Title: Evaluation of post-harvest storage potential of muscadine cultivars and advanced breeding lines and development of new muscadine cultivars.

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Research Proposal

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Objective:

The objective of this project is to evaluate the most common muscadine cultivars and advanced selections from the UGA breeding program for storage ability using industry standard protocols.

Justification and Description:

Similar to rabbiteye blueberries, muscadines are one of the few fruit crops well suited to the deep south. Since they are native to our region, muscadines are resistant to most of the pests and diseases that prevent the culture of bunch grapes in this region. Growth of muscadine vines is usually quite vigorous and vines can be grown on a small scale with few inputs. As a product, muscadines are relatively well known in the regions where they are grown. Outside of this relatively small area, however, purchasers are not familiar with this crop. In order to successfully introduce this crop to these consumers, there is a need for improved fruit storage ability so that high quality ripe fruit can be successfully shipped to distant markers. Even within their production region muscadines have a relatively narrow season of availability with the harvest window generally beginning in early August and ending in mid September. The availability of better storage protocols will extend the shelf life of the fruit and permit greater flexibility during marketing and distribution (Basiouny, 2001).

Reduction in berry quality with storage is primarily the result of two processes: 1) the spread of pathogenic fungi through the stored fruit or 2) fruit softening via water loss and the enzymatic breakdown of the fruit pulp (Basiouny, 2001). Storage temperature management is the primary tool available to growers for maintaining quality and

controlling fungal pathogens postharvest (Smit et al., 1971). However, latent infections from the field results in the mycelial spread and sporolation of numerous pathogens during storage. The majority of commercial cultivars are also extremely susceptible to stem-tear injury during harvest, which also contributes significantly to the susceptibility of the fruit to fungal infection (Ballinger and Nesbitt, 1982).

Delay of fruit softening is primarily accomplished through the control of relative humidity and temperature. When relative humidity is too low, transpiration from the fruit surface is increased leading to water loss and berry shrivel. However, storage at too high of a relative humidity aids in the spread of pathogens. Storage of fruit at a low temperature is vital in decreasing respiration and enzymatic activity that leads to softening of the fruit (Basiouny, 2001).

Postharvest temperature and relative humidity management are the current primary tools available to growers for maintaining quality and controlling fungal pathogens postharvest (Smit et al., 1971). Currently, temperature management (0-1ºC, 90-95% R.H.) and chlorine washes (100 ppm) are the only two tools that are routinely used, with the latter only being used immediately prior to transport. In the past, a few experiments have been conducted investigating the use of SO_2 on muscadine grapes, with varying conclusions being drawn. Smit et al. (1971) reported that treatment with SO_2 resulted in an acceptable product after storage for 2 months (0°C). In contrast, Takeda (1981) found that grapes can not be stored longer than 2 weeks (1°C), and that shelf-life can not be extended beyond these two weeks by SO_2 due to bleaching and off-flavor production. Finally, Ballinger and Nesbitt (1982) found that SO2 was effective in controlling decay, but that fruit from various cultivars varied widely in susceptibility to decay and to SO_2 injury. The results from these studies suggest that treatment with SO_2 is beneficial for muscadine grapes, and based on recent findings in table grapes, the required concentration for effective control may be significantly lower than those used in the aforementioned studies and may need to be made according to the cultivar being stored.

Numerous muscadine cultivars are of commercial importance. Olien (2001) listed 25 important cultivars, with various states growing from 1 to 14 of them. Newer cultivars have increased in importance since that report, and there is continuing interest in developing improved cultivars better suited to growers' needs. Fruit cultivars are well-known to vary in their potential to be stored and preserve consistent good quality (Ballinger and Nesbitt, 1982). The production of quality attributes of muscadine cultivars have been the focus of several published trials (Anderson, 1992; Clark, 2001; Conner, 2009; Stringer et al., 2008). However, none of these trials evaluated the storage potential of these cultivars, and thus growers have little information about which cultivars may have the potential for longer storage ability. In addition, storage trial experiments generally only make use of 1 or 2 cultivars, providing little information about the impact of cultivar on storage ability.

The University of Georgia is conducting an active breeding program and has several new fresh fruit selections in advanced trials. These selections vary dramatically in flesh firmness and skin thickness, and include selections with a very firm crisp flesh texture. The purpose of this experiment is to evaluate these new selections, along with the most recommended fresh fruit cultivars for storage ability. This will provide information to growers in which cultivars have the most potential to be stored and

conserve high quality. The use of SO2 generators will also provide information to growers as to which cultivars may benefit from the use of this technology. Testing of advanced selections will provide information to the breeding program as to which selections may have the most potential to benefit the industry by increasing marketing flexibility. In addition, this information will begin to elucidate which traits are associated with storage potential, allowing us to begin to incorporate these traits into the breeding program.

