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POSTHARVEST PHYSIOLOGY AND SENESCENCE IN MUSCADINES

MARY STARNES SAUNDERS AND FUMIOMI TAKEDA
Center for Viticultural Science and
Small Farm Development,
Division of Agricultural Sciences,
Florida A&M University,
Tallahassee, FL 32307

T. T. HATTON[1]
USDA/SEA/AR
2120 Camden Road,
Orlando, FL 32803

Abstract. **Fruit maintained in storage deteriorates as a result of both normal senescence and pathogen attack. At the cellular level, fruit deterioration is characterized by loss of membrane permeability, increase in the production of secondary metabolites and cell wall degradation as well as changes in respiration and hormonal levels. Muscadines can be held in cold storage at 1°C (34°F) with 85% relative humidity for up to two weeks without visible signs of tissue deterioration upon removal from cold storage and holding at room temperature for three days. Muscadines kept in cold storage for longer periods deteriorate rapidly upon removal from cold storage and holding at room temperature. The biochemical parameters that change during cold storage and senescence of muscadine fruit are discussed. These include percent decay, soluble solids, titratable acids, firmness, pectins, total phenols, organic acids, sugar and water loss.**

It has become increasingly evident that muscadines are well accepted in the southern markets as a fresh fruit delicacy (7). This market could be greatly expanded to other parts of the country if the short storage life of muscadines could be overcome either through improved preharvest cultural practices, improved postharvest handling and storage, new cultivars with high dry stem scar percentages or improved transportation methods or a combination of these.

Until recently, the majority of muscadines have been marketed for fresh fruit through "U-Pick" at the farm markets. With the increasing commercial acreage of muscadines to nearly 1,000 acres, this type of market is becoming saturated in some areas of Florida necessitating the need for marketing the fruit to wholesalers for shipping to other parts of the state or country. Muscadines from Florida are presently being marketed commercially to wholesalers in Florida, Georgia and Alabama. This market will also soon become saturated unless further markets become available, such as shipping muscadines to the Northeast. In addition to the commercial growers, many small backyard growers are also taking their excess fruit and selling this fruit either in roadside stands or directly to local grocery stores. The backyard growers are thus precipitating a large drop in the wholesale price of fresh fruit through these practices (Harold Crevasse, Grape Marketing Association, personal communication).

Characteristics of Fresh Muscadines

To market muscadines for fresh fruit presently requires manual harvesting, sorting and packaging. The general characteristics of muscadine which should be considered when used as fresh fruit have been summarized by Flora (8). Most of these characteristics can be noted as those which make muscadines difficult to ship for long distances or store for extended periods. In particular, the high percentages of wet stem scar on many of the cultivars which are most popular as fresh fruit such as Fry, Jumbo, Cowart and Higgins make long distance transport and storage prohibitive.

Fruit which is destined for the fresh market should be ripe and kept sound. Overripe and rotten fruit will decrease the market outlets at a rapid pace. Growers who are now involved in selling their fruit to wholesalers have indicated that it is necessary to get the fruit to the consumer within five to seven days if a good quality product is to be delivered. In order to accomplish this, fruit needs to be picked, sorted, packed and cooled to shipping temperature as soon as possible, and shipped to the wholesalers within 24 hours or less. It is also necessary to make sure the wholesale distributor is aware of the necessity to keep the fruit in cold storage at all times between 1°C and 4.5°C.

Characteristics of Stored Fruits

Are there unique physiological characteristics of muscadines, or grapes in general, which make them so susceptible to deterioration during storage? Grapes are classified as non-climacteric fruit and are characterized by the lack of a massive rise in ethylene production during ripening along with the lack of the subsequent increase in respiration. Grapes have low levels of ethylene present during ripening which decrease further as ripening proceeds (5). In contrast, in climacteric fruit, such as the apple, fig or banana, ethylene production increases dramatically with an increase in the respiration rate at the onset of ripening (10). It has been postulated that there are two systems of ethylene production (25). In non-climacteric fruit, such as the grape, only system I is present, where the synthesis of ethylene is initiated by some factor involved in the senescence process of the fruit. System II, the autocatalytic production of ethylene upon ripening, is not present in grapes.

Coombe (4) has associated the beginning of ripening of the grape with the onset of sugar accumulation, loss of acidity, softening and change in color. Ripening grapes show many of the features associated with senescence but ripened fruit only represent one stage in the process of senescence since senescence will continue after the fruit is harvested until cell death. Grapes essentially do not ripen after they are harvested and have thus entered the final stages of senescence at the time of harvest. Because of this, when grapes are put in storage, the biochemical changes that are taking place will ultimately lead to death of the fruit. Senescence is considered to be a programmed continuation of the development and differentiation of that organ which results in its death (25, 26). The purpose of storage of fruit is to attempt to retard the natural senescence process.

