

The Muscadine Experience:



Justin R. Morris
& Pamela L. Brady

Adding Value to Enhance Profits

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The Muscadine Experience: Adding Value to Enhance Profits

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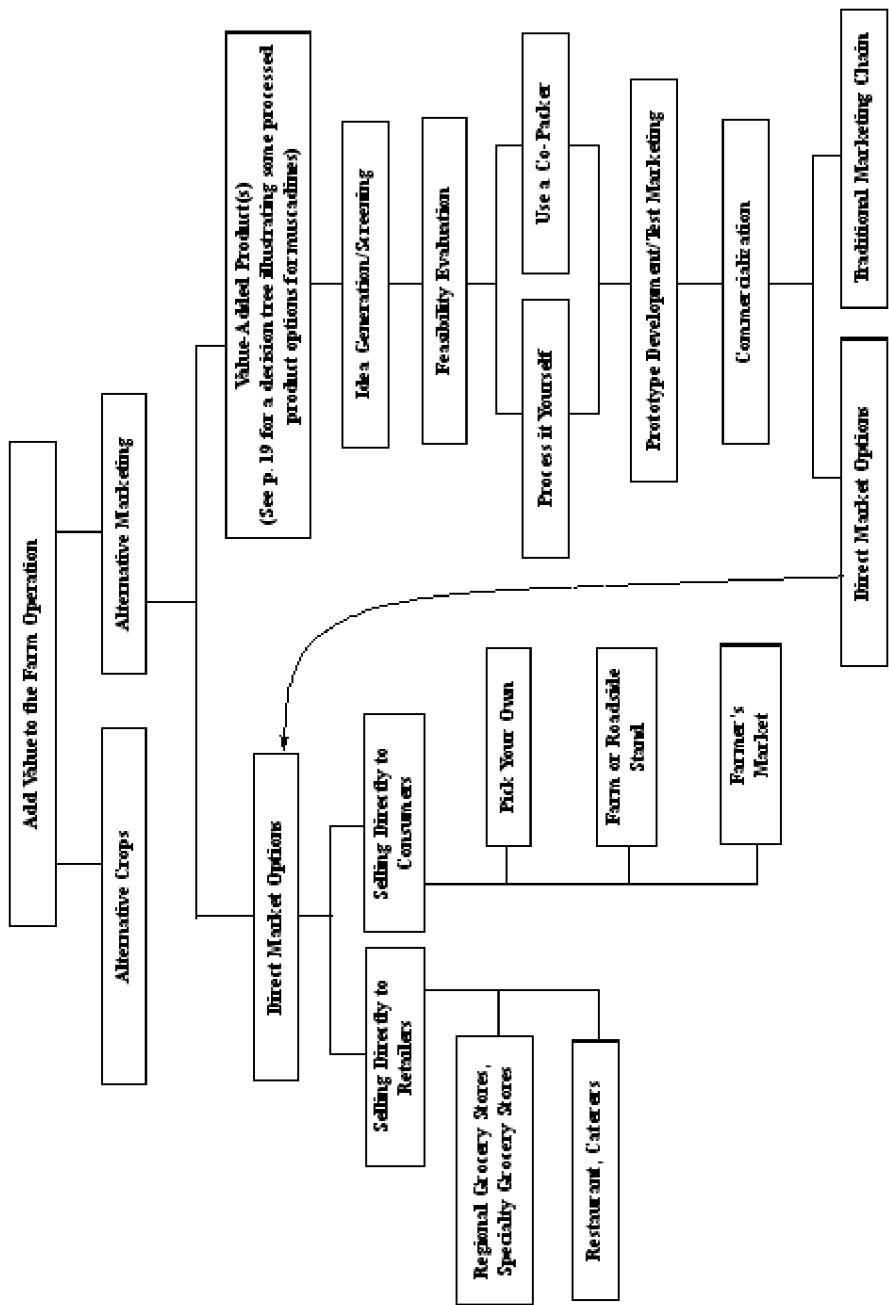
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Impact Statement

The University of Arkansas Division of Agriculture received a grant from the USDA's Initiative for Future Agriculture and Food Systems (IFAFS) program. The purpose was to help small- and medium-sized farmers and entrepreneurs become more profitable and therefore add stability to the family farm. One approach to doing this is to investigate opportunities to enhance profits by adding value to traditional raw products.

This publication looks at efforts by the UA Grape and Wine Research Program to enhance the profitability of muscadine grapes, an alternative agricultural product. Included are discussions of research designed to develop the market potential of muscadines as fresh fruit and as value-added products such as juice, wine, sweet spreads, vinegar, and dried products. The skin and seeds of muscadines have traditionally been considered waste; however, recent research has shown that they contain nutraceutical components. Reports are included of research to quantify these nutraceuticals and to develop products containing them.

Figure 1. Decision Tree for Adding Value to a Farming Operation



Forward

Historically, agriculture has been a major contributor to the economy of the state of Arkansas. The state ranks eleventh in the nation in total value of agricultural products sold, but first in the nation in the production of rice, second in broilers, fourth in turkeys, and seventh in soybeans and grapes. Despite the agricultural success of the state, as a whole, many farmers with small- and medium-sized farms have found it very difficult to make a living from these farms and are looking for alternative agricultural activities to increase farm income.

For many small farmers, increasing profitability may result from the development of nontraditional agricultural enterprises. Although most farmers think mainly in terms of raising conventional crops like rice, soybeans, horticultural products, poultry, or cattle, and marketing these through established channels, nontraditional crops, markets, and/or adding value to products may be the key to success in today's agriculture.

The University of Arkansas, Division of Agriculture, was the recipient of a grant from the USDA's Initiative for Future Agriculture and Food Systems (IFAFS) program. The purpose of the work funded by this grant was to provide research and training to assist small- and medium-sized farmers in the state in becoming more profitable and therefore to add stability to the family farm. One approach to doing this is to help identify alternatives to traditional farming operations. In the IFAFS publication entitled, "The Importance and Role of Value-Added in the Profitability of a Farming Operation," (Thomsen et al., 2004) a decision tree approach is used as a framework for discussing many of the factors involved in undertaking a new agricultural enterprise (Figure 1).

The concept of adding value to muscadine grapes, a nontraditional horticultural crop, is explored in this publication. The publication reviews research findings from University of Arkansas Division of Agriculture work on growing, marketing, and processing muscadine grapes. It is not intended as a "how-to" book on muscadines, but rather uses muscadines as an illustration of the kinds of information a farmer would need to collect to establish a nontraditional, value-added agricultural enterprise. Appendices contain more detailed information on the technology of muscadine grape processing, offer suggestions to help in developing value-added muscadine products, provide lists of helpful resources for those exploring alternative agricultural activities, and include a glossary of scientific and technical terms used in the text.

Introduction

The production of alternative or nontraditional crops is being explored by many small farmers as a way of increasing the value of their farming operations. Although these crops are usually in fairly low demand, they are especially suited for growing on farms with limited acreage and for use in niche markets.

Muscadines (*Vitis rotundifolia* Michx.) are grapes native to Arkansas that have tremendous undeveloped market potential as fresh fruit, in processed products, and for the production of nutraceuticals. Muscadines have the advantage of not being as seriously affected by disease or insects as other grape species grown in the South; therefore they can be produced with approximately one-half the sprays required by French-American Hybrid or *Vitis labruscana* grapes. There has been interest from Arkansas wineries in expanding commercial plantings of muscadine grapes in central and southern Arkansas regions where these grapes can be successfully produced.



Figure 2.
Muscadines are native to Arkansas and have tremendous undeveloped market potential.

For a number of years, the Grape and Wine Research Program in the Division of Agriculture, University of Arkansas, has been involved in work to identify the muscadine cultivars most suitable to commercial production in Arkansas, appropriate handling of these grapes, formulation and production of products from them, and markets for both fresh fruit and processed products. Because approximately 40% of the muscadine fruit is skin and seed, typically considered waste products, efforts are currently underway by some to develop seedless muscadines. Another alternative to reducing the percentage of the fruit that is lost as waste has been to identify uses for the press fraction from muscadine processing. In recent years it has been found that muscadine seeds and skins contain a number of components--nutraceuticals--which benefit human health. Research to further identify the nutraceutical materials present in mus-

cadine seeds and skins and ways to use and market these waste products is ongoing.

The Muscadine Grape

Few individuals outside of the southern United States are familiar with muscadine grapes (*Vitis rotundifolia*) since they are native to the southeast United States and not marketed widely in other parts of the country. The grapes have thick skins, large seeds, and a unique, soft, musky-flavored pulp. Cultivars vary in color from almost white, referred to as bronze, to pink, red, blue, purple, and nearly black. Common names for dark-fruited muscadines include bullace, bull grape, and bullet grape (Olien, 2001). The term “scuppernong,” often used to refer to all bronze-fruited varieties, is actually the name of a specific muscadine cultivar.

North Carolina claims credit as the place where muscadines were first discovered, citing a 1524 log book of French navigator Giovanni de Verrazano, who was exploring the Cape Fear River Valley, as the first recorded account of the grapes (Anon, 2000). A popular legend credits Sir Walter Raleigh’s colony with discovering the Scuppernong “mother-vine” on Roanoke Island in 1584 and spreading cuttings from it widely, including to the area of the Scuppernong River where, in 1811, it was identified in a newspaper report as the “Scuppernong grape.” Other authorities believe the first discovery of muscadines occurred in the mid-18th century along the Scuppernong River and that cuttings from this planting were eventually carried to Roanoke Island, where they became known as the “mother-vine” (Olien, 2001). Although the grape’s history is somewhat unclear, it is known that there is a vine on Roanoke Island that has been in continuous cultivation for nearly 200 years, and today this historic vine has a trunk over two feet thick and covers half an acre.

Figure 3.
Muscadine cultivars vary in color from almost white or bronze to nearly black.



Muscadine grapes need a long growing season since they usually require 100 days on the vine to mature the fruit (Olien, 2002). They grow best on fertile, sandy loams and alluvial soils and grow poorly on wet or heavy soils.

Muscadines are native to the region from Virginia to East Texas and south (Figure 4).

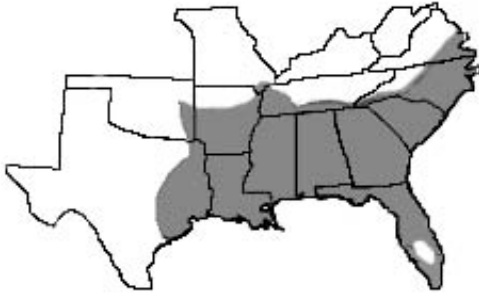


Figure 4.
Areas in gray
represent
regions of natu-
ral muscadines
distribution
(Modified from
Olien, 2002).

Although muscadines grow wild throughout Arkansas (except in the northern counties), they were not produced commercially in the state until 1972 (Moore, 1972). Figures are not available regarding the total acreage of muscadine production in Arkansas; however, it is known that muscadine processing is occurring in Altus, in the Arkansas River Valley (Clark, 2001), and that there are commercial plantings for fresh market sales in several counties, most notably White County.

The flavor and aroma of muscadine grapes are completely different from that of other grapes. The thick skins and seediness of the fruit along with their unique sensory characteristics are sometimes considered unappealing to consumers unfamiliar with these grapes (Leong, 2001). However, consumers who are accustomed to muscadines, or who have developed a taste for them, report that their unique characteristics make them a welcome alternative to the better known “California types” of grapes, giving them a unique niche in the grape market.

Those thinking about starting a muscadine vineyard should be aware that they will face a number of marketing challenges unique to these grapes (Leong, 2001). These include:

- lack of consumer familiarity with muscadines and muscadine products, requiring consumer education and market development;
- a restricted market for fresh fruit due to perishability issues and low demand in nontraditional marketing areas;
- inadequate formal market standards to associate price and quality.

Processing muscadines offers marketing alternatives for the fruit, but the production of muscadine grape products is small compared to that of Concord grapes. Wine continues to be a major market for muscadine grapes in the South. In recent years there has been an increase in interest, especially

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 deacclimate (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).

Cultivar	Flower Type ^a	Berry Wt. ^b	% Dry Stem Scar ^c	Yield ^d	Disease Resist. ^e	Cold Hardiness ^f	Flavor ^g	Sugar Content ^h	Uses ⁱ
Black Cultivars									
Black Beauty*	P	VL	W	H	F	G-VG	E	M	F,P
Cowart	S	M	W	M-H	F	F-G	G	M	F,P
Leon	S	L	W	H	E	G	G	M	F,P
Junco	P	VL	W	M	G	F	G	L	F,P
NC67A015-17*	S	S	VD	H	No data	No data	E	M	F,P
NC67A015-26*	S	VS	VD	H	No data	No data	E	H	F,P
Nebitt*	S	L	D	M	VG	F	VG	M	F,P
Southern Home*	S	M	D	L	E	F	G	H	F
Sugargate	P	VL	W	VL	F-G	P	E	VH	F
Supreme*	P	VL	W	VH	VG	G	E	M	F,P
Bronze Cultivars									
Carlos*	S	S	VD	H	G	E	G	L	P
Doneen	S	S	W	H	G	G	G	VH	P
Early Fry	P	L	W	VH	G	G	G	H	F
Fry	P	VL	VW	M	F	P-F	E	F	F
Gianry Val*	S	L	D	VH	F-G	P-F	G	VL	F,P
Late Fry	S	L	VD	H	E	E	G	VH	F
Scarlet	P	L	D	H	VG	G	VG	H	F,P
Sterling	S	S	W	M	VG	E	E	M	P
Summit*	P	L	D	H	G-VG	F	G-F	H	F,P
Tara	S	VL	VD	M	G	F	G	H	F,P
Triumph	S	M	VD	M	F-G	P	G	H	F,P

* Flower type: S = self-fertile or perfect flowered, P = pistillate or female-flowered. If pistillate cultivars are planted, one or more self-fertile cultivars must also be planted to provide pollen.

^b Berry weight (g/berry): VS = 28-40; S = 41-60; M = 61-70; L = 80-94; VL > 94

^c % Dry Stem Scar: VD > 85; D = 71-85; W = 51-70; VW < 50

^d Yield (bushes): VH > 80; H = 61-80; M = 46-60; L = 31-45; VL < 30

^e Disease Resistance, Cold Hardiness, and Flavor: P = poor; F = fair; G = good; VG = very good; E = excellent

^f Sugar Content (%): VH > 18.5; H = 17.4-18.5; M = 16.1-17.3; L = 14.6-16.0; VL < 14.6

^g 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.

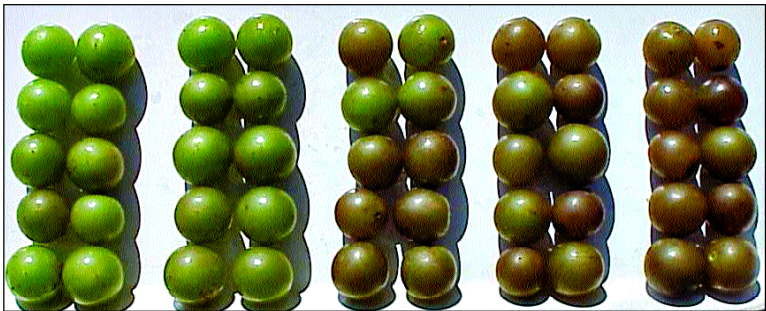


Figure 5. Density separation of muscadine fruit yields five density grades which UA research has shown to correspond to five levels of ripeness (Lanier and Morris, 1979).

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 Grade	Soluble Solids (%)	Tartaric Acid (%)	Berry Weight (g)	Sensory Scores ¹		
				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

¹Scale: 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 Level	Soluble Solids ¹ (%)	Tartaric Acid (%)	pH	Firmness (Newtons)	Sensory Ratings ¹ (Rank sums ²)		
					Firmness	Sweetness	Sourness
1	14.2c	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

¹ Means within a column not followed by the same letter are significantly different $P \leq 0.05$

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

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-

imum storage life of eight weeks to be competitive with other grape varieties for fresh market sales (Morris, 1980). However, muscadines generally have a much shorter storage life since they are highly perishable and have a very short harvest season.

Many factors affect the commercial acceptability of fresh market muscadines. These include fruit maturity, size, skin thickness, and berry integrity. Grapes with a wet stem scar have a much shorter market life since this is an ideal entry point for microorganisms (Ballenger and Nesbitt, 1982).