Methodologies:

Cultivars and Harvest.

Fruit will be obtained from both the Muscadine cultivar trial of Dr. Patrick Conner, located at the Tifton Campus and Ponder Research Farms, as well as from a commercial cooperator in Paulk Vineyards, located in Wray, GA. Fruit will be hand harvested and immediately taken to the Onion Laboratory at the Tifton Campus for initial evaluations and storage trials. Cultivars evaluated were 'Early Fry', 'Fry', 'Granny Val', 'Summit', 'Supreme', 'Tara', and 'Triumph'. University of Georgia selections trialed were 'GA 1-1-48', 'GA 5-1-28', and 'GA 6-2-46'.

Initial Evaluations.

A 3 replicate sample was placed at room temperature for initial physiochemical quality evaluations, including: firmness, using a bioWorks FirmTech II; soluble sugars, using a digital handheld refractometer; and titratable acids and pH, using a Mettler-Toledo automated titrator. Berry defects (bruises, pedicel separation/tears), and incidence of decay were also recorded. Berry texture analysis was evaluated by a TA-XT2i texture analyzer (Stable Micro Systems, Surrey, U.K.) equipped with a 2mm cylinder punch. Test speed was 1mm/sec and contact force was 1g. Berries were punctured at the equator and maximum force and deformation at first peak were recorded for 40 berries for each genotype.

Storage trials.

After the initial berry evaluation, cultivars will be commercially sanitized, graded and packed into boxes and stored at 0-1 °C (90-95% R.H.) for 1, 2, or 4 weeks. After each storage period boxes will be removed from cold storage, permitted to warm for 24 hours at room temperature (21 °C) and evaluated 1 and 4 days post-removal for firmness, soluble sugars, titratable acids and pH as described previously, as well as for the incidence of storage disorders, such as: shrivel, bruises, skin crack, and molds.

The ability of commercially available sulfur dioxide emitting sheets will also be evaluated for potential application to each of the tested muscadine cultivars. The UVASYS dual-stage fast/slow release sheet system currently being used by the table grape industry (Tedmark Corporation) will be placed inside commercially sanitized, graded and packed boxes of muscadine grapes, and stored at 0-1 °C (90-95% R.H.) for 1,

2, or 4 weeks. Upon removal from storage, fruit will be evaluated as in the normal storage trial and the fruit will also be evaluated for sulfur dioxide blanching.

Results:

Berry firmness evaluation of muscadine genotypes.

Berry firmness was measured in 10 muscadine genotypes after each storage period (Fig. 1). There was a large amount of variation in berry firmness initially, but differences declined after storage. 'Supreme' and 'GA 1-1-48' were firmer than all other genotypes initially. Day 14 firmness rankings largely reflected day 0 rankings, with 'GA 1-1-48' and 'Supreme' markedly firmer than all other genotypes. Day 17 showed differences among genotypes, but only 'Supreme' was dramatically firmer than all others. At day 28 'GA 1-1-48' and 'Supreme' were significantly more firm than all other genotypes, but by day 31 only 'Supreme' was markedly more firm. These results demonstrate that 'Supreme' maintains firmness well after both cold storage and room temperature storage, while GA 1-1-48 has good initial firmness and after refrigerated storage, but firmness declines dramatically after 4 days at room temperature (day 17 and day 31). This genotype showed extensive browning after refrigerated storage and this may be indicative of chilling injury. Trials are planned for next year to evaluate firmness of this genotype over several different storage temperatures.

The presence of wet scars significantly reduced berry firmness at all storage periods except for 17 days (Table 1). Interestingly berry firmness was reduced by the presence of a wet scar even during the initial measurements. This may indicate that the reduction in firmness may be more a result of mechanical relaxation of firmness rather than an increase of decay or loss of turgor pressure. The lack of differences at day 17 may be indicative of an overall softening of fruit at this time period.

Table 1. Effect of scar type on berry firmness (g/mm) after storage trials. Firmness ratings were averaged over all genotypes.

Scar type	Day 0	Day 14	Day 17	Day 28	Day 31
Dry	351	291	224	267	218
Wet	327	272	226	243	201
Sig.	0.001	0.001	N.S.	0.001	0.001