It is well known that there are several *Vitis vinifera* cultivars which can be held in long-term storage for up to six months (11). This has been accomplished through cultural practices and the use of fumigants in storage such as SO_2. In contrast, muscadines cannot be stored for long periods of time using SO_2 because there is extensive damage

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to the fruit such as bleaching and off flavor (27, 29). Such factors as temperature, relative humidity, handling, loss of weight, deterioration of flavor and influence of storage on behavior of fruit after storage were investigated by Lutz (19). He indicated that the storage life of muscadines was approximately two weeks when fruit were kept at 0°C. Higher temperatures decreased the storage life of the fruit further.

The parameters which are ordinarily monitored during both the ripening and storage of grapes are soluble solids, total acidity, pH of juice and phenols. Muscadines have been shown to increase in soluble solids and decrease in acidity at veraison, with the decline in acidity and increase in soluble solids continuing until full ripeness is reached and then leveling off (13, 23). Lanier and Morris (18) used brine solutions to separate once-over harvested muscadines and also noted as density of the berries increased, soluble solids increased and acidity decreased. This was concurrently determined by Flora and Lane (9) in a study using the cv. Cowart harvested at three different dates. They noted that the acidity decreased with increased ripeness of fruit and also later harvest dates.

The Center for Vitriculture Science and Small Farm Development has been involved in postharvest physiological studies with muscadines in cooperation with the USDA in Orlando for the past two years (29). The results of this work have shown when muscadines are placed in cold storage and acidity and soluble solids followed through the storage period, no further changes are noted (Table 1). Acidity and soluble solids are stable for cultivars with high wet stem scar as well (Table 2). Although firmness, measured by using Chatillon pressure gauge, does decrease

Table 1. Change in quality of cv. Southland during storage at 1°C.

Variable	Weeks in storage 0	2	4
Berry weight (gm)	4.7	4.9 ± 0.1	4.8 ± 0.2
Soluble solids (%)	15.0	14.1 ± 0.3	14.2 ± 0.5
Acidity (gm/100ml)	0.87	0.87 ± 0.08	0.89 ± 0.06
pH	3.0	3.1 ± 0.05	3.1 ± 0.08

Table 2. Change in quality of cv. Fry during storage at 1°C.

Variable	Weeks in storage 0	2	4
Berry weight (gm)	9.6	10.0 ± 0.6	9.7 ± 0.3
Soluble solids (%)	14.6	14.7 ± 0.8	14.0 ± 0.3
Acidity (gm/100ml)	0.53	0.54 ± 0.04	0.58 ± 0.04
pH	3.5	3.5 ± 0.07	3.5 ± 0.1

Table 3. Increase in % decayed berries in cv. Southland and Fry as related to type of berry and length of storage at 1°C.

		% Decay			
		2 weeks		4 weeks	
Cultivar	Berry type	At removal	Plus 3-days	At removal	Plus 3 days
Southland	mixed	0	53	8	45
	mixed/washed	0	14	5	51
	dry scar	0	36	3	35
	wet scar	0	47	6	32
Fry	mixed	13	43	23	58
	mixed/washed	7	32	12	54
	dry scar	0	26	0	56
	wet scar	17	65	52	100

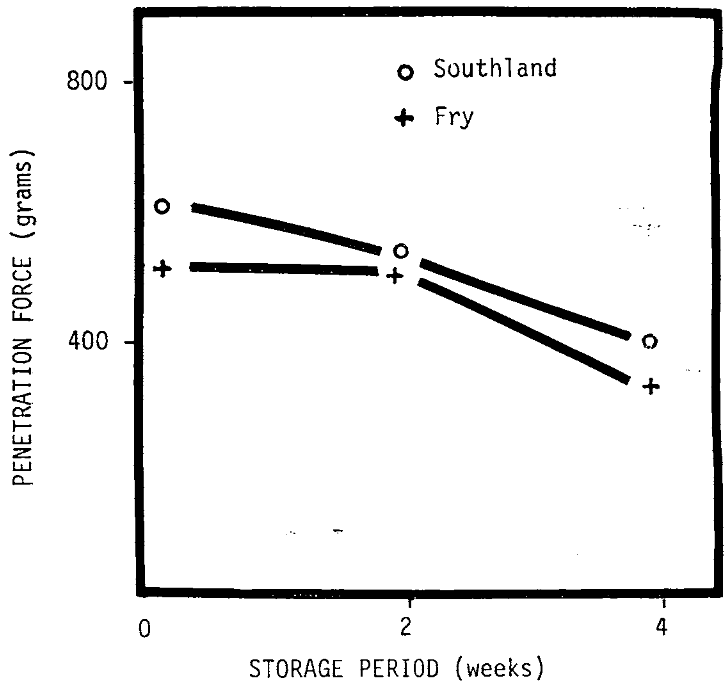

Fig. 1. Change in the firmness of cv. Southland and Fry during storage.