In research at the University of Arkansas, it was found that, without refrigeration, the shelf life of muscadines is only a few days. This could be lengthened to one to two weeks by refrigerating at 34°F and to almost four weeks by placing the fruit in polyethylene (plastic) storage bags in the refrigerator (Main et al., 1995). These findings were confirmed by Ballenger and Nesbitt (1998), who found that Carlos muscadines decay twice as fast at 68°F as at 50°F and three times as fast at 50°F as at 32°F. They also observed that muscadines with wet stem scars stored for one week at 50°F or three weeks at 32°F have six to ten times more decay than grapes with dry stem scars.

Research has shown that muscadines can be stored for at least six weeks under proper controlled atmosphere (CA) conditions (Himelrick, 2003). Storage conditions that result in maximum storage life are: temperature 34° to 36°F; relative humidity 90 to 95%; oxygen (O₂) 5%; carbon dioxide (CO₂) 15%; nitrogen (N₂) 80%; and air circulation of 25 cfm/ton.

Walker et al. (2001) looked at changes that occurred in Fry muscadines during a six week storage period (Table 4). As storage time increased, soluble solids and firmness decreased. Percent decay increased with increasing time in storage.

Table 4. Effect of storage time on Fry muscadine grapes stored at 35.6°F (Walker et al., 2001).

Storage (weeks)	Soluble Solids (SS) (%)	pH	Titratable Acidity (tartaric %)	Ripeness Index (SS x pH)	Decay (%)	Firmness (Newtons)
0	17.09a ¹	3.41	0.57	199.7a	0	10.35a
2	16.35b	3.41	0.57	191.0b	19.2	9.04b
4	15.97c	3.41	0.63	186.2c	25.7	8.55b
6	15.83c	3.38	0.61	181.7d	42.4	8.47b

¹ Means within a column followed by a different letter are different $p \leq 0.05$.

Value Added Products

Value-added food products are commodities whose value has been increased through the addition of ingredients or processes that make them more attractive to the buyer and/or more readily usable by the consumer. More

income may be obtained from a crop if a farmer can identify innovative ways to add value to it so that the farmer is able to receive a bigger share of the consumer dollar.

It should be noted, however, that value-added agricultural activities do not increase commodity prices; rather, they add value to products by performing activities usually done by others (Ellerman et al., 2001). The added value is reflected in higher market prices. The benefit to the farmer comes if the value is added at the farm level so that the added value of the product is received at the farm level, not by someone else.

Adding value to muscadines may be as simple as creatively packaging the grapes. This might be washing and packaging the fruit for a ready-to-eat snack or placing the fruit in a decorative container either alone or with other fresh fruit as a “farm fresh gift basket.”

Production of some value-added products goes beyond the simple steps of washing or creative packaging and may require processing the muscadines into new, very different forms. There are a number of value-added processed products that can be produced from muscadines. Figure 6 presents, in a decision-tree format, some of the options for processed muscadine products. Details of the technology of the actual preparation procedures for products identified with an asterisk on the decision tree are presented in Appendix A.

Juice

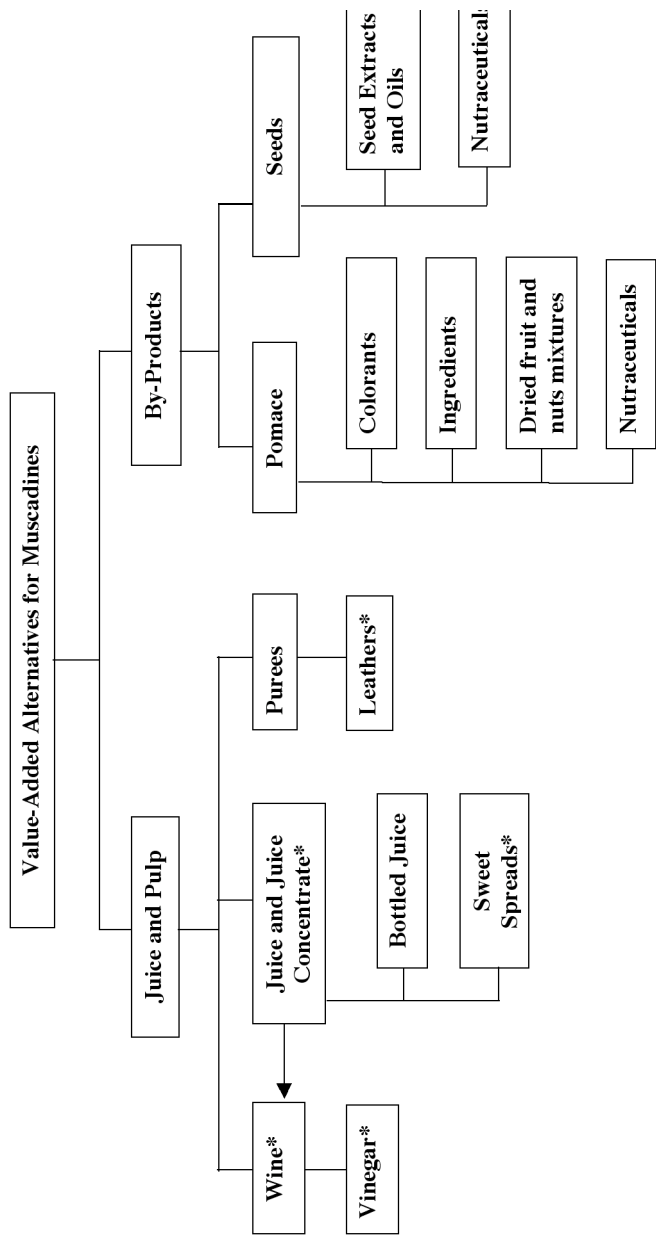
Muscadine juice has a unique flavor and bouquet. Scuppernong, a white muscadine grape, and Hunt, a red cultivar, were two of the original varieties used for processing juice for local consumption. High quality juices have also been produced from Creek, Dulcet, Yuga (Murphy et al., 1938), Noble, and Carlos (Sistrunk and Morris, 1982) cultivars.

Changes that occur in muscadine grapes during growth and maturation determine the quality of the juice (Bates, et al., 2001). Flavor and aroma develop during the ripening process. In general, as the fruit matures, sugars and color increase and pH and titratable acidity decrease.

The composition of muscadine grape juice is similar to that of the whole grapes except that the fiber (predominantly in the skins) and oils (predominantly in the seeds) are removed (Bates et al., 2001). The quality of grape juice depends to a great extent on the sugar level, acid content and flavor constituents. Glucose and fructose are the major sugars in grape juice. Other flavor components are acids, volatile esters, and aldehydes.

The specific composition of the juice from any cultivar varies from year to year and changes continually during ripening. The composition of a specific cultivar will also vary from one area of growth to another and from one vine-

Figure 6. Decision tree for some of the choices for processed muscadine products.



* Information on the technology of producing this product is provided in Appendix A.

yard to another since composition is affected by soil, climatic conditions, and vineyard management practices.

Color of muscadine juice is largely the result of anthocyanin pigments located in or near the skin. Different cultivars have different types and amounts of these pigments. This affects suitability of the cultivar for processing since it determines the color stability in processed products.

Carlos and Noble are representative of the muscadine grapes grown commercially in Arkansas (Sistrunk and Morris, 1982). Both have a good flavor and ripen evenly, making them adaptable for mechanical harvest. Carlos is bronze-skinned, and juice made from this cultivar has lower soluble solids, pH, and total phenols but higher titratable acidity than that from the black-skinned Noble variety (Table 5). No significant differences in the sensory quality characteristics of juices from these two cultivars were found except in color.

Table 5. Effect of cultivar on quality attributes of muscadine juice (Sistrunk and Morris, 1982).

Cultivar ¹	Soluble	Titratable	pH	Total	Sensory Attributes ²			
	Solids (%)	Acidity (%)		Phenols (%)	Color	Flavor	Lack of Browning	Overall Acceptance
Noble	14.1a	.688a	2.92a	.219a	7.12a	5.19a	7.36a	6.48a
Carlos	13.0b	.763b	2.89b	.105b	6.40b	5.19a	7.38a	6.34a

¹ Means within a column not followed by the same letter are significantly different by Duncan's Multiple Range test, 5% level

² Sensory rating conducted by a 12- to 15-member panel on a scale of 10 (best) to 1 (poorest)

Juice Production

The process for preparing juice from muscadine grapes is outlined in Appendix A. One limitation of producing juice from muscadines is poor yield. Muscadines yield about 130 gallons of juice per ton while other grapes average 180 gal/ton (Ahmedullah and Himelrick, 1989).

Muscadine juice can be extracted using either a hot-press or a cold-press technique. Threlfall et al. (2004) compared the juice yields of Black Beauty muscadines with those of Sunbelt (*Vitis labrusca* L.) grapes. Sunbelt is a large blue-colored grape that was developed by the University of Arkansas. It is similar to Concord in most plant and fruit characteristics, but it ripens more evenly (Moore et al., 1993). Sunbelt juice quality has been shown to be equal to or better than Concord. Juice was pressed from the grapes using either a hot-press method or by cold pressing (Table 6). Juice yields were greater from Sunbelt grapes than from the Black Beauty, and within cultivars, yields were greater with hot pressing than with cold.

Table 6. Juice yields from different processing treatments of Black Beauty and Sunbelt grapes (Threlfall et al., 2004).

Cultivar	Press Treatment	Juice Yield (gal/ton)
Black Beauty	Cold	127.5
	Hot	169.5
Sunbelt	Cold	152.1
	Hot	188.3

A comparison of juices extracted from three muscadine cultivars by either hot or cold pressing showed that extraction temperature has a significant effect on all quality characteristics for each of the cultivars tested (Threlfall, 2002). As shown in Figure 7, hot-pressed juice had better color than cold-pressed samples. The hot-press method also yielded more juice (See Table 7) than cold pressing. Within a cultivar, pressing method had no effect on soluble solids but did cause significant differences in pH and color density.

Table 7. Effect of pressing method on juice yields and quality attributes (Threlfall, 2002).

Variety	Press Method	Yield (gal/ton)	°Brix	pH	Color Density
Black Beauty	Hot	145	16.8b	3.19c	5.42c
	Cold	125	16.8b	3.29a	0.40ef
Carlos	Hot	144	14.6d	2.81h	0.78e
	Cold	120	14.7d	3.01g	0.15f
Nesbitt	Hot	139	16.9e	3.08f	7.08b
	Cold	125	15.6e	3.12e	0.43ef

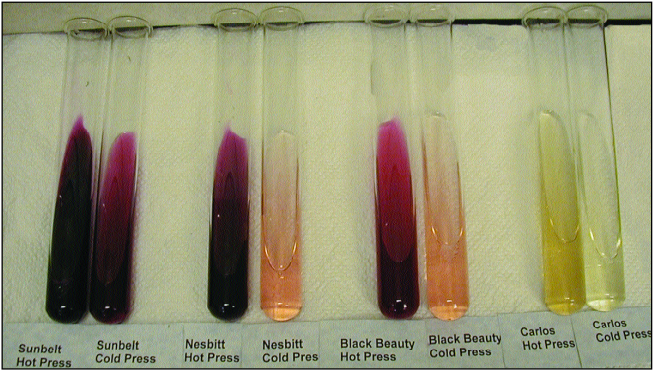


Figure 7. A comparison of the effect of extraction method on the color of juice from Sunbelt and three cultivars of muscadine (L to R. Sunbelt, Nesbitt, Black Beauty, and Carlos). Tubes on the left in each pair contain hot-pressed juice; tubes on the right were cold pressed (Threlfall, 2002).

In a study looking at juices from Carlos and Noble muscadines, extraction temperature had a significant effect on all quality parameters (Sistrunk and Morris, 1982). The lots extracted at higher temperatures were higher in acidity and total phenols, but lower in pH. Soluble solids were lowest when grapes were extracted at 140°F (Table 8). Color was darkest in juice from the 176°F extraction. Browning increased with increased extraction temperature. Crushing the grapes and adding polygalacturonase and SO₂, followed by holding the grapes for 24 hr at room temperature prior to low temperature extraction, resulted in juice with good color and flavor.

A sensory panel rated the juice extracted at 140°F high best for color (Table 8), although flavor and overall acceptance scores were not significantly different from juice extracted at 75°F (Sistrunk and Morris, 1982). Apparently, the more intense flavor and greater browning of juice extracted at 176°F were disliked by the panelists.

Table 8. Effect of extraction temperature on quality attributes of muscadine juice (Sistrunk and Morris, 1982).

Extraction Temperature ¹ (°F)	Soluble Solids (%)	Titratable Acidity (%)	pH	Total Phenols (%)	Sensory Attributes ²			
					Color	Flavor	Lack of Browning	Overall Acceptance
75°	13.8a	.699b	2.93a	.144c	6.66b	6.40a	7.77a	6.61a
140°	13.2b	.734a	2.90b	.156b	6.90a	6.24a	7.39b	6.48a
176°	13.6a	.743a	2.87c	.176a	6.71b	5.92b	6.95c	6.15b

¹ Means within a column not followed by the same letter are significantly different by Duncan's Multiple Range test, 5% level

² Sensory rating conducted by a 12- to 15-member panel on a scale of 10 (best) to 1 (poor)

Pressing muscadine grapes without heating creates several problems: 1) enzymes that promote browning are not inactivated; 2) juice yield from the grapes is poor because of the thick skins; 3) color extraction of dark-skinned cultivars is low; and 4) a high percentage of the flavor remains in the skins (Sistrunk and Morris, 1985). Some of these problems could be lessened by treating the grapes with enzymes prior to pressing.

Factors That Influence Juice Quality

The juice of muscadines is perceived by some consumers as being too strongly flavored and high in acidity and astringency (Flora, 1979). However, flavor characteristics of the juices vary depending on cultivar. Juice from Carlos grapes has natural acidity that is too high for the taste of many consumers, while Noble is naturally astringent, leading to a harsh flavor. Flora determined that storing muscadine juice at 36°F for seven days (cold stabilization) before bottling and pasteurizing aids in reducing acidity levels without affecting overall quality. He also found that the addition of up to 40% water improves the quality of Carlos juice by diluting the phenols and acids; however, this dilution

level is too great for Noble juice. The addition of 3% sugar also serves to improve quality. Flora observed that during 12 months of storage, the light-colored Carlos juice became darker due to browning while the dark Noble juice became lighter because of pigment loss.

In order to determine optimum storage conditions for muscadine juice and to characterize the changes in quality attributes which occur during processing and storage, Sistrunk and Morris (1982) evaluated the effects of three storage temperatures (36°, 75°, and 90°F), and three storage times (0, 7, and 12 months) on the juice from two muscadine cultivars (Carlos and Noble). The researchers observed that all quality parameters except soluble solids decreased as storage time increased (Table 9). Juice stored at 75° and 90°F had rapid loss of color at seven months because of browning. Panel scores decreased as storage time was increased reflecting the changes that were occurring during storage. Color was especially affected by storage temperature. All color parameters changed more in juices stored at 90°F than in those stored at 36° or 75°F. Juice stored at 75°F was rated acceptable by the panel after 12 months of storage; however, juice stored at 90°F was deemed unacceptable after seven months.

Table 9. Effect of storage temperature and storage time on quality attributes of muscadine juice (Sistrunk and Morris, 1982).

Main Effect	Soluble Solids (%)	Titratable Acidity (%)	pH	Total Phenols (%)	Sensory Attributes			
					Color	Flavor	Lack of Browning	Overall Acceptance
<i>Storage Temperature</i>								
36°F (2°C)	13.6a	.716c	2.92a	.161a	7.18a	6.76a	8.18a	7.03a
75°F (24°C)	13.5a	.725b	2.90b	.157a	6.89b	6.20b	7.55b	6.45b
90°F (32°C)	13.4a	.735a	2.90b	.158a	6.21c	5.60c	6.38c	5.57c
<i>Storage time</i>								
0 mo	13.4ab	.726a	2.99a	.189a	7.25a	6.43a	9.39a	6.61a
7 mo	13.2b	.720a	2.91b	.154b	6.56b	6.21b	6.42b	6.54a
12 mo	14.0a	.676b	2.81c	.133c	6.47c	5.92c	6.31b	6.08b

¹ Means within a main effect not followed by the same letter are significantly different by Duncan's Multiple Range test, 5% level

² Sensory rating conducted by a 12- to 15-member panel on a scale of 10 (best) to 1 (poor)

Juice from two cultivars (Carlos and Noble) was cold stabilized for 0, 7, and 60 days at 36°F then stored at 36° or 75°F for 0, 4, 8, and 12 months (Sistrunk and Morris, 1984). The two cultivars reacted differently to cold stabilization (Table 10). The color of Noble juice decreased significantly between 0 and 60 days at 36°F as shown by lower a, b, chroma, and total anthocyanin values. Subsequently, the browning increased. The color of Carlos juice became darker during cold stabilization as indicated by lower L values and higher b and chroma values.

