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SHELF-LIFE STUDY OF MUSCADINE GRAPES FOR THE FRESH FRUIT MARKET

JENNYLYND JAMES, O. LAMIKANRA, G. DIXON, S. LEONG,
J. MORRIS, G. MAIN, T. WALKER AND J. SILVA
Center for Viticultural Science and Small Farm Development
Florida A&M University
Tallahassee, FL 32307

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Abstract. **The fresh fruit market for muscadines has been limited by the short harvest season, the fruit's high perishability and a lack of information on postharvest handling. The objectives of this study were to enhance the commercial viability of muscadine grapes through the development of harvesting, handling and marketing systems for the fresh fruit market. A regional approach was undertaken using muscadine grape cultivars Fry, Summit and Granny Val from Florida, Arkansas and Mississippi, in order to extend the availability of grapes. Grapes were placed in polyethylene clam shells and shipped from each region in refrigerated trucks for subsequent storage at 0°C. A 1 × 3 × 4 × 3 factorial experiment was set up using three storage treatments - (a) SO_2 generators and enclosure in a polyethylene bag, (b) enclosure in a polyethylene bag without SO_2, and (c) the control without a bag. Grapes were evaluated at 0, 2, 4 and 6 weeks for changes in mass, percent decay, and fresh fruit quality in terms of pH, titratable acidity and degrees Brix. The greatest loss in mass, which could be mainly attributed to moisture loss, was obtained in the control treatment for all cultivars from 13.5% in 'Fry' to 21% in 'Granny Val'. The latter showed signs of shriveling within two weeks of storage, as moisture was lost. This occurrence was species specific. The pH, titratable acidity and degrees Brix remained relatively constant during storage of each muscadine variety. Treatment with SO_2 was found to retard spoilage during the initial storage period of 2 weeks, after which, the per cent decay was similar to the treatment with a polyethylene bag without SO_2. From the shelf life studies, the cultivar Fry maintained acceptable fruit quality based on sensory evaluation, for up to 4 weeks storage when enclosed in a polyethylene bag.**

The muscadine grape has been grown commercially in Southeastern United States for over four centuries. The climatic conditions of the south limit the types of grapes that can be successfully grown to muscadine grapes which are more resistant to diseases than other grape species. Muscadine production has been limited by the lack of adequate information and testing of treatments that would improve its postharvest storage life and marketing to make it competitive with other grapes and fruits (Morris, 1980).

Production of wines and other processed products from muscadine grapes cannot compete with those traditionally made with other grape species. Under refrigeration temperatures muscadine grapes have a shelf life of about 7-10 days (Savoy and Hatton, 1980). According to market research, harvested muscadine grapes must have a minimum of 8 weeks of storage life to be competitive with other grape varieties (Morris, 1980). There is also a very short harvest season of 3 weeks for most cultivars. This limits the exposure of the fruit to consumers and thus, repeat purchases.

Most imported and local table grapes in the United States traditionally undergo sulfur dioxide treatment and refrigeration prior to retail marketing. Smit et al. (1971), showed that grapes stored under SO_2 atmosphere had significantly less damage and weight loss than the control without SO_2. When packed with fast release generators, table grapes could be stored for up to 3 months in vented lugs when cooled to below 4°C within 4 hours of packing (Nelson and Ahmedullah, 1976). Some dual-release SO_2 generators continue to release SO_2 for 8 to 10 weeks. There is an inverse relationship between the extent of fruit decay and SO_2 concentration, time of exposure, and humidity (Harvey, 1956; Nelson and Ahmedullah 1976). Studies on the storage characteristics of muscadine grapes have been limited. Observations have shown that muscadine grape cultivars respond differently with regards to shelf-life (Ballinger and Nesbitt, 1982).

Improvements in the methods of harvesting, handling and marketing should be implemented to increase shelf-life. Also, shipping across state lines could be used to extend the marketing window for these grapes. The muscadine grape season begins in August in Florida and ends in September. In Arkansas the grape season is at least one month later for a given cultivar and in Mississippi some cultivars like Doreen may be harvested in late October. An organized shipping of treated muscadine grapes with proper storage, across the Southeastern states would offer the potential of having fresh produce on the market from August to December.

Thus, the objectives of this study were: (1) To enhance the commercial viability of muscadine grapes through the development of harvesting, handling and marketing systems for the fresh fruit; (2) To determine the most suitable storage and packaging methods to extend shelf life without significant loss in sensory and visual characteristics; (3) To address the problem of the short harvest season through studies on inter-state shipment of preserved fruits.