when muscadines are kept in storage at 1°C for 4 weeks (Fig. 1). In comparing the high dry stem scar cv. Southland with the high wet stem scar cv. Fry it can be seen that 'Fry' decreases in firmness to a greater extent than 'Southland'. When 'Fry' is kept in storage for two weeks there is greater than 50% decay unless only dry scar berries are stored (Table 3). 'Southland' which has high dry scar, has less than 10% decay after 2 weeks storage. It is also evident from Table 1 that muscadines cannot be held at room temperature for any length of time without decay. This again is due to the high degree of wet stem scar berries which lend itself to subsequent decay. Much of the research that has been done on storage characteristics of muscadines support the conclusion that muscadines do not store for periods longer than two weeks without undesirable amount of decay.

Improving Storage Life—Some Considerations

Physicochemical changes that occur after the grape is harvested are deteriorative. The rate of loss in fruit quality is a manifestation of preharvest vineyard practices and conditions. This deteriorative process can be greatly retarded by utilizing proper postharvest handling techniques as well as by good cultural practices in the vineyard. Some of the factors which influence storage life are: 1. choice of cultivar, 2. insect and disease control, 3. climatic conditions, 4. pruning, and 5. the use of growth regulators. Of course, care in harvesting, sorting, packaging and proper storage and cooling temperatures contributes to keeping quality. How these factors influence postharvest fruit quality are discussed below.

Cultural Practices and Conditions

Much improvement has been made in vineyard practices through the use of chemicals and new vineyard implements. The general production techniques, such as fertilization, trellising, pruning and insect and disease controls specifically for the muscadine grape have been developed and updated (1, 3, 6, 12). However the impact of these preharvest cultural practices on the storage and keeping quality have not been addressed until very recently. The work of Mainland et al. (20) essentially showed that the berries with a dry stem scar had a greater storage capability than those with a wet stem scar. Their work (20) and more recent work by us (unpublished data) and others (16, 22, 24) have shown that in some cultivars the percentage of berries with a dry stem scar can be increased with a foliar application of ethephon; however, berry softening, an undesirable characteristic, can be induced.

Preharvest application of fungicides can minimize fungal decays and improve storage life of the fruit. To have an effective program, the first fungicide application must be made during bloom and at every two weeks thereafter until harvest. Although the fruit is most susceptible to infection when it approaches maturity, spray programs must begin early because some fungal infection is thought to occur by the time fruit is half grown. Also, every attempt must be made to get the chemical on the berry surface.

The muscadine vine is a very vigorous plant and the shoots grow profusely during the summer. In many instances, the leaf canopy becomes so thick that the fruit underneath the canopy is not visible. Under these conditions, a high pressure sprayer is required to get a uniform coverage of the chemical on the fruit. To eliminate this thick canopy, spur placement in some cultivars must be modified by pruning to allow good penetration of spray through the canopy.

A recent survey of growers indicated that the 1981 crop had unusually high amounts of decay although they had followed the recommended spray program. A check of climatic conditions revealed that during the harvest season there were greater than average amounts of precipitation which washed off fungicides and significantly favored disease outbreaks. Therefore, the disease-causing organism as well as nature must be considered in producing a quality shipping fruit.

Harvesting

The muscadine grape is a perishable commodity. For it to be marketed as a fresh fruit, the injury must be minimal (torn skin and wet scar from harvesting and bruises from mishandling). It must be cleaned, sorted, and packed rapidly upon picking to retain its quality during transit to the consumers. However, quality control and packing equipment are almost nonexistent in this industry, and it is not uncommon to have decayed fruit packed with the good fruit. This practice surely contributes to the short life of the fresh muscadine grape. This is unavoidable because of 1. its inherent characteristics, i.e., nonuniform ripening, inability to detach cleanly from the pedicel and tight berry cluster, and 2. difficulty and economics of harvesting only the detachable, mature fruit. Once the fruit is off the vine, the damaged and sound fruit cannot be sorted effectively or economically with the equipment presently available. The damaged berry is an ideal place for microorganisms to proliferate and cause decay.

Continued efforts in breeding should produce cultivars with high dry stem scar percentage and more uniform ripening. Most of the existing cultivars are not suitable for the fresh market due to the fact that the fruit cannot be harvested with high percentage of dry stem scar (21). Two cultivars released recently by the Georgia Experiment Station, Summit and Triumph, appear to have very good dry scar characteristics (14, 15). In addition to breeding work, attempts have been made to artificially induce abscission for clean berry detachment with growth regulators (16, 20, 22, 24). However, the results up to now have been erratic and unpredictable due to differences in cultivar response, timing of applications, and environmental conditions. The fact that the fruit of most cultivars ripen over a period of 3 to 6 weeks also contributes to the ineffectiveness of the abscission chemicals.