Table 10. Influence of cultivar and cold stabilization on color quality of muscadine grape juice ^a (Sistrunk and Morris, 1984).

Cold Stabilization (days)	Color Difference			Chroma (a ² + b ²) ^{1/2}	Total anthocyanins (OD/gfw)	Browning index (OD520/430nm)
	L	a	b			
Noble						
0	11.7b ^b	6.8a	0.6a	6.93a	100.4b	5.49a
7	12.0a	6.2b	0.5b	6.28b	104.6a	5.52a
60	11.2c	5.1c	0.5b	5.17c	88.1c	4.83b
Carlos						
0	50.1b	-2.2b	13.8b	14.0b	0.9b	0.64b
7	50.8a	-2.3c	12.2c	12.5c	1.3a	0.68b
60	48.8c	-1.9a	14.5a	14.6a	0.9b	1.99a

^a Means represented by data – Cold stabilization n = 112^b Means in columns within a cultivar followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.**Table 11.** Influence of storage time and cultivar on quality attributes of muscadine grape juice ^a (Sistrunk and Morris, 1984).

Cultivar and Storage Time (months)	pH	Soluble solids (%)	Total (mg/100ml)	Acidity as tartaric (%)
Noble				
0	3.63b ^b	19.6a	587a	0.553a
4	3.67a	19.3b	553b	0.429b
8	3.63b	19.5b	552b	0.422b
12	3.42c	18.8c	536c	0.406c
Carlos				
0	3.28a	18.1a	291a	0.622ab
4	3.27a	17.8ab	289a	0.610b
8	3.25b	18.0a	293a	0.632a
12	3.08c	17.5b	275b	0.618b

^a Means represented by data are: storage time n = 84^b Means in columns within a cultivar followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

After cold stabilization, juices were treated by filtration or the addition of sugar (3%), water (20% or 40% plus sugar to equalize to original solids level), or CaCO_3 (0.1% or 0.2%), bottled, pasteurized, and stored for periods of 0, 4, 8 or 12 months.

The effect of storage time on quality changes in bottled juice from both cultivars was similar (Sistrunk and Morris, 1994). In general there was a decrease in pH, soluble solids, total phenols, and acidity during the 12 months of storage (Table 11). However, Carlos changed very little in total phenols and acidity while the changes in Noble were much greater.

Table 12. Influence of cultivar and storage time on sensory attributes of muscadine grape juice^{ab} (Sistrunk and Morris, 1984).

Cultivar and Storage Time (mo)	Color intensity	Color acceptance	Flavor	Acid balance	Overall acceptance
Noble					
0	8.9a ^c	8.6a	7.2a	6.9a	7.3a
4	8.6b	8.4a	6.8b	6.8a	7.2ab
8	8.5b	8.0b	6.8b	6.9a	7.0b
12	8.4b	7.3c	6.0c	6.1b	6.3c
Carlos					
0	7.6a	6.9a	7.5a	7.4a	7.4a
4	7.7a	7.1a	7.2a	7.1b	7.2b
8	7.4b	6.1b	7.1a	7.0b	7.0c
12	6.9c	5.8c	6.4b	6.4c	6.1d

^a Means represented by data are: storage time n = 84

^b Rated on a 9-point Hedonic scale: 9 = like extremely to 1 = dislike extremely

^c Means in columns within a cultivar followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

Because of the obvious differences in color between the two cultivars, sensory panelists were instructed to rate each on its own merits and not to make comparisons between the cultivars. The change in color intensity in the Noble juice was barely detectable because of the browning of the sample (Table 12). There were significant changes in the color intensity of the Carlos juice during storage with the color becoming less intense as storage time increased. Sensory ratings for color acceptance, flavor, and overall acceptance decreased with increasing length of storage for both cultivars.

Table 13. Effects of cultivar and treatment on quality attributes of muscadine grape juice (Sistrunk and Morris, 1984).

Treatments by cultivar	pH	Soluble solids (%)	Total Phenolics (mg/100ml)	Acidity as tartrate (%)
Noble				
Control	3.48c ¹	19.3b	603a	0.541a
Control, filtered	3.48c	18.8bc	597a	0.526a
20% H ₂ O*	3.49c	18.9bc	488b	0.451b
40% H ₂ O*	3.49c	18.8bc	420c	0.367d
3% added sugar	3.49c	21.9a	588a	0.527a
0.1% CaCO ₃	3.70b	19.1bc	602a	0.427c
0.2% CaCO ₃	3.96a	18.6c	600a	0.326e
Carlos				
Control	3.18c	17.5b	329a	0.740a
Control, filtered	3.17dc	17.5b	313b	0.711b
20% H ₂ O*	3.17dc	17.4bc	255d	0.596c
40% H ₂ O*	3.18c	17.0c	209e	0.477e
3% added sugar	3.15d	20.6a	299bc	0.700b
0.1% CaCO ₃	3.27b	17.5bc	297c	0.605c
0.2% CaCO ₃	3.42a	17.3bc	307bc	0.511d
Means by cultivar				
Noble	3.58a	19.3a	557a	0.452b
Carlos	3.22b	17.8b	287b	0.620a

* 20% or 40% water dilutions had sugar added to equalize samples to original solids level

¹ Means in columns within a cultivar followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

The pH was higher and the acidity lower in Noble juice than in Carlos juice (Table 13). The addition of water did not change the pH significantly with either cultivar but did decrease the titratable acidity. With both cultivars, the CaCO₃ treatments increased pH and lowered acidity. Sensory ratings for color intensity were decreased by the addition of water for both cultivars (Table 14). With Carlos juice, the unfiltered control was judged lighter than the filtered juice. Color acceptance of the Noble juice was lowered significantly in samples diluted with 40% water or treated with 0.2% CaCO₃. Carlos samples diluted with water were the most acceptable in color while those treated with CaCO₃ were the least acceptable. Ratings for flavor and sugar/acid balance were the highest for the diluted samples and those with added sugar.

Table 14. Effects of cultivar and treatment on sensory attributes of muscadine grape juice (Sistrunk and Morris, 1984).

Treatments by cultivar	Color Intensity	Color Acceptance	Flavor	Acid/Sugar Balance	Overall Acceptance
Noble					
Control	8.86a	8.23a	6.58cd	6.35cd	6.81b
Control, filtered	8.84a	8.42a	6.78bc	6.63b	7.10a
20% H ₂ O*	8.29b	8.14a	7.11a	7.10a	7.26a
40% H ₂ O*	7.56c	7.51b	7.02ab	7.13a	7.15a
3% added sugar	8.88a	8.45a	7.00ab	6.94a	7.28a
0.1% CaCO ₃	8.89a	8.17a	6.41d	6.60bc	6.77b
0.2% CaCO ₃	8.68a	7.63b	6.03e	6.11d	6.33c
Carlos					
Control	7.40b	6.65b	6.62b	6.39d	6.64bc
Control, filtered	7.89a	6.70b	6.72b	6.71c	6.80b
20% H ₂ O*	6.98c	6.99ab	7.50a	7.38a	7.12a
40% H ₂ O*	6.17d	7.30a	7.52a	7.43a	7.20a
3% added sugar	7.75a	6.66b	7.33ab	7.07b	7.10a
0.1% CaCO ₃	7.71a	6.21c	6.83b	6.88bc	6.79b
0.2% CaCO ₃	7.85a	5.79d	6.82b	6.89bc	6.57c
Means by cultivar					
Noble	8.57a	8.80a	6.70b	6.69b	6.96a
Carlos	7.39b	6.62b	7.05a	6.96a	6.89a

*20% or 40% water dilutions had sugar added to equalize samples to original solids level

¹ Means in columns within a cultivar followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

The conclusions from this study (Sistrunk and Morris, 1984) were that cold stabilization for seven days was sufficient to remove much of the acidity from muscadine juice without significantly changing the quality. In this study the addition of up to 40% water improved the juice quality. This was probably because the water reduced the phenols and acidity but the sugar that was added to equalize the samples to their original solids levels prevented a dilution effect on flavor. The addition of 3% sugar also improved juice quality. Reduction of acidity with CaCO₃ was not beneficial, mainly because of the adverse effect on flavor and color after storage. The highest quality juice was obtained by adding water and/or sugar.

The quality of juice made from a number of muscadine cultivars commonly produced in Arkansas was evaluated by Main et al. (1995). Sugar levels for Fry, Sterling, and Tara cultivars were below the optimum 16% level (Table 15). The authors suggested that sugars might have been increased in Fry and Sterling by allowing longer ripening on the vine. However, the Tara grapes were

at full maturity. Very few of the cultivars in this study had sugar to acid ratios in the optimum range, however, it would have been possible to adjust this ratio in the juices by adding juice concentrate or acid. While it is fairly easy to increase acidity using citric or tartaric acid, it is very difficult to reduce the natural acid levels of fruit.

Table 15. Objective measures of juice quality for muscadines grown in Arkansas (Main et al., 1995).

Cultivar	Soluble Solids (%)	pH	Tartaric Acid (%)	SS:Acid Ratio
Bronze				
Fry	14.8	3.25	0.72	20.6
Sterling	14.4	2.88	0.80	17.9
Summit	16.1	3.25	0.54	29.8
Tara	14.7	3.12	0.56	26.2
Purple				
Jumbo	15.2	3.19	0.61	24.9
Sugargate	16.4	3.24	0.61	28.5

Sensory panelists evaluating the juices detected the flavor attributes of sweetness and sourness (Table 16). They found very little difference among the samples when assessing bitterness, muscadine flavor intensity, or astringency.

Table 16. Mean sensory scores for juice made from muscadine grapes grown in Arkansas.¹

Cultivar	Sweetness	Sourness	Bitterness	Flavor Intensity	Astringency
Bronze					
Fry	8.0	9.9	0.5	7.3	4.9
Sterling	7.3	10.5	0.7	6.9	5.7
Summit	8.0	7.7	0.4	7.7	4.9
Tara	7.7	7.9	0.3	7.5	5.4
Purple					
Jumbo	7.5	8.7	0.7	7.0	5.7
Sugargate	8.3	6.8	0.4	7.1	4.9

¹ Scored on a 15-point hedonic scale with 1 = lowest score, 15 = highest.

Juice Blends

Consumer acceptance of muscadine juice has been limited to some extent by its strong flavor. Consumers are more accustomed to Concord (*Vitis labrusca* L.) grape juice which makes up the majority of grape juice produced commercially in the United States and is considered the standard in the indus-

try (Morris, 1985). Another juice that is widely accepted commercially is Niagara, also a *Vitis labrusca*, a white juice grape.

Flora (1979) showed that muscadine juice could be successfully blended with commercial fruit juices without sacrificing quality and, in some cases, improving acceptability. Blends of Concord and Niagara juices with muscadine juice can have good color and a refreshing taste. In addition, blending muscadine juice with juices from different varieties of grapes can improve the acceptability of the strong-flavored muscadine and therefore increase the market potential for muscadines.

Sistrunk and Morris (1985) looked at the acceptability and storage stability of muscadine juice blends. Two varieties of muscadine grapes, Noble (black skinned) and Carlos (bronze skinned) were each blended at three levels with apple juice, cranberry juice, Concord and Niagara grape juice, and with each other. The Noble/Concord blends were found to be the most acceptable of the dark blends (data not shown). They also retained the most flavor during a 12-month storage period. Carlos juice blended with light-colored apple juice or with the light-colored Niagara grape juice was rated higher than blends with darker juices. The light amber color of the Carlos-light juice blends was stable during a 12-month storage period, and the flavor and overall acceptability ratings were the highest of all of the blends.

Another approach which needs to be investigated for increasing the acceptability of muscadine juice would be to blend it with Thompson Seedless grape concentrate. This white juice is used extensively commercially for blending with other juices since it provides the light color preferred by consumers, but is inexpensive compared to other juices used in blending. Concentrate from Thompson Seedless has been successfully used commercially for many years to stretch the flavor of the Niagara (white) cultivar.

Muscadine Wine

Most of the commercial muscadine grape crop is used to produce wine. Wine made from suitable cultivars of muscadine grapes has a fruity flavor that appeals to an increasing number of people. Procedures for making muscadine wine are described in Appendix A.

Muscadine grape wines are very susceptible to browning and overall loss of color quality during processing and storage (Sims and Morris, 1985). This color instability severely limits shelf-life and hinders marketing of muscadine wines. In a comparison of the color stability of Noble muscadine wine and Cabernet, Noble browned to a much greater extent during twelve months of storage. This browning was revealed by greater increases in CDM 'b' and absorbance (Abs.) at 420 nm in Noble than in Cabernet (Table 17). Apparently, chemical changes in the pigments of the Cabernet wine, measured as chemical

aging, served to protect this wine from darkening. The pigments of Noble changed much less than those of Cabernet during storage as shown by a much lower increase in chemical age.

Table 17. Effect of species¹ on color changes of red wine during 12 months of storage (Sims and Morris, 1985).

Cultivar	Increase in CDM 'b'	Increase in Abs. @420nm	Increase in Chemical Age
Noble	2.9a ²	0.94a	0.098b
Cabernet	1.3b	0.68b	0.398a

¹ *Vitis rotundifolia*, c.v. Noble, and *Vitis vinifera*, Cabernet Sauvignon

² Means within columns followed by different letters were significantly different at $p \leq 0.05$

Initial chemical content and conditions of processing and storage have been shown to influence the color quality and stability of muscadine wine (Sims and Morris, 1984). Raising the pH of muscadine wine causes the wine to have a lighter color as indicated by higher 'L' values and lower scores for visual intensity (Table 18). Lowered 'a' values and absorbance at 520 nm show that higher pH also decreases redness of the wine. These effects of altering the pH were seen initially and after three and nine months of storage. Higher pH initially resulted in increased blueness, as indicated by lower 'b' values. However, at three and nine months, increased blueness was not observed, probably because of increased browning which caused 'b' values to go up.

Table 18. Effects of pH on the color of red wine from Noble muscadines initially and after 3 and 9 months storage (Sims and Morris, 1984).

pH	Visual	Absorbance			
	intensity ¹	@ 520 nm	CDM L	CDM a	CDM b
Initial					
2.90	9.0a ²	0.185a	12.4c	25.5a	4.2a
3.20	7.0b	0.118b	15.2b	24.8b	1.5b
3.80	5.0c	0.077c	18.8a	12.5c	-0.4c
3 Months					
2.90	7.5a	0.118a	18.5c	18.8a	5.1c
3.20	6.5b	0.095b	19.8b	16.8b	5.7b
3.80	4.3c	0.079c	21.4a	11.2c	6.0a
9 Months					
2.90	6.1a	0.103a	20.2c	13.1a	7.0c
3.20	5.4b	0.086b	21.2b	11.6b	7.3b
3.80	4.7c	0.067c	24.0a	8.7c	8.2a

¹ Rated on a scale of 1 to 10 with 10 = dark red color and 1 = light red color

² Means within pH and storage time separated by a different letter are significantly different $p \leq 0.05$

Storage temperature had a tremendous influence on the browning of muscadine wine (Table 19). During nine months of storage, as storage temperatures increased, there were increases in visual browning, absorbance at 430 nm, and CDM 'b' values, all of which indicate increased browning (Sims and Morris, 1984). This was probably due to greater destruction and/or chemical changes to the anthocyanin color pigments at higher temperatures. Wine stored at 104°F had browned to an unacceptable level after only three months, and wine stored at 86°F had become unacceptable after nine months of storage (data not shown). Wine stored at 68°F browned slowly during nine months, but was still judged acceptable.

Table 19. Effect of storage temperature on color changes of Noble muscadine wine during 9 months of storage (Sims and Morris, 1984).