Materials and Methods

Harvesting and Transport

This was a joint project with Florida A&M University (FAMU), the University of Arkansas (UA) and Mississippi State University (MSU). Cultivars of muscadine grapes (*Vitis rotundifolia*, Michx) were shipped by refrigerated trucks from each institution to the other two. Florida A&M packaged and shipped the cultivar Fry, the University of Arkansas packaged 'Summit' and Mississippi State University packaged 'Granny Val'. Grapes were hand picked and cooled immediately to 0°C. They were then packaged in 600 g polyethylene clam shell type cartons which were placed inside corrugated cardboard boxes and shipped in refrigerated trucks. Each institution retained identical samples of the grapes shipped, for inhouse control studies.

Chemicals and Equipment

All reagents were purchased from Sigma Chemical Company (St. Louis, Mo.) unless otherwise specified. Slow release sulfur dioxide generators, UVAS Quality Grape Guard, were obtained from Imal Ltda. (Santiago Chile). Grapes were crushed in a blender from Commercial Vita Mixer (Ontario, Canada). Grape extract was centrifuged in a Sorval Super T21 refrigerated centrifuge (Newtown, Connecticut). Per cent soluble solids was measured using a hand held refractometer (America Optical Corp., Buffalo, N.Y.) and pH was measured using a Corning pH meter (Corning Glassworks, Medfield, M.A.). SO_2 was detected using the Dioxor II sulfur dioxide analyzer (Bacharach, Inc., Pittsburgh, PA). Grape texture was measured using a Precision Universal Penetrometer (Varlen Instruments, Bellwood, IL).

Experimental Design and Treatments

Three different storage treatments were identified. Treatment 1 involved attaching two packets of slow release SO_2 generators on the top of the clamp shell which was then placed in a polyethylene bag. Treatment 2 was to place the clamp shell in a polyethylene bag without SO_2 and treatment 3 was the control without the bag and SO_2. A factorial design was used to give many permutations and combinations of treatments and storage times for the shelf life study: $1 \times 3 \times 4 \times 3 = 36$ treatments × 3 sets; where '3' stands for three replications of the experiment, '4' stands for four test periods, i.e. 0, 2, 4 and 6 weeks of storage, and '3' for three treatments.

Grape Analyses

During periods of storage, the grapes were evaluated for changes in mass, pH, soluble solids, titratable acidity, grape texture, and per cent spoilage. Clam shells were weighed initially when they were packed, and thereafter at subsequent storage periods to determine mass loss. The percent decay was determined by counting the number of berries with visible signs of mold and softening. Titratable acidity (%TA) was estimated as tartaric acid:

$$\%TA = (\text{ml NaOH} \times \text{Meq} \times \text{Normality NaOH} \times 100)/\text{Sample Volume ml}$$

Where Meq = 0.075.

A random sample of 5 whole grapes was selected from each replication of each treatment for grape texture measurements, using a Precision Penetrometer. Grapes were punctured with the penetrometer needle for 5 sec, then the depth of penetrations was read in units of tenth-millimeters.

Sensory Evaluation

Grapes were evaluated at time periods 0, 2, 4, and 6 weeks for the parameters:

Flavor Intensity, Off-flavor Intensity and Texture. Taste testers were selected based on their knowledge of muscadine grapes and over 10 panelists were used for each evaluation. A 15 cm horizontal line encompassing the extremes of each parameter was used and a mark was placed on the line as the result of product evaluation. For example, in estimating firmness, 0 cm was very soft, while 15 cm was very firm.

Results and Discussion

Minimal loss of mass (0.5% - 1.0%) was obtained for all cultivars when stored under treatments 1 and 2, since packages maintained high humidity during storage. In treatment 3 which was without the overwrap, up to 15% loss in mass was obtained for the Fry cultivar at 6 weeks storage. The loss of mass was directly proportional to a decrease in grape firmness (Fig. 1). When the penetrometer was used to measure grape firmness, there was a close correlation with results obtained in the sensory evaluation of grapes. Thus, the loss in mass of grapes under treatment 3 corresponded to a large decrease in firmness. In the sensory evaluation of firmness, there was a slight decrease during 6 weeks storage for treatments 1 and 2. However, there was a large decrease in firmness in treatment 3, i.e., the control which was without a polyethylene bag.

