is a problem when using once-over machine harvesting (Morris, 1980). The presence of immature fruit in a once-over harvest is undesirable since it lowers the quality of processed products. Cultivars are available that ripen more uniformly and therefore are better for machine harvesting.

Lanier and Morris (1978b) developed a density sorting system for separating mechanically harvested muscadine grapes into maturity classes. Fruit separation is accomplished by flotation in salt solutions of 8, 9, 10, and 11%.

The separation procedure yields five density grades (Figure 5). Fruit is poured into the 8% solution, and the fruit that floats is removed and rinsed twice with fresh water; this fruit is classed as density/maturity grade 1. The fruit that sinks in 8% brine is transferred to the 9% solution. Floating fruit is removed, rinsed, and classed as density/maturity grade 2. This procedure is repeated for the 10 and 11% brine solutions, with floating fruit being classed as density/maturity grades 3 and 4, respectively. Fruit that still fails to float in the 11% brine is rinsed and classed as density/maturity grade 5.

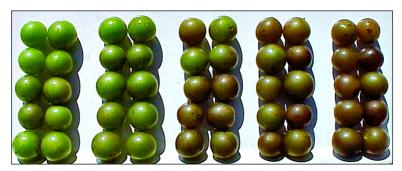


Figure 5. Density separation of muscadine fruit yields five density grades which UA research has shown to correspond to five levels of ripeness (Lanier and Morris, 1979).

Evaluation of berry color and sugar and acid contents showed that fruit ripeness increased with increasing density (Lanier and Morris, 1979; Walker et al., 2001). Since sugars increase and acids decrease during the normal ripening of grapes, percent soluble solids and tartaric acid are two parameters commonly used to determine grape maturity. As fruit density increased, there was a corresponding increase in percent soluble solids and a decrease in titratable acidity, expressed as percent tartaric acid (Tables 2 and 3).

Table 2. Quality factors from Carlos muscadine grapes from five density/maturity grades (Lanier and Morris, 1979).

Density	Soluble	Tartaric	Berry		Sensory Scores	1
Grade	Solids (%)	Acid (%)	Weight (g)	Flavor	Aroma	Color
1	8.0	1.87	2.69	1.0	1.9	1.7
2	10.1	1.41	3.58	2.1	2.8	3.2
3	12.0	0.96	4.41	4.3	5.1	5.7
4	12.9	0.96	4.67	6.2	6.7	7.0
5	15.0	0.92	4.18	7.8	9.0	8.7
LSD@5%	.3	0.09	0.22	0.6	0.9	0.7

Scale: 10 = Excellent, 5 = Acceptable

Another quality attribute that can be used to judge ripeness within certain cultivars is berry weight. As the berries became more dense, berry weight increased to a maximum in density grade 4, then decreased in density grade 5 (Table 2). When the berries from these density grades were observed, it was apparent that density grade 5 berries were over-ripe to the point that they were starting to dehydrate and shrivel, as opposed to grapes from density grade 4 that were still turgid (Table 2). For all sensory attributes, there was a significant increase in acceptance with each increase in density grade.

In studies designed to further evaluate the effectiveness of density separation, Walker et al. (2001) found that this method successfully sorted Fry muscadines into maturity levels (Table 3). Sensory analysis revealed that grapes from maturity level 1 were more firm, less sweet, and more sour than those from level 5. Panelists had difficulty ranking sweetness and sourness for levels 2-4.

Table 3. Quality factors of Fry muscadine grapes from 5 density/maturity grades (Walker et al., 2001).

Maturity	Soluble Solids ¹	Tartaric Acid	pН	Firmness		Sensory Ratings ¹ (Rank sums ²)		
Level	(%)	(%)		(Newtons)	Firmness	Sweetness	Sourness	
1	14.2e	0.65	3.33	10.01a	56b	123a	68bc	
2	15.2d	0.59	3.39	9.51ab	90a	92ab	98ab	
3	15.8c	0.57	3.41	9.16b	103a	63b	114a	
4	17.0b	0.59	3.42	8.88b	91a	102a	66c	
5	19.5a	0.58	3.46	7.97c	114a	70b	104a	

 $^{^{\}rm I}$ Means within a column not followed by the same letter are significantly different P[] 0.05

Density separation is a rapid and inexpensive method of removing fruit of undesirable maturity. The spherical shape of the muscadine berry and the relatively small variation in its fruit size make it ideal for mass density sorting.

Good management of temperature and humidity is the single most important factor in determining the ultimate quality of fresh muscadines (Morris and Brady, 2004). For optimum quality, product deterioration must be slowed as much as possible. This is best achieved by slowing respiration (Mitchell, 1991). One way to do this is to lower the temperature. As a general rule, each 18°F (10°C) reduction in temperature lowers respiration rate by a factor of two to four. This can have a significant effect on maintaining quality of muscadines. For optimum quality, pre-cooling with forced air to 36°F or lower within twelve hours of harvest is recommended (Perkins-Veazie, 2002).

Direct Markets

According to market research, harvested muscadine grapes must have a mini-

²Low rank sum values indicate the most firm, sweet, and sour fruit