Storage Temperature	Increase in CDM 'b'	Increase in Abs. @420nm	Increase in Visual Browning
68°F (20°C)	2.1c ²	0.031c	2.5c
86°F (30°C)	5.7b	0.069b	4.3b
104°F (40°C)	9.3a	0.096a	7.0a

In a comparison of the color stability of Noble muscadine wine and Cabernet, the Noble had better color initially (after four months), but had browned to a much greater extent and lost more redness after ten and sixteen months of storage (Sims and Morris, 1985). The color and stability of the muscadine red wine were damaged by higher pH to a greater extent than those of the *Vitis vinifera* red wine.

Vinegar

The word vinegar means sour ("aigre") wine ("vin") in French. Vinegars can be made from a variety of raw materials; however, with muscadines, vinegar is usually produced by bacterial fermentation of wine. Wine connoisseurs may consider it a waste to convert good wine into vinegar, however, there are economic reasons why this could be a profitable plan. First, high quality vinegars often sell for more than the wines from which they were made (Diggs, 1999). In addition, an abundant crop of muscadines can result in a large quantity of wine. Placing an oversupply of even a very good wine on the market will lower the price, but, storing it to control the market supply can be costly. Adding value by further processing the wine to vinegar will eliminate these problems while producing an additional or alternative product to place on the market.

The production of vinegar is described in Appendix A. Those consider-

ing producing vinegar are cautioned to use separate facilities for their wine and vinegar production. Lactic acid bacteria used in the production of vinegar can contaminate the fermenting wine, causing the development of poor appearance, undesirable aroma, and off-flavors.

Sweet Spreads

The process of making muscadine grape jelly, jam, preserves, butter, or marmalade consists mainly of cooking the grapes and/or their juice in combination with sweeteners and pectins to the proper solids level (See Appendix A). There are federal standards that dictate the ingredients, their proportions, and the final concentration of soluble solids in each type of sweet spread. The minimum total soluble solids to fruit as required by the Federal Food and Drug Administration for grape jelly, jam, preserves, and fruit butter is:

Finished Product	Soluble Solids	Parts by Weight	
		Fruit to Sweetener	
Grape butter	43% minimum	5	2
Grape jelly	65% minimum	45	55
Grape preserves/jam	68% minimum	45	55

Jam, preserves, and grape butter are made from whole or crushed fruits (Brady, 1995a). Preserves differ from jam, only in that the fruit pieces are usually larger. Muscadine butter is made by cooking the screened fruit (seeds and skins removed) to a smooth, thick consistency. It differs from jam in its ratio of fruit to sweetener and in the final solids concentration. Jelly is made from the fruit juice so that the product is clear and firm enough to hold its shape when removed from the container.

Making sweet spreads from muscadines is a challenge because these grapes have a characteristic thick, leathery skin that does not soften during normal cooking and because muscadines tend to have a poor juice yield. A study by Rizley et al. (1977) looked at various treatments to soften the skins of two cultivars of muscadines so that preserves could be made without removing the skins. Treatments investigated included water blanching, blanching in 2% citric acid, treatment with 0.4% pectinase prior to water or citric acid blanching, and pressure cooking.

Following pre-treatment with pectinase to soften the skins, muscadine preserves could be made from the whole berries (Table 20). With the Noble cultivar, the enzyme treatments resulted in greater skin softening than pressure cooking. Neither blanching in citric acid or in water alone resulted in sufficient skin softening.

Table 20. Effect of cultivar and pretreatment to soften skins on quality of muscadine preserves (Rizley et al., 1977).

Cultivar and pretreatment	Shear	Color Lightness - ‘L’ value ¹	Sensory Ratings ²			
			Color	Flavor	Texture	Overall
Carlos						
Water blanch	329	19.4	6.5	6.9	3.9	5.8
Citric acid blanch	442	21.9	6.8	6.6	2.8	5.4
Water blanch + pectinase	226	20.8	7.8	6.9	7.0	7.2
Citric blanch + pectinase	204	21.5	8.0	7.1	7.5	7.5
Pressure cooking	187	22.5	8.0	7.5	6.1	7.2
Noble						
Water blanch	428	8.2	8.5	9.5	3.8	7.3
Citric acid blanch	334	7.5	8.5	9.0	3.8	7.1
Water blanch + pectinase	29	8.2	9.5	8.3	9.5	9.1
Citric blanch + pectinase	21	8.3	9.5	8.5	9.5	9.2
Pressure cooking	144	8.3	9.7	9.3	6.8	8.6

¹ Percent white standard plate L = 92.1

² Scale: 1 = poor to 10 = best

There was little variation in the color of the preserves due to skin softening treatments. Sensory ratings of the preserved products indicated an overall preference for products made from grapes that had been blanched in citric acid and pretreated with pectinase. The panelists in this study preferred darker preserves as indicated by higher sensory scores for preserves made from Noble grapes than for those from Carlos.

Dried Products

Drying involves the removal of moisture from foods to inhibit microbial growth and prevent spoilage. At the same time, it is important to preserve as much of the product's nutritive value, natural flavor, nutraceuticals, and quality as possible.

Product development experiments are being conducted at the University of Arkansas looking at the feasibility and technological requirements for commercially producing and marketing products containing dried muscadines such as trail mix and fruit leathers.

Fruit leathers get their name from the fact that, when dry, the product

is shiny and has the texture of leather (Brady, 1995b). Fruit leather is essentially the same as commercial fruit roll products. They are made by drying puree of fruit on a flat surface. A single fruit can be used or purees of more than one fruit can be mixed to give a mixed fruit flavor. Sugar may be added to the leather to reduce the tartness of the fruit, or sugar may be omitted to produce a product appropriate for use by those on a reduced sugar diet. The procedure for making fruit leather is described in Appendix A.

By-Products and Nutraceuticals

In addition to research looking at processing muscadines into traditional products like juice, wine, and sweet spreads, a great deal of interest has recently been focused on using muscadine by-products, most notably the skins and seeds. Information regarding potential health benefits of muscadine consumption has led to interest in the development of foods and nutraceutical products containing muscadine components.

By-Products

After muscadines are pressed to remove the juice, the remaining press fraction, or pomace, consisting of skins and seeds (Figure 8), is a large percentage of the fruit (Woodroof et al., 1956; Flora, 1977). Rizley et al. (1977) reported that the muscadines used in their study were approximately 40% skin, 50% pulp and 10% seed. Thus for processing operations like juice, wine, and jelly production, approximately half of the fruit may be lost as press fraction. The use of muscadine pomace could have an important economic impact on the muscadine industry both by increasing the market value per ton of fruit and decreasing or eliminating waste disposal problems (Ector, 2001).



Figure 8. The seeds and skins represent a large percentage of the muscadine fruit. Pictured are the pomace portions from (l to r) Ison, Carlos, and Nesbitt muscadines.

Research at Mississippi State University has led to the development of a process to produce a seedless muscadine pomace puree (Ector, 2001). This puree has been used in a variety of products including fillings and toppings for baked goods, fruit extenders and blends, fruit roll-ups, sauces, toppings, and as ingredients in fruit drinks, frozen fruit bars, cakes, muffins, candies, and breads.

A variety of grape seed extract products are coming into the ingredient market. Individual manufacturers have developed their own systems for removing components that contain nutraceutical properties from the grape seeds. These extract products have recently been the subject of a great deal of research since their antioxidant effects may both inhibit oxidative deterioration of product components, such as fats and vitamins, and may provide antioxidant benefits to human diets (Leigh, 2003). Grape seed extracts are currently being used as nutritional supplements in fruit-flavored beverages and beverage mixes and will soon appear in hot and cold ready-to-eat cereals, meal replacers, snack bars, yogurts, and frozen dairy desserts (Anon., 2004).

Grape seed oil is a by-product of the grape industry. The oil can be extracted from the seeds in a variety of ways including pressing, soluble extraction, and through centrifugation (Axtell, 1992; Peterson, 2001). Grape seed oil is low in saturated fat and high in unsaturated fat (the heart-healthy kind). A tablespoon of grape seed oil has about 10 milligrams (14 IU) of vitamin E, slightly more than sunflower or safflower oil, which are also high in this vitamin. The RDA for vitamin E is 15 milligrams a day.

Grape seed oil has been used in soaps and paints and for food use. It can be used as a cooking oil since it has a high smoke point, meaning that it can be used to cook at high temperatures. It is virtually tasteless, and so it is a good carrier for infused flavors like those from herbs and spices. The president of a company making a mayonnaise-like product containing grape seed oil has reported that, although this product costs about one third more than the company's canola-based variety, it is outselling the more traditional product (O'Donnell, 2004). The grape seed oil product is marketed as a heart-healthy alternative to mayonnaise, and its packaging includes a hang tag that refers to studies showing the oil's ability to raise HDL cholesterol and lower LDL.

Pigments extracted from grape skins are other by-products of the juice and wine industry that are receiving considerable attention as food ingredients. Depending on the level of usage, these pigments have the potential to both color products and increase the nutraceutical content of the foods containing them (Katz, 2004). Canandaigua Wine Co. has recently released two color agents derived from grapes. The company has suggested that, since the color pigments of these products are stable at pH 3 to 4.5, these pigments have potential for use in acidic products where many other coloring agents fail.

All of the current commercial applications of grape seed extract, grape seed oil, and grape pigment have been developed using seeds and skins of *V.*

vinifera or *V. labrusca* grapes. The large scale production of juice and wine from these grapes assures an abundant supply of these by-products. The much lower level of production of muscadine products means their volume of seeds and skins is less; however, the excellent nutrient profile of muscadine materials would suggest that niche market products from these grapes could be developed and marketed successfully.

Nutraceuticals

Muscadines are significant sources of several phytochemicals (chemicals found in plant foods) that have been associated with disease prevention in humans. High concentrations of gallic acid, catechin, epicaechin, ellagic acid, and resveratrol found in the seeds and skins give muscadines a high antioxidant capacity (Ector et al., 1996; Striegler et al., 2004).

Antioxidants are substances that prevent or slow destructive oxidation reactions. They protect key cell components by neutralizing the damaging effects of "free radicals," natural byproducts of cell metabolism. Free radicals form when oxygen is metabolized or burned by the body. They travel through cells, disrupting the structure of other molecules, causing cellular damage. Such cell damage is believed to contribute to aging and various health problems. Antioxidants scavenge free radicals, convert them to harmless substances, absorb them or attach to them before the free radicals can attack normal tissues, destroy cellular proteins or enzymes, or even cause DNA mutations leading to cancer.

A number of components contribute to the antioxidant capacity of muscadine grapes. Antioxidant compounds include vitamins, phenols, carotenoids, and flavonols. As interest in the antioxidant capacity of muscadines has increased, there has been expanded interest in quantifying the amounts of these materials in these grapes. Pastrana-Bonilla et al. (2003) looked at the phenolic content of various portions of the fruits of ten cultivars of muscadines (five bronze and five purple). They found that most phenolics in the grapes were located in the skins and seeds. Muscadine pulps were found to have very low phenolic content. The main phenolics found in muscadines were ellagic acid, kaempferol, myricetin, and quercetin. The seeds were found to have the highest antioxidant capacity compared to the other fruit parts.

Laboratory tests frequently used to measure antioxidant capacity include tests for total phenolics, anthocyanins, and oxygen radical absorbance capacity (ORAC). In general, the higher the values per equivalent weight of fruit for each of these components, the more antioxidant potential the fruit contains.

Threlfall et al. (2004) compared the nutraceutical levels of Black Beauty muscadines with those of Sunbelt (*Vitis labrusca* L.) grapes. Juice was pressed from the grapes using either a hot-press or cold-press method. Nutraceutical

analysis (total phenolics, anthocyanins, and ORAC) was completed on the juices obtained from each cultivar by each pressing method as well as on the whole frozen grapes and dried seeds and skins. The juice had lower levels of all three nutraceutical components than the whole grapes except that the total anthocyanin level of the juice from heated Black Beauty samples showed no difference (Table 21). The juice from heated Black Beauty and Sunbelt samples had higher total phenolics and anthocyanins than juice from the cold-pressed samples.

Table 21. Nutraceutical analysis of juice and frozen, thawed grapes from Black Beauty and Sunbelt grapes processed with and without heating (Threlfall et al., 2004).

Cultivar	Processing	Product	Total	Total	ORAC ³
	Treatment		Phenolics ¹	Anthocyanins ²	
Black Beauty	Hot	Juice	1354 b ⁴ BC ⁵	414 a C	25 b C
		Grapes	3461 a A	464 a C	28 a B
	Cold	Juice	424 c D	89 b E	5 c D
		Grapes	3823 a A	451 a C	38 a B
Sunbelt	Hot	Juice	1937 b B	513 b C	23 b C
		Grapes	4028 a A	1312 a B	63 a A
	Cold	Juice	880 c CD	247 c D	23 c C
		Grapes	3684 a A	1424 a A	55 a A

¹Total phenolics expressed as mg/kg fresh weight for whole grapes or mg/ml fresh weight for juice

²Total anthocyanins expressed as mg/kg fresh weight for whole grapes or mg/ml fresh weight for juice

³ORAC = oxygen radical absorbance capacity expressed as μ mol of Trolox equivalents (TE) per gram fresh weight for whole grapes and per milliliter for juice.

⁴Within a column and variety, numbers followed by the same lowercase letter are not significantly different $P \leq 0.05$

⁵Within a column, numbers followed by the same uppercase letter(s) are not significantly different $P \leq 0.05$

The dried seeds had more phenolics and less anthocyanins than the skins (Table 22). The highest total phenolic level was in the Black Beauty seeds from cold-pressed samples (Threlfall et al., 2004). The skins of the cold-pressed Sunbelt grapes had the highest amount of anthocyanins. Although the data for the seeds and skins are on a dry weight basis, the press fraction had higher levels of phenolics and ORAC than the whole grapes and juice.

Striegler et al. (2004) looked at the ORAC values and nutraceutical components of the berries and juice from several cultivars of muscadines recommended for production in Arkansas (Table 23). They found that all cultivars have similar levels of total phenolics and ORAC values. As expected, there were no measurable anthocyanins (the pigments that provide the red-purple color) in the bronze cultivars (Carlos, Granny Val, and Summit), and the levels in the dark cultivars (Black Beauty, Ison, Nesbitt, Southern Home, and Supreme), varied with the color intensity of the grapes. In the dark cultivars, the whole fruit had higher total anthocyanin levels than the juice.

Table 22. Nutraceutical analysis of dried seeds and dried skins from Black Beauty and Sunbelt grapes processed with and without heating (Threlfall et al., 2004).

Cultivar	Processing Treatment	Product	Total Phenolics ¹ (mg/kg)	Total Anthocyanins ² (mg/kg)	ORAC ³ (μM TE/g)
Black Beauty	Hot	Seeds	77615 b ⁴ B ⁵	273 c D	893 a B
		Skins	22944 d E	2489 b C	332 b E
	Cold	Seeds	95338 a A	65 c D	1100 a A
		Skins	34543 c D	4942 a B	422 b DE
Sunbelt	Hot	Seeds	42665 ab D	187 c D	571 b CD
		Skins	25732 c E	3743 b BC	383 c E
	Cold	Seeds	51389 a C	232 c D	667 ab C
		Skins	40530 b D	11889 a A	700 a C

¹Total phenolics expressed as mg/kg dry weight²Total anthocyanins expressed as mg/kg dry weight³ORAC = oxygen radical absorbance capacity expressed as μmol of Trolox equivalents (TE) per gram dry weight⁴Within a column and variety, numbers followed by the same lowercase letter are not significantly different P≤0.05⁵Within a column, numbers followed by the same uppercase letter(s) are not significantly different P≤0.05**Table 23.** Juice nutraceutical analysis from muscadine grape cultivars grown at the Southwest Research and Extension Center, Hope, Ark. in 2002 (Striegler et al., 2004).