The high humidity in packages of treatment 1 and 2 encouraged mold growth faster than in treatment 3 with the Fry cultivar. The per cent spoilage increased with time and spoilage took the form of bitter rot, black rot and mold growth. 'Summit' had an average shelf life of about 3 weeks when eval-

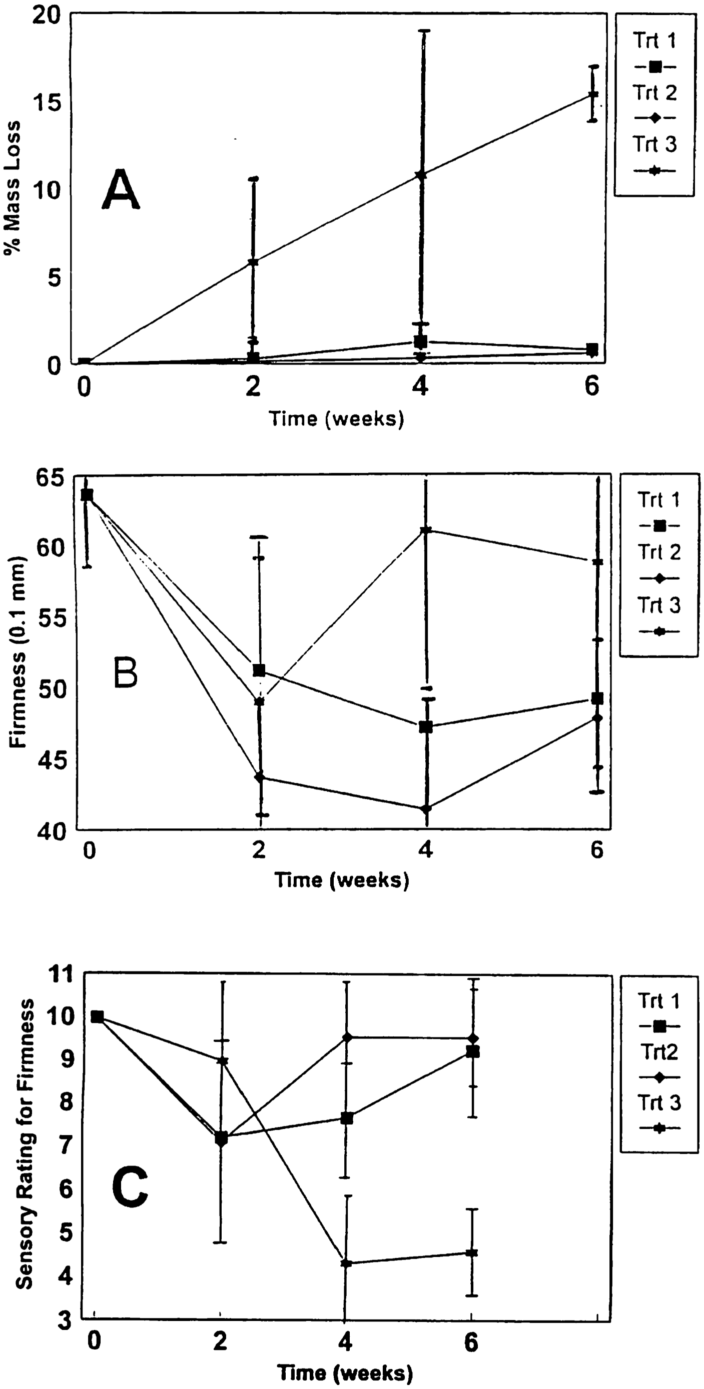

Figure 1. The effects of storage treatments and time on grape texture and mass loss of 'Fry' muscadine grapes. (A) Mass loss vs time; (B) Objective measurement of grape texture during storage; (C) Subjective measurement of grape texture during storage. Treatment 1 (Trt 1) = with polyethylene bag and SO_2 treatment 2 (Trt 2) = with polyethylene bag alone, treatment 3 (Trt 3) = without polyethylene bag or SO_2.