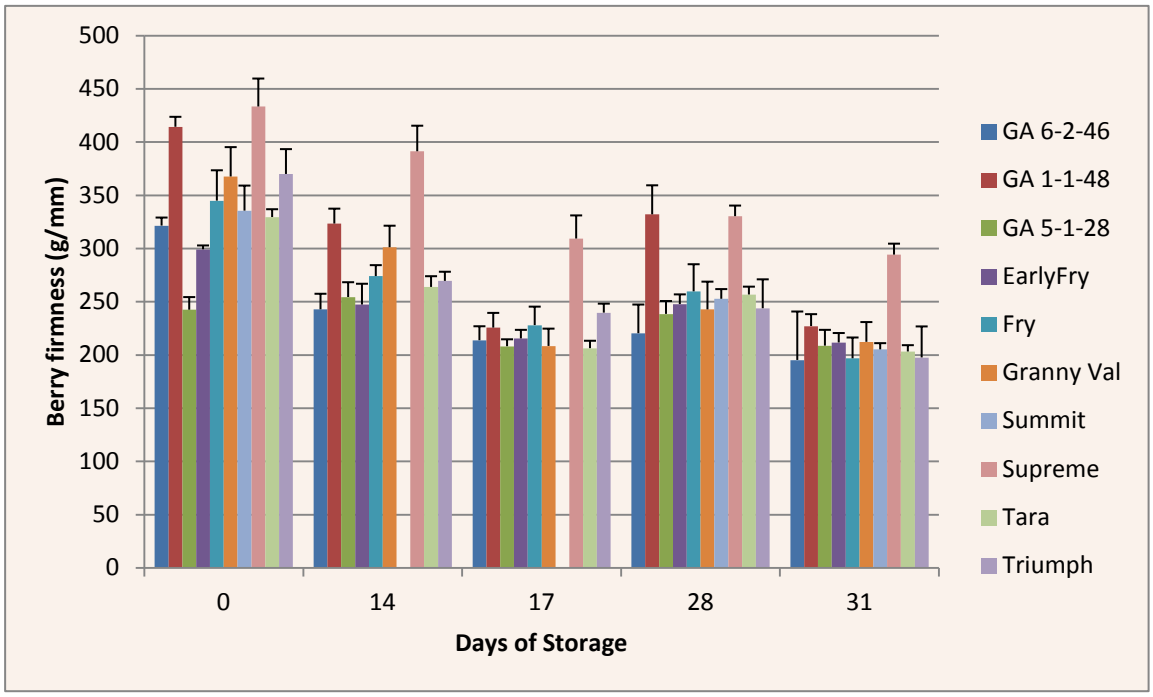

Figure 1. Berry firmness of muscadine genotypes after storage. Firmness was measured immediately after harvest (0), after 13 days cold storage 1 day room temp. (14), 13 days cold storage and 4 days room temp. (17), 27 days cold storage 1 day room temp. (28), and 27 days cold storage and 4 days room temp. (31). Error bars represent standard deviation of four replications of 20 berries.

Juice evaluation of muscadine genotypes.

Juice samples were obtained from each replicate of berries after each storage trial. These 400 samples were frozen and are currently being analyzed by a student worker, but results are not yet available (11/28/2011).

Effect of SO_2 generators on muscadine storage.

The overall effect of sulfur dioxide generators was to increase overall berry firmness at each storage period (Table 2). However, there were significant genotype x SO_2 interactions. Several cultivars showed no improvement in berry firmness with the addition of SO2 generators, and no cultivar showed improvement over every storage period tested. SO_2 generators only had an effect on percentage of berry rot observed on day 28, with only a decline of 4% rot with SO_2 treatment (data not shown). Taken together these results suggest that the SO_2 generators only have a very modest effect on controlling berry rot and improving berry firmness. No bleaching or other ill effects were observed with the SO_2 generators.

Table 2. Effect of SO_2 generators and genotype on muscadine berry firmness (g/mm) after differing periods of storage.

	Day 14		Day17		Day 28		Day 31	
Genotype	Control	SO_2	Control	SO_2	Control	SO_2	Control	SO_2
Ga 6-2-46	243a*	256a	214a	227a	220a	225a	195a	198a
GA 1-1-48	323a	354b	226a	244b	332a	336a	227a	231a
GA 5-1-28	254a	239a	208a	193a	239a	249a	209a	201a
Early Fry	247a	274b	215a	226a	248a	250a	212a	221a
Fry	274a	291a	228a	274b	260a	269a	197a	262b
Granny Val	301a	281a	208a	210a	243a	243a	212a	201a
Summit					253a	277b	205a	235b
Supreme	391a	394a	309a	309a	330a	378b	294a	319b
Tara	264a	293b	206a	200a	257a	265a	203a	193a
Triumph	270a	276a	240a	249a	244a	253a	198a	213a
Overall	285	295	228	236	262	274	215	227
ANOVA	MS	P	MS	P	MS	P	MS	P
Genotype	356129	0.001	182099	0.001	282221	0.001	164830	0.001
SO2	35756	0.002	26421	0.001	57013	0.001	58988	0.001
Genotype x SO2	13758	0.001	12298	0.001	7891	0.026	21984	0.001

*Values within a Genotype x Day test are significantly different if followed by different letters.