Cultivar	Product	Total Phenolics ¹	Total Anthocyanins ²	ORAC ³ (μM TE•g ⁻¹)
Grapes				
Black Beauty		3012 a ⁴ E ⁵	303 a D	23 a C
Carlos		9498 a A	5 a E	66 a A
Granny Val		5740 a BCD	7 a E	43 a B
Ison		4560 a CDE	612 a B	53 a AB
Nesbitt		5099 a BCD	422 a C	51 a AB
Southern Home		4417 a ED	298 a D	42 a B
Summit		6586 a B	5 a E	50 a AB
Supreme		6072 a BC	737 a A	45 a AB
Juice				
Black Beauty		297 b ABD	35 b C	2.9 b BC
Carlos		179 b D	2 a D	3.9 b A
Granny Val		356 b A	3 a D	2.6 b BC
Ison		251 a BCD	104 b A	2.5 b BC
Nesbitt		206 b CD	97 b A	2.1 b C
Southern Home		251 b BCD	83 b B	4.1 b A
Summit		373 b A	4 a D	2.6 b BC
Supreme		339 b AB	35 b C	3.4 b AB

¹Total phenolics expressed as mg/kg fresh weight for whole grapes or mg/ml fresh weight for juice²Total anthocyanins expressed as mg/kg fresh weight for whole grapes or mg/ml fresh weight for juice³ORAC = oxygen radical absorbance capacity expressed as μmol of Trolox equivalents (TE) per gram fresh weight for whole grapes and per milliliter for juice.⁴Within a column and product, numbers followed by the same lowercase letter are not significantly different P≤0.05⁵Within a column, numbers followed by the same uppercase letter(s) are not significantly different P≤0.05

Nutraceutical analyses of the seeds and skins (dried press material), were compared (Striegler et al., 2004). The seeds had higher total phenolic levels in all cultivars than the skins (data not shown). The seeds also had higher ORAC values in all cultivars than the skins. Although the data for the seeds and skins is on a dry weight basis, the press fraction had higher levels of phenolics and higher ORAC values than the whole grapes and juice.

There has been a great deal of interest recently in resveratrol, a phenolic substance produced by plants, such as grapevines, in response to stress. Consumption of resveratrol has been shown to lower blood levels of low density lipoproteins (LDL), bad cholesterol, and it also has cancer chemopreventative activity (Ector et al., 1996). Resveratrol is the active ingredient in red wine that has been associated with its beneficial effects in reducing the risk of coronary heart disease. Ector et al. (1996) showed that resveratrol is a natural constituent of both bronze- and dark-skinned muscadine grapes with dark-skinned muscadine products having only slightly higher concentrations of resveratrol than most bronze-skinned varieties. Although the seeds of *V. vinifera* or *V. labrusca* grapes have very little resveratrol, muscadine grape seeds were found to have a high resveratrol concentration.

Also present in muscadines is ellagic acid, a phytochemical which has been shown to have a number of human health benefits, including a possible role in preventing some forms of cancer. Strawberries, raspberries, and blackberries are often cited as the best dietary sources of this material, however, the ellagic acid content of muscadine grapes far exceeds that of the other berries (Ector, 2001; Akoh and Pastrana-Bonilla, 2002). Since ellagic acid is found predominantly in the skins of the muscadines, development of consumer products made from this portion of the grape would not only aid in increasing consumption of this nutritional component, but would also make use of a major part of the waste from muscadine processing.

Muscadines are also an excellent source of fiber. The beneficial effects of fiber consumption have been recognized for many years. Fiber-rich foods help prevent constipation, hemorrhoids, and diverticular disease. Some types of fiber may have a cholesterol-lowering effect which could lead to reduced risk of heart disease. In addition, fiber may reduce the incidence of certain types of cancer, particularly those associated with the digestive tract; it may also be helpful in controlling diabetes. Ector (2001) reports that the fiber content of both light- and dark-skinned muscadines is greater than that of most other fruits and is almost three times higher than that of other types of grapes.

Based on the many ways muscadines can contribute to health, researchers and those in the muscadine industry have sought creative new ways to offer these grapes and/or their products to the public. For example, one grower in Georgia has reported that he not only markets his muscadines on the fresh market, but also deseeds and extracts the juice from the pulp and skins,

freezes it, and sells it to a commercial winery. The winery uses it to make bottled juice and wine (Omahen, 2001). In addition, the grower grinds the seeds to a powder that is sold in capsules and is currently working on a way to also powder the skins for use as an ingredient in a variety of products.

Although muscadines have been shown to contain significant amounts of several compounds that are known to contribute to health, very little research currently exists demonstrating the bioavailability of these components. Until this research is conducted, care must be taken in making marketing claims about the health benefits of muscadines and products made from them.

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APPENDIX A

Processing Muscadine Grape Products: Technology and Equipment

Juice and Juice Concentrate

In most commercial operations, the continuous pressing method is used for extracting juice from grapes (Morris and Striegler, 1996). Juice can be extracted by either a hot-press or a cold-press method. A hot-press method yields more juice that contains higher soluble solids, more non-sugar solids, tannins, pigments, and other substances than a cold-press juice method. The basic steps for both methods of preparing juice from muscadine grapes are shown in Figure A-1.

In the hot-press method of muscadine juice production, harvested grapes are dumped into a hopper and transported by augers or pumps to a crusher. The crushed muscadines are pumped through a steam-jacketed, vacuum preheater in which the pulp is heated to 140-145°F and passed into holding tanks. At this point, a pectolytic enzyme is added to break down the naturally occurring pectins, and paper pulp or rice hulls are added to facilitate extraction of the juice. When hot pressing, the temperature and time in processing can be varied within a range to produce juice with uniform color from grapes harvested throughout the season. Excessive extraction temperatures (exceeding 150°F or 65°C) must be avoided to preserve juice quality (Sistrunk, 1976; Flora, 1976; Sistrunk and Morris, 1982; Morris et al., 1986).

Next a dejuicer removes the free-run juice. The remaining pulp empties into a continuous screw press which presses out the remaining juice. The free-run and pressed juices are combined, and the blend is filtered or centrifuged to remove most of the insoluble solids. After juice extraction, the argols (tartar in crude form) and tartrates must be removed. To accomplish this, the filtered juice is flash-heated to 176-185°F, rapidly cooled, and placed in tanks to allow the argols to settle. Once the argols have settled, the juice is racked off, heated to 171°F, and filled into pre-heated bottles. The bottles are capped, pasteurized at 185°F for three minutes, cooled, and labeled.

The cold-press method of juice production is essentially the same as the hot-press method except that the steps that allow for heating the crushed berries and holding in tanks with enzymes are omitted (Morris and Striegler, 1996). Without these steps, the dark color from the dark-skinned grapes is not extracted, and the juice is light in color. Enzymes are added to the cold-press

juice to facilitate the clarification and filtration process following cold stabilization.

Grape concentrate can be made of depectinized juice. Generally, juice is concentrated to 55°, 65°, or 68° Brix although concentrates as high as 72° Brix can be made (Morris and Striegler, 1996). Juice may be concentrated by evaporation or freeze concentration. Historically, evaporation has been the most important concentration process for grape juice. Many types of evaporators are available; however, they all work in essentially the same manner – by heating the juice to evaporate excess liquid. With grape juice, it is desirable to heat the juice for as short a time as possible and to rapidly cool the product. This minimizes the effect on flavor, aroma, and sugar components.

Juice HACCP

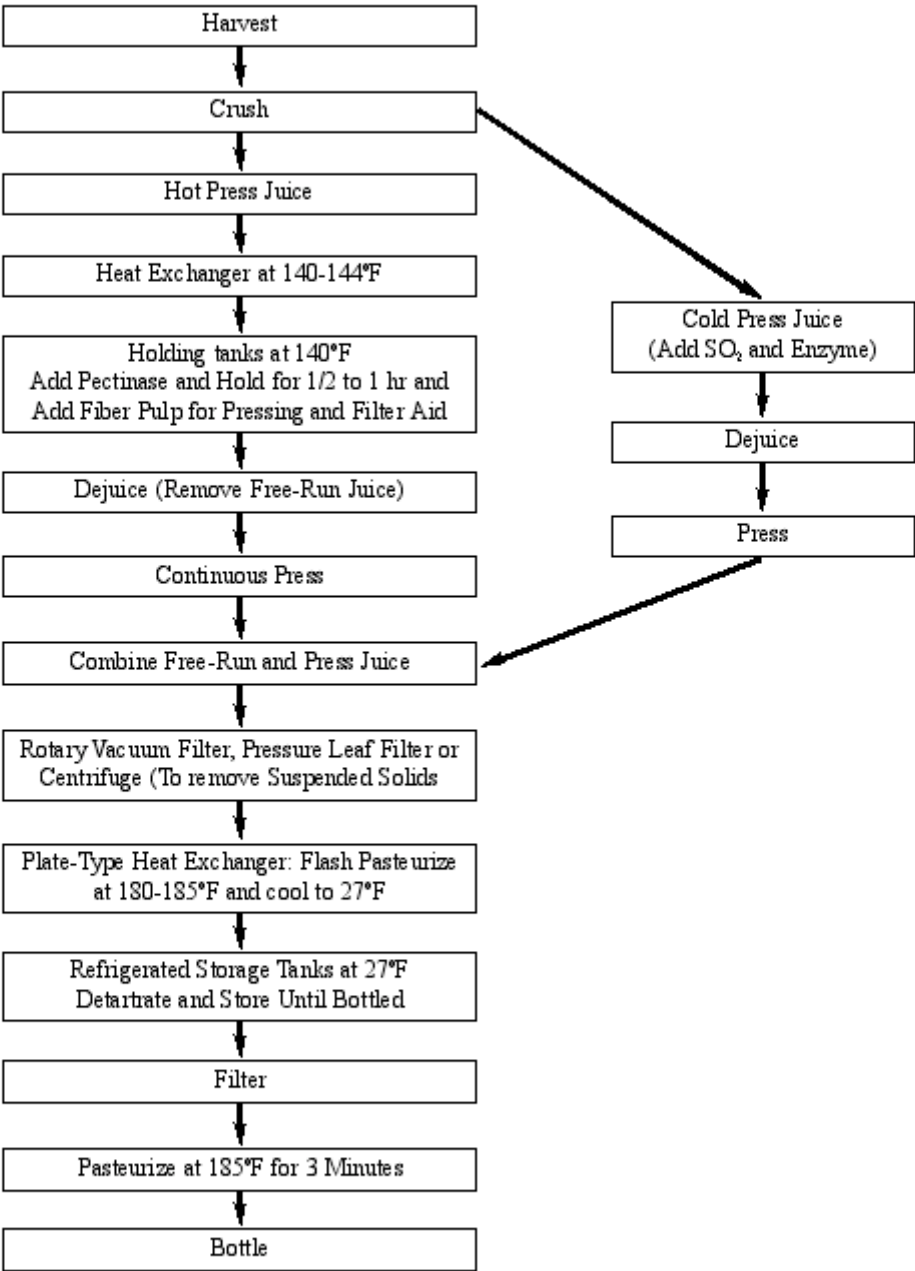
On January 19, 2001, the FDA published a final rule in the Federal Register that requires processors of juice to develop and implement Hazard Analysis Critical Control Point (HACCP) systems for their processing operations. The regulation is defined in Chapter 21, Part 120 of the Code of Federal Regulations (21 CFR 120) and can be found on the Internet at <http://www.cfsan.fda.gov/%7Elrd/fr01119a.html>. These regulations apply equally to juices produced and sold within the same state and juices sold in interstate commerce.

The regulations require that processors apply HACCP principles if they make juice or juice concentrates for subsequent beverage use. The juice HACCP regulations apply to the processing of juice that is sold either as juice or for use as a beverage ingredient. For beverages containing less than 100% juice, only the juice ingredient must be made applying HACCP principles.

HACCP is a science-based system designed to prevent, reduce, or eliminate hazards in food products through appropriate controls during production and processing. Performance of a hazard analysis involves the identification of all hazards that could potentially occur. Potential hazards may be microbiological, chemical, or physical. In addition, the analysis determines how hazards can best be controlled. Examples of control measures include thermal processing of juice and culling produce to eliminate visibly moldy, rotten, or damaged fruit. Key components of the system include identifying potential problems that could cause food to be unsafe to eat; establishing and monitoring targeted control points to minimize such problems; and documenting the results.

The regulations require that a trained individual, whether an employee or consultant, conduct the hazard analysis and that a written analysis be pre-

Figure A-1. The basic steps in producing grape juice (Source: Dillon et al. 1994)



pared. Steps in preparing this written analysis include:

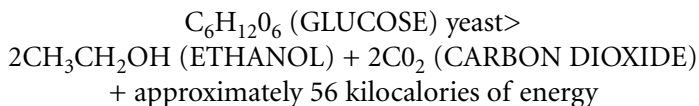
- (1) List all potential physical, chemical, and biological hazards that might occur in your juice.
- (2) For each of the hazards identified in step 1, assess the likelihood of occurrence and the severity of health consequences in the absence of control; then, determine, based upon the information gathered, whether each hazard is reasonably likely to occur in your product. You do not have to include hazards in your HACCP plan that are not reasonably likely to occur.
- (3) Identify the measures that can be applied to control the food hazards identified in step 2 as reasonably likely to occur.
- (4) Review the current process to determine whether modifications are needed.
- (5) Identify critical control points for hazards determined in step 2 to be reasonably likely to occur.

The FDA has prepared a number of publications to assist food processors in implementing a HACCP program. The document *Guidance for Industry - Juice HACCP: Small Entity Compliance Guide* was written specifically to help small juice processors comply with these regulations. This document is available online at <http://www.cfsan.fda.gov/~dms/juicgui7.html>.

Winemaking

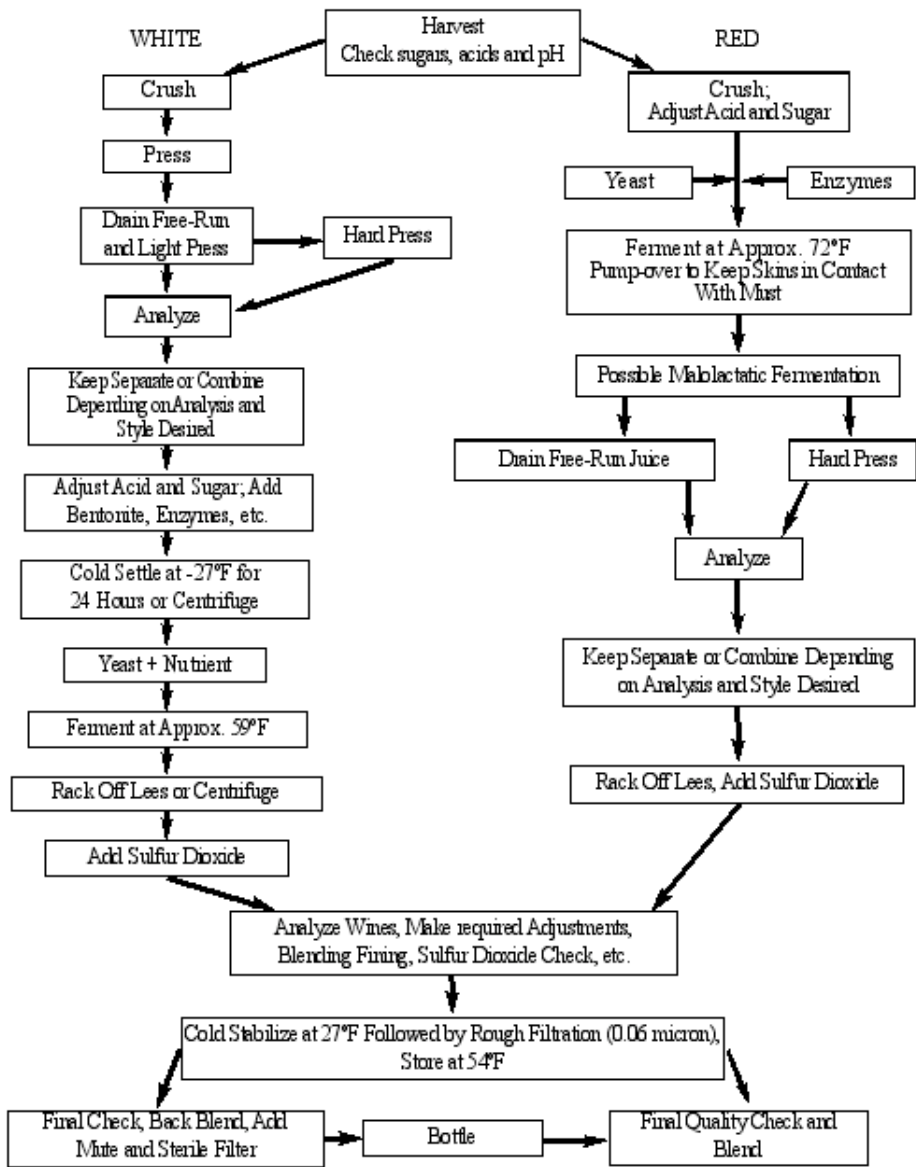
The making, aging, and marketing of high-quality muscadine wine can be an expensive and complicated process that involves both science and art. While there is no single distinct, all-inclusive pattern for winemaking, there is a series of steps or stages that are followed in the process. A discussion of the steps involved in both white and red wine production follows (See also Fig. A-2).