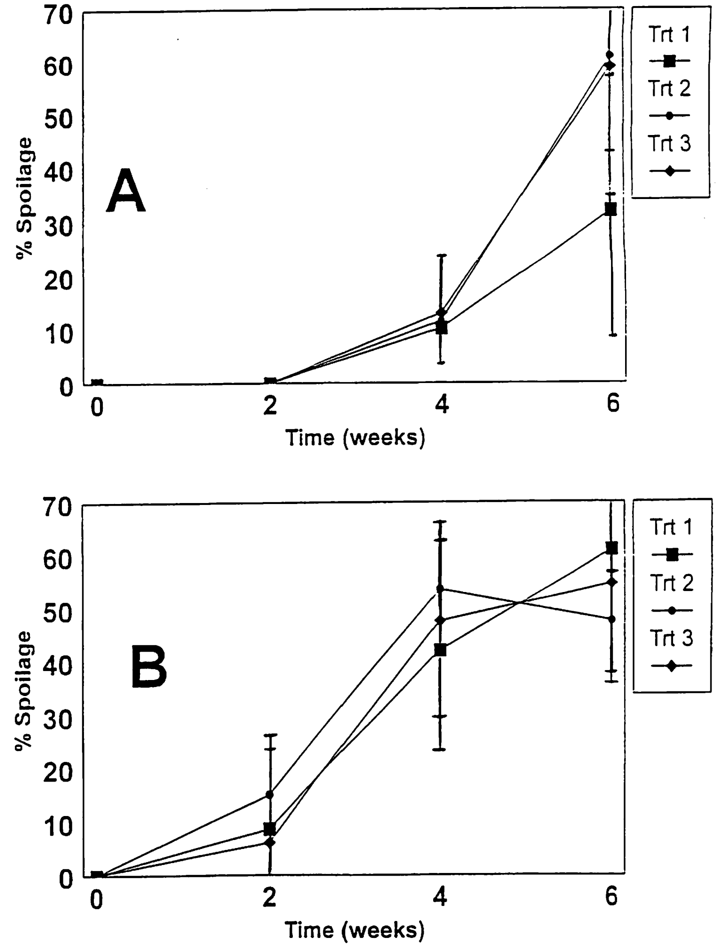

Figure 2. Comparison of spoilage in Fry muscadine grapes with and without shipment. (A) Shelf-life study of 'Fry' at FAMU, (B) Shelf-life study of 'Fry' at Mississippi State University. Treatment 1 (Trt 1) = with polyethylene bag and SO_2 treatment 2 (Trt 2) = with polyethylene bag alone, treatment 3 (Trt 3) = without polyethylene bag or SO_2.

uated after transportation. The cultivar Granny Val was most noticeably wrinkled from as early as two weeks during storage, and this cultivar was less acceptable based on appearance only, when evaluated after transport. In the Mississippi State University study, 'Granny Val' was the most robust cultivar with a shelf life up to 4 weeks at 0°C. The cultivar Fry had the best shelf-life (6 weeks) under treatment 1, in the in-house study at FAMU while in the MSU study, the shelf life of 'Fry' was about 4 weeks (Fig. 2). It is possible that the handling of grapes during transportation decreased the shelf-life of all cultivars, hence the variation of shelf life for each cultivar at each test site.

Sulfur dioxide in treatment 1 caused damage in the form of bleaching around the stem scar in the 'Fry' cultivar. This scarred tissue appeared to be an area of initial spoilage during storage over 2 weeks. Moreover, increased humidity and condensation in the package with treatment 1 caused wetting of the SO_2 generators making them ineffective. However, 'Summit' grape shelf-life was extended to 4 weeks by treatment with SO_2, since 21% spoilage was obtained with treatment 1, as opposed to 29% and 42% spoilage with treatments 2 and 3 respectively in the study at FAMU.

Biochemical properties of the three test cultivars remained fairly constant over the storage time of 6 weeks. The pH of all grape cultivars was relatively unchanged, with 'Fry' having an average of 3.43 (Fig. 3). Studies conducted at the University of Arkansas and Mississippi State University revealed similar results with pH remaining fairly constant with time for all cultivars tested. Titratable acidity and soluble solids remained close to the average values with time in the Fry cultivar during storage (Fig. 4, Fig. 5). In the University of Arkansas study, similar results were obtained with the Fry culti-

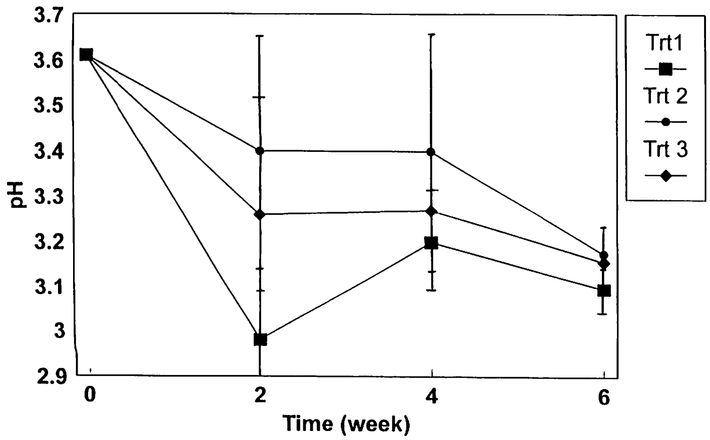

Figure 3. Effect of storage treatment and time on the pH of 'Fry' muscadine grapes. Treatment 1 (Trt 1) = with polyethylene bag and SO_2 treatment 2 (Trt 2) = with polyethylene bag alone, treatment 3 (Trt 3) = without polyethylene bag or SO_2.