Postharvest Handling

The purpose of postharvest handling is to retard the physiological degradation and control the microbial activity by regulating the environment. Postharvest handling becomes more paramount as muscadines are shipped to more distant markets and the transit time is increased. The existing handling techniques must be modified and improved to reduce quality loss during storage and transit.

As stated previously, storage deterioration is due to natural physiological breakdown and/or decay caused by microorganisms. In the case of muscadines under refrigerated storage (between 1° and 4.5°C), there is no measurable change in biochemical parameters, except that the skin color changes and the berry softens slightly. Quality loss appears to be mainly due to incidence of decay caused by microorganisms. A number of fungi and yeasts have been isolated and identified (27, 29). It is reasonable to assume that even under a most strictly followed fungicide program, the fruit will not be completely rid of fungus. Therefore, attempts have been made to control fungal decay in storage with SO_2 (2, 17, 27, 28, 29). Fumigating the fruit with SO_2 has controlled the fungus, but the chemical is caustic and can cause tissue damage and skin discoloration, especially on fruit with torn skins. Fumigation with SO_2 should not be attempted with boxes of fruit containing berries with a wet stem scar. An alternative may be to use other chemicals which have fungistatic properties but do not damage the fruit. Chlorine washes containing 50 to 125 ppm are often used commercially with fruits and vegetables. Chlorine reduces the population of microorganisms in the wash water but it is questionable whether at these concentrations it would have much effect on control of decay (28).

Outlook

The application of technology to improve the long-term storage of muscadines will require the efforts of both growers and scientists so that this fruit can become of larger economic significance to the Southeast. This will include, among others, such efforts on the part of the growers to improve or enhance their cultural practices and harvest practices as well as efforts on the part of the scientists to improve cultivars and ascertain new technologies for improving postharvest handling and storage of muscadines. Mechanical harvesting of muscadines for the fresh fruit market is becoming a reality with the development of a "selective harvester" by B. E. I. Agri-Quipt of South Haven, MI. A commercial blueberry brine solution separator available from the same company may be modified for muscadines to minimize postharvest handling.

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GRAPE PROCESSING AND UTILIZATION IN FLORIDA[1]

ROBERT P. BATES
University of Florida, IFAS,
Food Science Department,
Gainesville, FL 32611

RICHARD L. COLEMAN AND CHARLES J. WAGNER, JR.
U.S. Citrus and Subtropical Products Laboratory,
P.O. Box 1909,
Winter Haven, FL 33880

Abstract. **To maintain growth, the grape industry must balance production with marketing. From 1977 to 1981, the industry grew from 400 to 1000 acres and 2000 acres is estimated by 1986. From the third year after planting there is usually more than 160% increase in production each year until about the fifth year, when this begins to level off. Although "muscadines have been sold through retail supermarkets" and the "you pick" market, these have limitations and production is currently ahead of marketing capacities.**

Processed products provide the logical area for expansion. Possibilities include: wine, juices, beverage, jams, jellies, raisins, canned grapes, and by-products. Wine making has been promoted through improved varieties, a strong grower commitment and increased understanding of grape chemistry through research. Juice quality has improved with better processing procedures. Many products depend on refinement of a deseeder and/or development of seedless varieties. Grape pomace has animal feed and by-product value.

Grape Processing and Utilization in Florida

Although the combined volume of processed grape products in the U.S. exceeds the fresh market quantity by about a ratio of 3 to 1, the amount contributed by Florida grapes to both categories is negligible. However, it is clear from the above example that a healthy grape processing industry is an integral part of successful commercial viticulture.

At present Florida ranks about 19th in grape production and acreage is expanding steadily. The two factors which have limited grape processing in state—suitable varieties and adequate quantity still operate, but progress is being made (3). The major categories of processed products are: wine, juice, conserves, raisins and by products. This report will discuss problems and progress with these items and emphasize the technical needs and research strategy required for the development of a viable grape processing industry in Florida.

Processing Overview

The wine picture was brightened considerably due to increased knowledge of enology practices suitable for either bunch or muscadine types and the development of improved varieties. Table 1 shows the processing grape situation as of 1981. By far most wine efforts are with muscadine grapes due to their regional popularity and their potential ease of harvesting. Light shaking of the vine results in release of most ripe berries. If the variety has a dry stem scar and ripens fairly evenly, harvesting costs can be substantially reduced compared to bunch grapes (1), although with hand harvesting, bunch grapes are collected somewhat more efficiently.

In addition, maturity grading by density separation in a series of brines of varying specific gravity may provide a simple way of eliminating extremes in maturity, thus improving the quality of raw material for processing (9). At present the fruit volumes involved preclude standard machine harvesters, except for hand-held shakers for muscadines (1).

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