Making wine from muscadine grapes or any other grape involves the process of fermentation, i.e. converting the sugars in the muscadine juice into alcohol and carbon dioxide. The equation for the fermentation reaction is:



The character and quality of the wine is determined by 1) the chemical composition of the muscadines, which in turn depends to a large extent on cul-

Figure A-2. Flow charts for processing white and red muscadine wine
(Adapted from: Dillon et al. 1994).



tivar, site, season, grape cultural conditions, canopy-management, and fruit maturity; 2) the fermentation style and method; and 3) the changes that occur naturally, or are made to occur, during the post-fermentation and aging period (Amerine et al., 1980).

Harvesting and Handling

Once muscadines have been harvested at a point of high fruit quality, it is critical that they be handled in a manner that will prevent deterioration of quality. Juice from damaged muscadines is subject to enzymatic oxidation and spoilage that will deteriorate wine color and produce off-flavors.

The higher the fruit temperature at harvest, the faster undesirable reactions occur. When machine harvesting is used, the vineyards need to be near the winery. If the grapes are to be transported long distances, they need to be crushed and chilled using a must chiller before transportation. In some cases, for short hauls of 4 to 6 hours, mechanical harvesting at night, while the muscadines are cool, is adequate to delay fruit deterioration. Sulfur dioxide may be added during the mechanical harvesting operation to delay enzymatic oxidation and suppress unwanted yeast and bacterial growth (Morris, 1983). Facilities at the winery for rapid crushing and pressing are as important as preharvest and harvest practices in assuring a quality wine.

Crushing



Figure A-3.
A crusher is used to break the muscadines so that the juice can be drained.

The objective of crushing is to break every grape so the juice can be easily drained with minimum damage to the grape skin. This is especially important for most white wines. The chemical composition of the juice can be changed during crushing as the result of the maceration of the skin (Ough, 1991). This maceration stimulates enzyme activity and may cause undesirable reactions. Also, if the outer shells of the seeds are broken during crushing, high levels of phenolic materials from the seeds will impart a bitter taste to the wine. The crushing rollers should be designed and spaced to allow for crushing without chopping the skins or cracking the seeds.

Fermentation

The optimum temperature for most yeast used in the fermentation of juice is 70° to 80°F. To stay as close as possible to this optimum, the temperature of the fermenting liquid or pulp should be maintained between 75° and 80°F. Since fermentation causes the temperature to rise due to the heat given off during the conversion of sugar to alcohol, cooling fermentation tanks is usually necessary. This is generally accomplished by fermenting in stainless steel tanks that are jacketed so that glycol circulation can be used to control temperature. Many of these temperature-controlled, stainless-steel tanks are equipped for automatic pumping over the cap for red wine production and designed so that the tank bottom is sloped with openings allowing for easy pomace removal. This pumping over process is extremely important during the primary fermentation step in the production of red wine.

Crushed dark muscadines are allowed to ferment in an open tank or vat to extract the color from the skins of the grapes. During fermentation the crushed mass is stirred occasionally, usually by drawing off some of the free-run juice and pumping it over the surface of the skins. After four to five days of fermentation, the free-run wine or fermented juice is drawn off and the drained solids pressed. The two liquids are combined and pumped to a storage tank for completion of fermentation.

Pressing

Presses, like fermentation tanks, come in many sizes and shapes. Many large wineries in the past have installed presses that work on the principle of an endless spiral screw that continuously presses the pomace against a counter-weighted movable stop that allows for a buildup of a thick plug. As a general rule, the highest quality wine is obtained from the free-run juice that has been recombined with the first press juice. The hard press juice is high in phenolic

compounds as well as other compounds that can have a significant effect on pH, bitterness, and astringency. The winemaker blends the various press fractions depending on the wine style desired.

Most small wineries (5,000 to 8,000 gal) producing premium quality wines use what is known as a bladder press. This consists of a horizontal, pneumatic batch press that uses compressed air to inflate an internal bag made of thick rubber. The bag crushes the must against an outer perforated, cylindrical stainless steel cage that acts as a sieve. In some presses, the juice or wine is collected through internal draining pipes. The breaking up of the press cake for harder and more complete pressing is accomplished by releasing the pressure on the bladder and breaking up the pomace when the horizontal cage is rotated. However, bladder presses are very expensive and out of reach for many of the smaller wineries.

An alternative, economical press for small wineries would be the vertical Idopress (water-operated bladder press). This press is built like the traditional vertical basket press but has an internal rubber bladder that is inflated to produce the pressing action. The water pressure from a garden hose is adequate to inflate the bladder and press the fruit evenly against the basket. Some small wineries will use two of these units. One unit will be pressing while the other is being emptied and refilled with grapes (Metz, 2004).

The quality of the pressed wine or juice and the final method or wine style selected are determined by analyses of the various press fractions. The best wineries are designed to transform the grapes into must or juice in a minimum amount of time to prevent oxidation.

Settling and/or Centrifuging

Following fermentation, the yeast and fruit pulp settle rapidly to form a compact sediment in the fermentation tank. When the fermentation is completed and the yeast has settled, the fermented liquid should be separated from the yeast sediment as completely as possible, since this sediment tends to undergo decomposition, resulting in the formation of undesirable flavors. The process of separating the liquid from the sediment is known as “racking.”

For white wine production, the settling of the insoluble solids can be accomplished either by cold temperature and gravity or by centrifugation. Membrane-type presses will reduce the amount of settleable solids compared to other types of presses. Some wineries use cold temperature settling of juice of white wine grape cultivars prior to fermentation and only use the centrifuge after fermentation. The centrifuge also could be used on red wines after fer-

mentation. Removing the insoluble solids allows for the production of fruitier white wines and eliminates many off-flavors.

Fining

Although the extraction of phenolic compounds from the grape skins usually neutralizes the proteins in red wines so that the wines are clear but astringent, proteins suspended in white wines produce a cloudy appearance. The softening and clarification steps in commercial winemaking are known as fining.

Gelatin, Kieselsol, bentonite clay, and Sparkolloid® mixtures are commonly used for the fining of young white wines (Vine et al., 1997). A typical application is about 1 oz per 100 gallons of wine; however, it is recommended that laboratory trials be used to determine the minimum amount of finings that can be used since these can reduce both color and flavor of the wine. Although red wines are typically clear, egg-white fining may be used to soften the harsh flavor caused by tannins. After the fining material has been added, enough wine is added to assure the containers are full and each container is sealed and allowed to rest for four to six hours at room temperature. Cold stabilization, storing the wine at 27°F for at least three weeks, follows the fining treatment.

Filtering

Proper filtration results in the removal of insoluble solids. Also, filtration is used to remove all microorganisms, assuring a microbiologically stable bottled product. During filtration the wine should come into contact only with surfaces made of stainless steel, since stainless steel is inert and can be easily steam cleaned. Stainless steel is expensive enough, though, that some vintners in small wineries choose to use plastic.

Some 5,000-gallon wineries may start out with simple cartridge filters. Even though the housings are inexpensive, the high cost of the cartridges may make it more practical to use a plate and frame filter. Another method of filtering wines uses a Diatomaceous Earth (DE) filter. A skilled operator of a DE filter can rough-filter a wine or can use the filter to accomplish a nearly complete filtration. However, these units require more expertise than do pad or cartridge filtration. Also, DE disposal is becoming a problem in some states because it is not allowed in landfills (Metz, 2004).

A lees filter, which is used to clean up the lees and tank bottoms, is usually a good investment. It increases wine yields and pays for itself quickly. Also,

in small wineries, a lees filter can replace, to some extent, the need for cold settling or centrifuging juice by removing the insoluble solids (Metz, 1992).

Bottling

Bottling is the logical end process for wines. Bottling is an important operation, and many enological problems can be prevented by proper bottling. It is important to keep out oxygen and microorganisms, especially any contamination from the bottling apparatus itself.

Most wineries rinse and clean new bottles. In recent years many new bottles have arrived at the winery containing mold, dust, and other particles. Most bottle washers rinse with an SO₂ (sulphur dioxide) solution. A few wineries still use a jet of compressed air to remove dust. This method is not considered very effective and can be used only when glass bottle plants are nearby, when there is a quick turnover in glass inventory, or when glass bottles are stored under clean, low-humidity conditions.

Filling of bottles must be accomplished with minimum exposure of the wine to air. A small 5,000- to 10,000-gallon winery may be able to justify only a six-spout gravity filler and a hand operated "floor corker." Descriptions of numerous modern bottling and corking machines are available from their respective manufacturers.

Capsuler

A capsule, or thin cap, is often placed over the top of the bottle to protect the cork and make the seal airtight. A capsule improves the appearance of the wine bottle and maintains the image of quality. Until 1990 the lead or tin/lead capsule was the choice of most premium wineries. However, because of safety issues associated with the use of lead, wineries are using other options, such as tin/aluminum, heavy duty plastic and plastic heat-shrink capsules.

Most small wineries (5,000 to 8,000 gallon) apply these capsules by hand using a single motorized, bench-mounted, hand-fed spinner. Capsules can also be applied automatically. An automatic capsule distributor should be installed when labor for hand application becomes too expensive. This usually occurs in the 20,000-gallon and larger wineries. Automatic distribution machines can hold up to 1,500 capsules in stacks in a magazine. As each bottle passes underneath, a photo-electric cell detects the bottle, checks for a cork and then drops a capsule over the neck. Speeds of 1,000 to 6,000 bottles per hour are possible (Metz, 2004).

Labeling

In an effort to save on capital investment, most small wineries label by hand. Hand labeling can cost as much as \$1.00 per case, including labor, and is usually a separate operation from bottling. Small wineries (5,000 to 10,000 gallon) can use either total hand labeling or a choice of semi-automatic labeling machines. After a winery reaches the 20,000-gallon capacity, labeling automation becomes more prevalent. Many options are available. An automatic, in-line, pressure-sensitive labeling machine with an automatic capsule distributor and foil spinner or a heat-shrink oven is one choice. A linear labeling machine for full-width, wet-glue wrap-around labels, or a rotary labeling machine with full-width glue application for a front, back, and shoulder label are other options. These machines have the capacity of labeling from 2,000 to 3,000 bottles per hour (Metz, 2004).

The Laboratory

The laboratory is the heart of the winery. This is where the winemaker gathers information, formulates decisions, directs responsibilities, and records proceedings and data. A good laboratory is needed if quality control is to be maintained. Since the cost of some laboratory equipment can be prohibitive, a small winery may want to begin with the minimum equipment (e.g. ebulliometer, pH meter, hydrometers, refractometers, glassware, etc.) for traditional and required analyses and examine the cost of having the wines analyzed by a commercial laboratory before purchasing specialized equipment. The winemaker in a small winery usually becomes the liaison between the winery and the Alcohol and Tobacco Tax and Trade Bureau (TTB). Usually, state and local regulations that are applicable to the small winery are also handled by the winemaker (Vine, 1981).

Alcohol and Tobacco Tax and Trade Bureau (TTB)

Until January 2003, federal regulation of the production and sale of alcoholic beverages was centered in the Bureau of Alcohol, Tobacco and Firearms (ATF). The Homeland Security Act split the functions of the ATF into two new organizations. The new Alcohol and Tobacco Tax and Trade Bureau (TTB) is in the Department of the Treasury, while certain law enforcement functions of ATF were placed in the Department of Justice.

TTB's broad mission is to collect taxes owed and to ensure that alcoholic beverages are produced, labeled, advertised, and marketed in accordance

with Federal law. To accomplish this mission, TTB enforces Federal laws and regulations for the labeling of alcoholic beverages. It also examines formulas for wine and distilled spirits, statements of process, and pre-import applications filed by importers and proprietors of domestic distilled spirits plants, wineries, and breweries for proper tax classification and ensures that the products are manufactured in accordance with Federal laws and regulations.

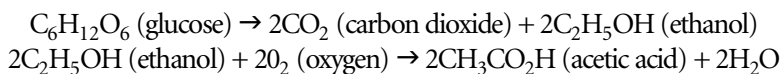
Every person who produces, processes, or warehouses wine shall obtain a basic permit from TTB. The permit must be approved before the business begins operation. Information about regulations administered by TTB, forms for obtaining permits, tax rates and fees, product labeling requirements, and contact information may be found at <http://www.ttb.gov/alcohol/index.htm>

HACCP

The regulations for the use of HACCP in the production of juice do not apply to juice used as the starting material for a fermented alcoholic product if the original juice becomes modified to the extent that it becomes an alcoholic beverage and is no longer recognizable as juice when the processing is complete. However, any unfermented juice that is added to an alcoholic beverage as an ingredient to adjust flavor or sweetness and retains its flavor, color, and nutritional value in the finished beverage must be prepared using a HACCP system.

Vinegar

The manufacture of vinegar occurs through two fermentation steps (Cruess, 1958). The first is the winemaking process in which sugars are fermented to alcohol and carbon dioxide. This is accomplished by yeast. The second leads to the oxidation of the alcohol to acetic acid and is caused by vinegar bacteria. The reactions involved are:



The two fermentation steps cannot take place at the same time because the acetic acid formed by the vinegar bacteria retards yeast growth and activity. Vinegar bacteria themselves are not necessarily injurious to the growth of yeast; it is only the product of their activity, acetic acid, that is harmful.

Steps in the production of wine were discussed in the previous section.

The fermented wine should not be so high in alcohol that the vinegar bacteria cannot function, so, prior to making vinegar, wine should be diluted to about 10% alcohol content.

There are a number of different methods for the conversion of alcoholic liquids to vinegar (Amerine et al., 1980). The slow process for which there are several modifications is older and less frequently used; however, many argue that it results in the best final product. Faster processes, such as those using a vinegar generator or an aerator, produce vinegar more quickly; but the resultant product is often somewhat harsh in flavor and odor and requires aging to obtain desirable quality characteristics. In all production processes, vinegar bacteria, often in the form of fresh vinegar, are added to the fermented wine, and the mixture is exposed to oxygen, allowing the bacteria to convert the alcohol to acetic acid.

The Orleans process is the best of the slow processes (Amerine et al., 1980). Only a small portion of the vinegar on the market today is produced using this process; however, vinegars made by this process are often of very high quality. In the Orleans process, barrels of about 50- gallon capacity are used. They are positioned on their sides and holes are drilled into both ends slightly above the fill level to let air in. The barrels are filled about 3/4 full with wine (about 30 gallons), and then a mass of vinegar bacteria, generally in the form of fresh vinegar, is added. No heat is used to speed up the process, so the barrels remain at 70° to 85°F. It takes three or four months to complete the acetification process, the turning of alcohol into acetic acid. When the concentration of acetic acid reaches about 5%, 1/4 to 1/3 of the vinegar is drawn off through a spigot at the lower end of the barrel and replaced with wine. This occurs about 3 to 4 times a year. Properly handled, barrels last about 25 years and require emptying and cleaning every six to eight years. Because the process is slow, and uses simple materials, the power requirement is minimal. In addition, the slow process allows aging and acetification to occur simultaneously so that the vinegar is ready to use after acetification is complete.

Since the rate of vinegar production is proportional to the oxygen supply, faster rates of vinegar production can be achieved by increasing the area where the vinegar bacteria grow and by improving oxygenation of the liquid undergoing acetification. Two methods of accomplishing this are "vinegar generators" and "acetators".

The generator has a fixed bed of inert material on which the vinegar bacteria grow (Amerine et al., 1980). Wood chips frequently are used for this

bed, but charcoal, ceramics, and coke have also been used. The wine to be acetified is sprayed over the top of this bed and trickles down over the filling material. Air is forced up through the material so that the wine is in constant contact with the air. Many modern generators are recirculating with the acetified liquid pumped from the bottom to the top so that it passes through the generator several times to achieve complete acetification. Batch-wise, a generator will produce its volume in vinegar in four to five days. Thus vinegar production is much faster in a generator than in the Orleans process. However, energy requirements are much greater since the wine is pumped over the fermentation bed, and heat generated by the process usually needs to be removed with some type of cooling. An additional negative aspect of this process is that a great deal of alcohol is lost during the process due to evaporation, oxidation to carbon dioxide and water, and utilization by the bacteria so that percent yields from a given amount of wine are reduced.