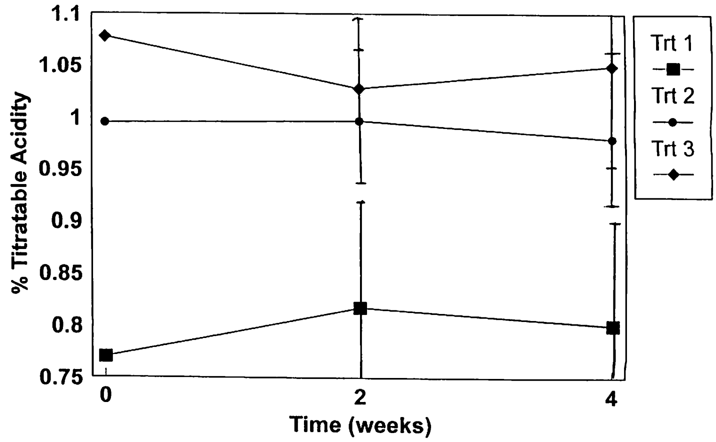

Figure 5. Effect of storage treatment and time on the titratable acidity of 'Summit' muscadine grapes. Treatment 1 (Trt 1) = with polyethylene bag and SO_2 treatment 2 (Trt 2) = with polyethylene bag alone, treatment 3 (Trt 3) = without polyethylene bag or SO_2.

var of grapes. With respect to soluble solids, in the study at FAMU, the cultivar Granny Val had a lower degrees Brix than 'Fry' and 'Summit', and the values remained fairly constant with time. 'Granny Val' was perhaps harvested prior to physiological maturity and so proper ripening with the release of sugars did not occur.

The main criterion for taste testers was familiarity with muscadine grapes. When flavor intensity was evaluated, this parameter remained fairly constant with time, for all three treatments. In the study at University of Arkansas there was a slight increase in flavor intensity at 4 weeks of storage of 'Fry'.

The mean off-flavor value tended to be higher for the cultivar 'Granny Val' since this grape was more sour to taste. In the University of Arkansas study, a lower off flavor score was obtained for the same cultivars as the FAMU study, but again the cultivar Granny Val had the highest off-flavor score. The cultivar Granny Val was astringent with a low degrees Brix, and high acidity. This variety also wrinkled very quickly during storage and this may have been because the fruit was not physiologically mature at harvest time.

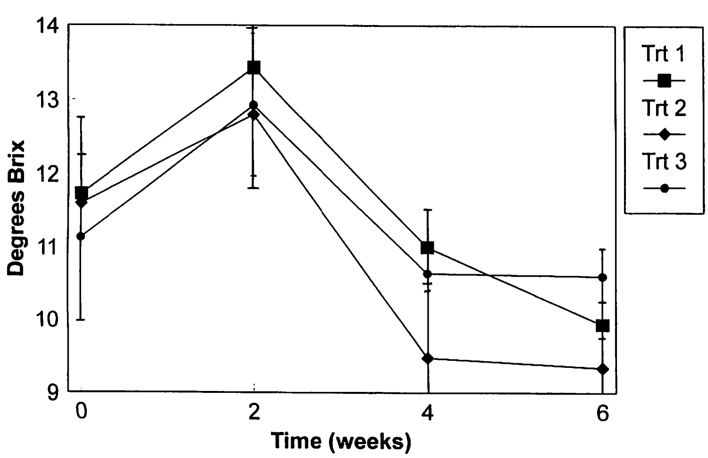

Figure 4. Effect of storage treatment and time on the soluble solids content of 'Granny Val' muscadine grapes. Treatment 1 (Trt 1) = with polyethylene bag and SO_2 treatment 2 (Trt 2) = with polyethylene bag alone, treatment 3 (Trt 3) = without polyethylene bag or SO_2.

Summary

Biochemical properties of the grapes remained fairly constant during 6 weeks storage at 0°C. Grape texture decreased during storage, for all cultivars, especially with treatment 3 which allowed for extensive loss of moisture. In addition, the cultivar Granny Val sustained visible signs of wrinkling which made it least acceptable by visual examination alone. There were only small changes in flavor intensity and off-flavor for the grape cultivars tested during this storage time. The results of this study indicate that the influence of transportation and storage treatments on the quality of grapes is cultivar specific.

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