The acetator is a submerged culture system using stainless steel vessels with aerators and is the way most modern large vinegar companies make their products. In this process the wine containing the vinegar culture is saturated with fine air bubbles. The vinegar bacteria grow rapidly so that a batch of vinegar is made in a day or two. A reliable aeration system is critical to the process, and interruption of the air supply for as long as a minute will completely stop acetification. Because of the heat of metabolism of the bacteria, acetator vessels must be equipped with a cooling system.

As mentioned previously, freshly made vinegar produced by the quick processes is often somewhat harsh in flavor and odor. These vinegars generally require aging for at least six months in tanks or barrels. During this aging the harsh flavor disappears and is replaced by a mild, agreeable flavor and pleasing odor.

Vinegar should be clear and free of suspended particles. As with wine, this is accomplished by fining or filtering. Fining agents commonly used include bentonite, isinglass, casein, gelatin, or tannin. The fining agent is thoroughly mixed into the vinegar, then the mixture is allowed to sit undisturbed for a week to ten days to allow the fining agent to settle. The vinegar is then racked to remove the clear liquid from the sediment.

The more common method of clarifying vinegar is filtration. The filter should be made of stainless steel, hard rubber, or some other material that will not be affected by the acetic acid (Amerine et al., 1980). After filtration, vinegar sometimes becomes cloudy because of the growth of vinegar bacteria. This may be prevented by heating the filtered or clarified vinegar to 140°F for a few seconds.

Vinegar is commonly marketed in glass or plastic bottles. Vinegar in bottles should be clear, well aged, and have a pleasing flavor and aroma. Bottled vinegar should be pasteurized or contain a small amount of SO₂ so that it will not become cloudy due to the activity of vinegar bacteria.

Sweet Spreads

The process of making grape jelly, jam, preserves, butter, or marmalade consists mainly of cooking the grapes and/or their juice in combination with sweeteners and pectins to the proper solids level. There are federal standards that dictate the ingredients, their proportions, and the final concentration of soluble solids.

Table A-1. Ratios of minimum total soluble solids to fruit sweetener as required by the Federal Food and Drug Administration for grape jelly, jam, preserves, and fruit butter are (Rushing, 1995):

Finished Product	Soluble Solids	Parts by Weight	
		Fruit to Sweetener	
Grape butter	43% minimum	5	2
Grape jelly	65% minimum	45	55
Grape preserves/jam	68% minimum	45	55

Jam, preserves, and grape butter are made from whole or crushed fruits. Preserves differ from jam, only in that the fruit pieces are usually larger. Muscadine butter is made from screened fruit and differs from jam in its ratio of fruit to sweetener and in the final solids concentration.

Ingredients

Sweet spreads are made from fruit, sweetening agents, pectin, acid, and water. The sugar and acid cause the pectin to undergo a physical change so that a gel is formed. To produce a spreadable product, the concentration of the water-sweetener-acid-pectin mixture must be in the proper proportions (Morris and Striegler, 1996). If the grape juice or fruit does not provide sufficient quantities of acid and/or pectin to form a good gel, then federal standards allow supplementation of the pectin and/or acid in a quantity that “reasonably compensates for any deficiency.” Since federal regulations fix the proportions of the grape juice or fruit, the sweetener, and the final concentration of the final product, acids and pectin are the only variables. When whole grapes are used in the

product, the fruit provides some spreadability and decreases the need for pectin.

Sweeteners. For home production of sweet spreads, sugar is the sweetener most commonly used. Sugar helps in gel formation, serves as a preserving agent, and contributes to the flavor of the jellied product (Brady, 1995a).

Corn syrups are widely used by commercial manufacturers of quality jellies, jams, preserves, and butters (Morris and Striegler, 1996). Corn syrup is not only economical but also aids in preventing sugar crystallization, improving texture, and helping retain color.

Federal standards authorize replacing up to 25% of the total sweeteners with corn syrups for jellies, jams, preserves, and butters and up to 50% in marmalades (Morris and Striegler, 1996). To substitute corn syrup in any preserve recipe or formula, 1-1/4 lb of corn syrup is used for every pound of sugar replaced since this amount corn syrup contains 1 lb of solids, replacing the

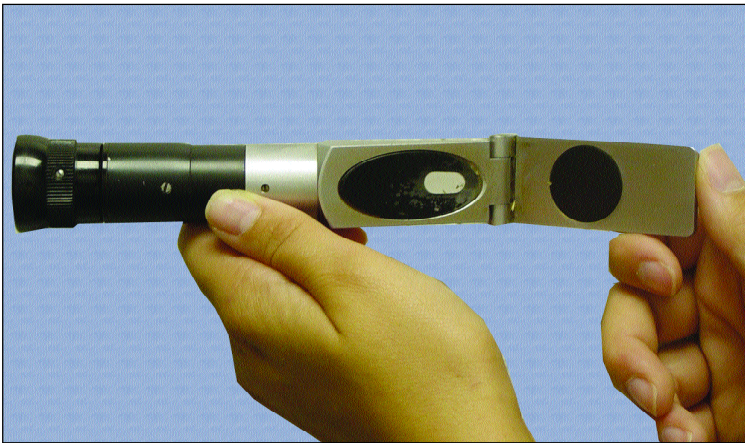


Figure A-4. A hand-held refractometer provides a simple, inexpensive means of determining the solids content of juices for making sweet spreads.

sugar, on a solids basis, pound for pound. Cooking the product to the designated end temperature removes excess water added by the syrup.

To determine the amount of sugar needed for a sweet spread formula, you must know the soluble solids content of the fruit or juice (Moysl et al., 1962). The best way to get this information is to use an instrument which measures soluble solids called a refractometer. Suppose you want to make a 100-lb batch of muscadine jelly. According to the information in Figure A-1, jelly should be 65% total solids and contain 45% fruit. The refractometer reading on the muscadine juice is 15.5% soluble solids (ss). The sweetener needed would be calculated as:

Total soluble solids desired per 100 lb of jelly	65 lb
Soluble solids in 45 lb of juice at 15.5% ss	7 lb
Amount of sugar needed	58 lb

Suppose you want to substitute corn syrup for 1/4 of this sugar (14.5 lb). It takes 1 1/4 lb corn syrup to equal 1 lb of sugar so you would use 14.5×1.25 or 18 lb corn syrup

Sweetener to be used would be $58 \text{ lb} - 14.5 \text{ lb} = 43.5 \text{ lb}$ sugar and 18 lb corn syrup

Acids. A correct acidity (pH) is necessary for a perfect gel. The optimum pH range for “setting” pectin is 3.0 to 3.35 (Morris and Striegler, 1996). At a specific pH within this range, the consistency of the product will be primarily determined by the amount of pectin present.

Federal regulations allow the addition of vinegar, lemon juice, lime juice, citric acid, lactic acid, malic acid, tartaric acid, or any combination of two or more of these, in a quantity that reasonably compensates for the deficiency of the natural acidity of the fruit ingredient without requiring a label declaration of added acid (Morris and Striegler, 1996). Each acid has a slightly different flavor and may impart a slightly different tartness to the final product, so the selection of acid is important in assuring the desired flavor of the product.

If grape juice has too low a pH in the natural state, the end product will have a pH lower than the optimum 3.0 - 3.35 (Morris and Striegler, 1996). This will cause premature setting of the pectin. Buffer salts may be added to adjust the pH in this situation. The buffer salts (sodium citrate, sodium potassium tartrate, or any combination of these) may be added dry (mixed with the pectin) or in solution. No label declaration is required.

A pH meter is the best way to determine the acidity of the juice. To determine how much acid is needed to make jelly with the proper pH, begin by preparing a standard solution of citric acid (Moyle et al., 1962). To do this, dissolve 2 oz of citric acid crystals in pure water to make 100 ml. Each milliliter of this solution would then contain 0.02 oz of citric acid. Next, determine the amount of acid that must be added to reach the required pH for jelling. This is done by taking a 1 lb sample of the juice and titrating it with the citric acid solution (citric is best if it will be used in the actual jelly making) to the desired pH. This should be about 0.1 pH lower (more acid) than needed in the final prod-

uct as it will increase slightly during boiling. If a 1-lb sample of your juice required 8.8 ml of the standard citric acid solution to lower the pH to 3.1, the amount of powdered citric acid required for 100 pounds of juice would be calculated as:

1 lb of juice requires 8.8 ml of standard solution

1 ml of standard solution contains 0.02 oz of citric acid.

Therefore, 1 lb of fruit requires $8.8 \times 0.02 = 0.176$ oz.

100 lb would then require $0.176 \times 100 = 17.6$ oz of powdered citric acid

Pectin. Pectin is the substance which causes fruit juice to “gel” (Brady, 1995a). Pectin is a carbohydrate present in all plants, which, along with cellulose, is responsible for structural properties of the plant. Pectin is used in jams, jellies, and preserves for two major purposes: (1) to create a desired texture and (2) to bind water. If the water binding effect is not completely obtained, the final gel will show a tendency to contract and exude juice. This phenomenon is known as syneresis.

All fruits contain some pectin but the amount and quality vary with the fruit, its ripeness, and the conditions under which it was grown (Morris and Striegler, 1996). Muscadines are fairly high in pectin, so sweet spreads can be successfully made without adding more pectin if the acid level is appropriate. However, commercial pectin is usually added because it compensates for the variability in pectin content in fruit, results in shorter cooking times, and is standardized so that the yield from a given amount of fruit is greater (Brady, 1995a). Commercial pectins are normally produced either from citrus fruits or apples and are used to impart the “gel” property to food products such as jellies, jams, and preserves. They are produced in accordance with internationally accepted specifications for identity and purity.

Pectins are graded according to their ability to set a specific weight of sugar under standardized conditions (Morris and Striegler, 1996). For example, 1 lb of 100-grade pectin will set 100 lb of sugar into a standard jelly, if the acid level is right. Pectins are also categorized by how quickly they set on cooling, and the pectin must be carefully chosen to assure the desired final product. For jellies in which air bubbles slowly rise to the top to yield a clear final product, slow set pectin is desirable. Rapid set pectin, which thickens soon after the acid is added, would be used to prevent the fruit in preserves from floating to the top.

Pectin may be added to the sweet spread mixture either as a powder or

in solution, however, it must be completely dissolved to gel (Moyls et al., 1962). Because pectin dissolves best if the sugar solids are less than 20%, powdered pectin works best when mixed with a small amount of sugar and added at the start of cooking before the bulk of the sugar is added. Liquid pectin may be added anytime during the process. This is an advantage since prolonged cooking can destroy some of the pectin and lessen its effectiveness.

The best way to determine the pectin requirements of a formula is to prepare a small test batch (for example 5 lb) using the proportions of juice, sugar, and acid you have calculated (Moyls et al., 1962). So for the 100-lb formula in the examples above, the formula for a 5-lb test batch would be:

Juice	2.25 lb
Sugar	2.2 lb
Corn syrup	0.9 lb
Acid per pound X 5	
Pectin	0.2 lb

Follow the preparation procedure below. About twelve hours after processing, evaluate the jelly. If it is satisfactory, convert the amounts to factory size batches. If it is unsatisfactory, continue experimenting on a small scale until the correct proportions for a satisfactory jelly are determined.

Preparation Procedure (Adapted from: Morris and Striegler, 1996)

The basic formula for grape jelly given in Table A-2 conforms to the federal standards of identity. Although this formula has been tested on a commercial scale, manufacturing processes and conditions vary. Before a formula is used for commercial production, several test batches should be prepared and evaluated.

The basic procedure for making jelly is:

Table A-2. Basic Jelly Formula

Ingredients	lb	%
Standard grape juice ¹	82	45
Sucrose	75	55
Corn syrup (43° Baume)	31	
Acid		n.a. ²
Pectin, slow set	1/2 to 1	n.a. ³

¹Any juice containing the specified amount of soluble fruit solids (15.5%).

²Quantity may be varied to obtain a pH of 3.0-3.35 in the finished product.

³Quantity will be varied, depending upon type of juice and the pectin manufacturer's recommendation.

Source: *Corn Syrup* in *Jams, Jellies and Preserves* , Technical Service Bulletin No. 1D1a, Clinton Corn Processing Company, Clinton, IA.

- (1) Pour the standardized unsweetened fruit juice into the cooker and begin heating.
- (2) Blend the pectin with six to ten times its weight of dry sugar. Add the pectin/sugar mixture to the juice in the cooker.
- (3) Add the balance of the sugar and corn syrup. Cook until the desired temperature or solids content is reached. This finishing point is determined in one of the ways listed here, in order of their preference:
 - (a) cook to a refractometer reading of 65% soluble solids;
 - (b) cook to 5° to 6°C (9° to 10°F) above the boiling point of water—at sea level this would be about 105°C (221°F);
 - (c) cook to a Brix of 65° to 68°.
- (4) Do not add the acid solution until just before the filling operation. In some cases, it is desirable to add the acid directly to the container and pour the jelly on top of it.

The federal regulations stipulate that the juice portion of the basic jelly formula must contain a minimum percentage of soluble fruit solids. The average required soluble solids content of grape juice used to prepare jelly is 14.1°Brix. However, many juices have solids contents that differ from this average.

The FDA has established a factor, based on the average solids content, which is used in a shortcut method to calculate the amount of juice that must be used to equal the soluble fruit solids of a “standard” juice in a basic formula. The factor for grape juice (calculated as the reciprocal of the percentage times 100, i.e. $(1/14.1) \times 100$) is 7.0.

Suppose the grape juice on hand contains 10% soluble solids. If the juice was “standard,” the 82 lb of the grape juice in the basic formula above (Table A-2) would contain 11.66 lb of soluble fruit solids (that is, 14.1% of 82). In order to calculate the amount of the 10% juice that would be needed to give a comparable amount of soluble fruit solids, the formula would be:

$$\frac{82 \text{ lb (of “standard” grape juice)}}{0.10 \text{ (soluble fruit solids)} \times 7 \text{ (factor)}} = 117 \text{ lb}$$

Therefore, 117 lb of juice would be required for each 100 lb of sweetener solids. Since the basic formula contains 100 lb of sweetener solids (75 lb sucrose + 25

lb sugar as corn syrup - corn syrup is 80% sugar therefore $31 \text{ lb} = .8 \times 31 = 25 \text{ lb}$), this would be the amount of 10% juice needed in the basic formula.

Fruit Leathers

Fully ripe fruit are recommended for making leathers as they have a more balanced flavor (Brady, 1995b). Wash and destem muscadines. Crush enough grapes to provide juice in the bottom of the cooking vessel. Remaining grapes may be crushed more easily after they are hot. Heat grapes for eight to ten minutes at low temperature (not over 180°F degrees) to loosen skins. Do not boil. Put through a food mill or wire mesh strainer. Discard seeds and skins. The remaining product is puree.

If additional sweetening is desired, sugar, corn syrup, or honey may be added (Brady, 1995b). Sugar is best for immediate use or short storage. For long-term storage, corn syrup or honey works best since neither crystallizes as easily. Sweetener may be added as desired, however, unless fruit is very tart, 2 tablespoons sugar or 1 tablespoon corn syrup or honey for each 2 cups of puree will usually make the leather sufficiently sweet. Saccharin and acesulfame-K based sweeteners may be used in amounts equivalent to the amount of sugar that they replace. Aspartame-based sweeteners are not recommended since they may lose their sweetness during drying.

For purees from light-colored fruit, 2 teaspoons lemon juice or 375 mg (1/8 tsp) ascorbic acid may be added for each 2 cups of puree to help prevent darkening during drying.

Once the puree is prepared, it is spread in thin layers (1/4 to 1/2 inch thick) on drying trays (Brady, 1995b). Drying trays may be as simple as large cookie sheets or may be specially made plastic or metal trays. Some commercially-made drying racks are equipped with liners made of plastic or Teflon to facilitate removal of the dried leather, however, lining the trays with plastic wrap, carefully smoothed to eliminate wrinkles, will also serve this purpose.

Puree may be poured onto the drying racks in a single large sheet which is cut into portions after drying. As an alternative, puree may be poured in portion-size circles prior to drying.

Muscadine leathers are dried at 140°F. Drying may be accomplished in an oven with the door propped open two to six inches to allow for air circulation, or in a dehydrator. If drying in a dehydrator, follow the manufacturer's instructions for the particular equipment you are using.

Leathers dry from the outside toward the center. Test for dryness by

touching the center of the leather. If no indentation remains, the leather is dry. Dry leathers should peel easily from the plastic tray liner. Drying times will be approximately six to eight hours in a dehydrator and up to 18 hours in the oven.

Fruit leathers are generally sold in the form of a roll. A sheet of grease-proof paper or plastic is generally rolled with the leather to prevent it from sticking together. The warm leather is removed from the plastic drying tray liner. Pieces of the required weight are laid on the grease-proof paper or plastic and the leather and paper rolled into a tube shape. The tubes are allowed to cool and then packaged for marketing.

APPENDIX B

Adapting Muscadine Recipes for Commercial Production

Often an idea for a commercial product may evolve from a recipe used in the home that has been so well received by friends and family that you believe the product could be produced and sold commercially. Other sources of ideas are recipe books and publications from the Extension Service and trade organizations promoting the commodity you want to market. Table B-1 provides a sample list of some Internet sites that offer recipes for muscadine products.

Table B-1. Examples of Internet locations offering muscadine recipes.

Sponsoring Organization	URL for Muscadine Recipes
NC Department of Agriculture and Consumer Sciences 1001 Mail Service Center, Raleigh, NC 27699-1001	http://www.ncwine.org/recipe.htm
Florida Grape Growers Association 343 West Central Avenue #1 Lake Wales, FL 33853	http://www.fgga.org/
LSU AgCenter NEWS LSU AgCenter Communications Baton Rouge, LA 70894-5100	http://www.lsuagcenter.com/Communications/news/NewsArchive/6nws0831.htm

Once there is an idea for a product the next step is to screen the idea for feasibility of production. Considerations involved in the screening and feasibility steps are discussed in the publication "The Importance and Role of Value-Added in the Profitability of a Farming Operation" (Thomsen et al., 2004). If the screening and feasibility studies indicate good potential for launching the product, the actual development of the product follows.

The goal at this stage is to produce a prototype product that meets the quality criteria of the original idea. What seemed like an excellent idea in the home kitchen or when read in a cookbook may become a problem as steps are taken to make it commercially. While recipe variability is acceptable for home preparation, product consistency is a requirement for commercialization. For some products, meeting regulatory product standards may also significantly change the characteristics of the product. Achieving a consistent, satisfactory product without sacrificing the unique characteristics of the home-prepared product can be difficult and, with some products, may prove impossible.

Let's assume you have decided to produce a muscadine jelly. After mak-

ing a number of different recipes for this jelly, you choose the following to develop for commercial production.

Muscadine (Scuppernong) Jelly

Source: NC Department of Agriculture

7 cups sugar
4 cups muscadine juice
2 tsp bottled lemon juice
1 box Sure-Jell®

- Measure sugar and set aside.
- Put muscadine juice and lemon juice in large saucepan. Mix in Sure-Jell®.
- Bring to a boil stirring constantly. Add sugar. Bring to a full rolling boil and boil hard for 1 minute, stirring constantly.
- Remove from heat. Skim off foam with metal spoon. Pour at once into prepared jars.

Yield: 8 half pints

The first step in adapting a home-style recipe to a commercial formula would be to standardize all ingredient measurements. Converting all measurements to weights will help assure accuracy in measuring. Some volume to weight equivalents which might be useful in preparing formulas for muscadine products are provided in Table B-2.

Table B-2. Volume to weight equivalents for some ingredients in muscaddine product.

Ingredient	Volume measurement	Weight Measurement
Grape juice	1 cup	0.56 lb (9 oz)
Sugar	1 cup	0.44 lb (7 oz)
Lemon juice	1 cup	0.54 lb (8.6 oz)
	1 Tablespoon	0.03 lb (0.5 oz)
Powdered pectin	1 box	0.11 lb (1.75 oz)
Corn syrup	1 cup	0.70 lb (11.3 oz)
Vinegar	1 cup	0.53 lb (8.5 oz)

For the example recipe these conversions would be:

Ingredient	Recipe Amount	Weight
Sugar	7 cups	3.1 lb
Muscadine juice (15% solids)	4 cups	2.2 lb
Lemon juice	2 tsp	0.32 oz (0.02 lb)
Sure-Jell® pectin	1 box (1.75 oz)	1.75 oz (.11 lb)
Total weight		5.4 lb

The amount of juice must be determined based on the “standard” juice (See Appendix A). This would be calculated as:

$$\frac{2.2 \text{ lb “standard” juice}}{0.15 \text{ (ss of juice)} \times 7 \text{ (factor for grapes)}} = 2.1 \text{ lb juice}$$

The minimum total soluble solids to fruit sweetener as required by the Federal Food and Drug Administration for grape jelly is 55% sweetener to 45% fruit (Morris and Striegler, 1996). Therefore sugar solids may be no higher than 55/45 or 1.22 times the weight of the juice (1.22 X 2.1 = 2.6).

Based on these calculations, the formula for the jelly would be:

Ingredient	Weight
Sugar	2.6 lb
Muscadine juice (15% solids)	2.2 lb
Lemon juice	0.32 oz (0.02 lb)
Powdered pectin	1.75 oz (.11 lb)
Total weight	5.4 lb

The best way to determine if the revised formula results in an acceptable product is to prepare a test batch using the adjusted quantities. About twelve hours after processing, evaluate the jelly. If it is satisfactory, convert the amounts to factory size batches. If it is unsatisfactory, continue experimenting on a small scale until the correct proportions for a satisfactory jelly are determined.

Suppose you want to make batches using 100 lb of juice. To determine the multiplication factor for increasing the amounts of all of your ingredients:

$$100 = 2.6 \text{ lb} \times \text{multiplication factor (y)}$$

$$100/2.6 = y$$

$$y = 38.5$$

Ingredient	Original Weight	Original Weight x 38.5 = Commercial Batch Weight
Sugar	2.6 lb	100 lb
Muscadine juice	2.2 lb	84.7 lb
Lemon juice	0.32 oz	12.3 oz (0.8 lb)
Powdered pectin	1.75 oz	67.4 oz (4.2 lb)

Although lemon juice and powdered pectin like Sure-Jell® are convenient and readily available for home use, these forms of acid and pectin are expensive for large-scale production operations. The procedure for determining the amount of powdered citric acid needed in a formula to replace the lemon juice is described in Appendix A. There are a number of types of commercial pectins on the market. Manufacturers of these, your co-packer (if you are using one), and food processing experts like those at The Food Processing Center in the Institute of Food Science and Engineering (IFSE) and the Department of Food Science, University of Arkansas, Fayetteville, can provide assistance in selecting the type best suited to your needs.

Pilot plant scale production provides an intermediate step between the small scale, home-type product preparation and commercial production. Look for places where you can manufacture a test-market batch of your product. The Food Processing Center in IFSE and the Department of Food Science, University of Arkansas, Fayetteville, offer a facility to test produce commercial-size batches of product to evaluate for quality and acceptability (See Appendix D for contact information). However, product produced in the IFSE facility cannot be sold. An alternative would be to have your product manufactured by an approved food-processing facility (co-packer) in your area. Although the IFSE will probably be less expensive than working with a co-packer, the co-packer offers the advantage of providing an actual commercial environment for this process and the opportunity for commercial distribution, thus simplifying the process of moving to the commercialization stage.

APPENDIX C

Glossary

Alternative agricultural activity – nontraditional farming activity. Examples of alternative agricultural activities include growing alternative crops, sales through direct marketing systems, or the production of value-added products.

Anthocyanins – natural, water-soluble pigments responsible for the color in grapes and most fruits. Anthocyanins have demonstrated a wide range of health benefits including antioxidant, anti-carcinogenic, anti-inflammatory, and anti-microbial properties.

Antioxidant – a substance that retards oxidation, a reaction that generally leads to degradation or breakdown of the base material.

Argols – tartar in crude form as deposited in wine and/or juice tanks.

Astringency – a physical sensation occurring in the mouth when tasting; it is characterized by the puckering of the mouth's tissue.

Bioavailability – the extent to which a substance, such as a drug or a nutrient, becomes available to the body.

Blanching – heating by direct contact with hot water or live steam. Blanching serves to soften the tissues, eliminate air from the tissues, and destroy enzymes.

Brix – a scale used to measure dissolved solids (primarily sugar) in juice and other fruit products.

Brokers and/or sales representatives – intermediaries hired by the grower, manufacturer or distributor to sell their product to their designated retail trade.

Color Difference Meter (CDM) – laboratory method for measuring color. Determines the difference in color between the test sample and a standard color plate in terms of three values, L (lightness/darkness), a (redness-greenness), and b (bluish-yellowish).

Cold press – a process in which grapes are pressed directly after crushing with little or no skin contact.

Controlled atmosphere storage – storage conditions involving carefully controlled temperature, oxygen, carbon dioxide, and humidity.

Co-packing – someone else produces and packages your product with your label.

Decision tree – graphical representation of the decisions involved in a process and the possible outcomes of these decisions.

Direct sales markets – markets where sales are made directly to the customer or final user.

Enzymatic oxidation – oxidation and browning caused by enzyme activity.

Enzyme – a protein that induces or accelerates a chemical reaction.

Fermentation – biological reaction in which organic substances are converted by organisms, especially bacteria, fungi, or yeasts to produce other substances. An example of fermentation is the action of yeasts to converting sugar in juice to make wine.

Filtration – the act of passing a material through a filtering medium to remove suspended solids, yeasts, and/or bacterial cells.

Fining – the application of specific agents to clarify and stabilize wines.

Free radicals – natural byproducts of cell metabolism. Free radicals form when oxygen is metabolized, or burned by the body. They travel through cells, disrupting the structure of other molecules, causing cellular damage. Such cell damage is believed to contribute to aging and various health problems.

Free-run juice – the portion of juice that flows by gravity from a holding tank into a receptacle after the fruit is crushed.

Hazard Analysis Critical Control Point (HACCP) – a system of food control. It involves examining and analyzing every stage of a food-related operation to identify and assess hazards; determining the 'critical control points' at which action is required to control the identified hazards; establishing the critical limits that must be met, and procedures to monitor, each critical control point; establishing corrective procedures when a deviation is identified by monitoring; documentation of the HACCP plan and verification procedures to establish that it is working correctly.

Hot press – a process in which the juice is pressed from grapes after heating and enzyme treatment.

Hydrometer – an instrument that uses buoyancy to measure the density of a liquid; it consists of a weighted tube that floats vertically and determines the specific gravity of the liquid by a comparison of the scale on the tube with the level it floats in the liquid.

IU – International Unit

Muté – a fruity flavored juice added back to wine for flavor enhancement.

Nutraceuticals – food components that provide medical or health benefits

ORAC (Oxygen Radical Absorbance Capacity) – a measure of antioxidant capacity. Generally, the higher the ORAC value the better the antioxidant capacity.

Oxidation – a chemical reaction that occurs when a substance is combined with oxygen; may lead to degradation or deterioration of the substance.

Pectinase – an enzyme which is capable of breaking down pectin.

Pectins – a water-soluble carbohydrate from fruit that yields a gel.

pH meter – an instrument to measure the acid or base levels (pH) of a substance.

Phenolics – chemical compounds identified by a ring structure. A number of phenolics are found in grapes and wine, including many color, tannin, antioxidant, and flavor compounds.

Phytochemicals – chemicals found in plants that are not essential nutrients for humans but may be important for preventing chronic disease, particularly cancer.

Polygalacturonase – enzyme that degrades polygalacturonans, which are large molecules derived from the sugar galactose.

Pomace – by-product of juice and wine production containing seeds, skins and sometimes pulp and yeast cells.

Pureé – a smooth, thick mixture usually made by blending and straining fruit.

RDA (Recommended Dietary Allowance) – safe levels of intake for essential nutrients, based on current scientific knowledge.

Refractometer – instrument that measures the percent of soluble solids in a solution by the extent which a beam of light passed through the solution is bent (refracted). The soluble solids scale is based on sugar concentration in a pure sucrose solution.

Resveratrol – a phenolic substance produced by plants, such as grapevines, in response to stress. Consumption of resveratrol has been shown to lower blood levels of low density lipoproteins and bad cholesterol and, possibly, to aid in the prevention of some cancers.

Sulfur dioxide (SO₂) – widely used preservative to keep wine from browning or spoiling.

Tannins – special phenolic compounds found in grape stems, seeds, and skins that contribute to astringency and bitterness.

Value added products – commodities whose value has been increased through the addition of ingredients or processes that make them more attractive to the buyer and/or more readily usable by the consumer.

APPENDIX D

Resources For Developing Alternative Agricultural Activities

UA Institute of Food Science and Engineering (IFSE)

The IFSE Food Processing Program was developed to provide technical support to the food industry. The Program assists new food business entrepreneurs in such areas as product development, determination of process times, shelf-life studies, and labeling issues. Experienced scientists and production personnel can assist in developing products and can produce small runs of finished product for evaluation. In addition to responding to requests for one-on-one assistance, Institute personnel have prepared a number of publications to provide information to the food industry entrepreneur. The free publication, *Starting a Food Business*, provides an introduction to such topics as regulations, safety, labeling, ingredients, packaging, and the business of food processing. This factsheet serves as a starting point for establishing a new business. A comprehensive manual, *Starting a Food Processing Business*, is offered for sale. This guide provides in-depth information on the topics introduced in the factsheet. A third publication, *Developing Your Product*, is also offered for sale. A number of other factsheets providing in-depth information to assist those looking to enter the food industry also have been developed. A list of these may be found at the IFSE Web site: <http://www.uark.edu/depts/ifse/pub.html>. All publications are available through county extension offices, the state extension office, and through the IFSE Web site.

Arkansas Small Business Development Center (ASBDC)

The ASBDC provides, at no cost, one-to-one professional consulting for business owners and entrepreneurs related to the business aspects of entering the food industry. Help available includes advice on operating challenges in existing businesses, review of business plans and strategies, guidance in starting new businesses, preparation of loan requests, financial analysis, and budget development. A "Start-up Guide," available in the Consulting section of the Web site at <http://asbdc.ualr.edu/start/>, offers guidance in handling new business operations and finances. The ASBDC neither lends money nor administers grants. However, business consultants can assist small business owners in meeting their operating challenges. ASBDC is a statewide organization, consulting is offered to residents throughout the state. ASBDC offers training on a variety of business topics at locations around the state. The topics and scheduling vary

between ASBDC offices. The training schedule for all of the offices can be accessed on the Web site at <http://asbdc.ualr.edu/training/>.

UA Cooperative Extension Service (UACES)

The Cooperative Extension Service is the outreach arm of the University of Arkansas providing education and information to address the issues and needs of the people of Arkansas. UACES offers educational programs on a variety of topics including business development, food safety and quality. The county extension offices can provide information on programs available in your area. They also can assist in making initial contact with the IFSE Food Processing Specialist. To locate the extension office in your county see the business section of your phone book or visit the UACES Website at http://www.uaex.edu/Other_Areas/contact/Counties.asp.

FDA Small Business Assistance Program

The U.S. Food and Drug Administration's Small Business Assistance Program offers a unique opportunity for small and start-up companies to obtain confidential advice on compliance and to avoid situations that could delay product approval. The objectives of this service program are to provide an efficient way for small businesses to obtain general guidance for compliance requirements and to reduce the complexities faced by small businesses in dealing with a large bureaucratic organization.

The Program has representatives throughout the country who administer the regional Small Business Assistance Program and respond to industry inquiries about current FDA policies and legal and regulatory requirements. A response can vary from sending out forms and publications to providing regulatory guidance and technical assistance through phone calls or on-site visits. In addition, these representatives may provide technical assistance to small companies, hold exchange meetings to hear the views and perspectives of small businesses, conduct educational workshops, develop informational materials, and provide an accessible, efficient channel through which small businesses can acquire information from the FDA. The primary purpose of these activities is to increase communication between FDA and the small business community.

The Small Business Representative for the FDA, Southwest Region (Ark., Colo., Iowa, Kan., Mo., Neb., N.M., Okla., Texas, Utah, Wyo., US-Mexico Border Imports) is David Arvelo and the Small Business Technician is Sue Thomason. They can be reached at:

4040 N. Central Expressway, Suite 900
Dallas, TX 75204
Phone (214) 253-4952 or (214) 253-4951
FAX (214) 253-4970
Email: oraswrsbr@ora.fda.gov

The FDA has created a pamphlet so that small businesses can have a quick reference guide when they have questions regarding the regulations under the authority of the FDA. This guide can be found at http://www.fda.gov/ora/fed_state/small_business/sb_guide/default.htm.



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