Berry texture analysis.

Initial berry texture analysis was performed with a 2 mm needle punch and a 2 mm cylinder punch. The needle punch was found to be inferior because genotypes showed little variation in maximum force despite obvious differences in skin toughness upon mastication (data not shown). The 2 mm cylinder punch demonstrated good separation of both within muscadine genotypes and between muscadine and *vinifera* table grape cultivars (Fig. 2). Deformation at first peak (DFP) represents the distance the probe moves from initial contact with the berry surface until the skin ruptures. Maximum force (MF) represents the maximal force recorded by the probe until skin rupture. Ideal fresh market grape berry texture is generally considered to be a tender skin in combination with a crisp flesh. A tender skin would be represented by a low MF and a crisp flesh would be represented by a small DFP.

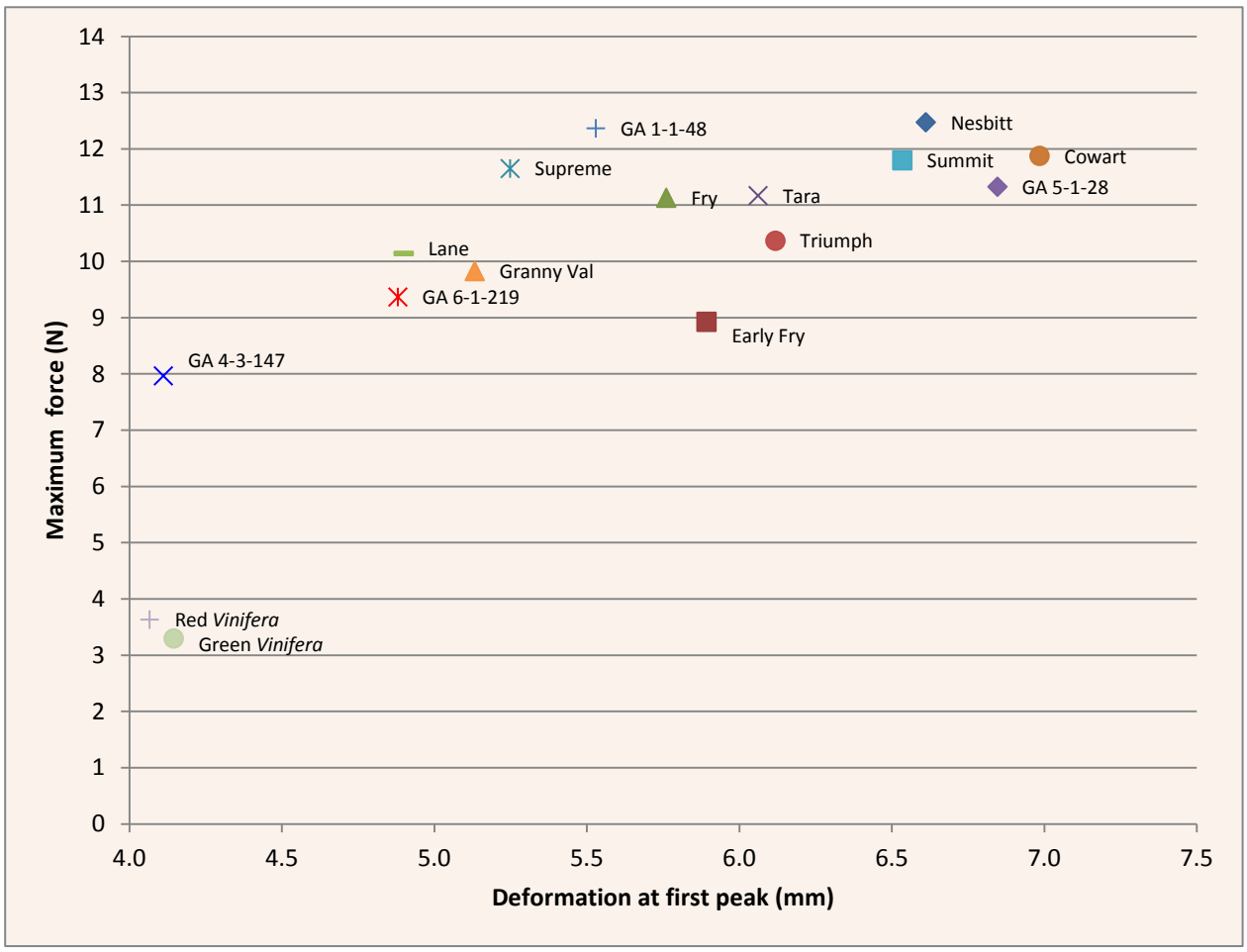

Figure 2. Variation of maximum force and deformation at first peak of muscadine and *vinifera* table grape genotypes. Values represent the average of 40 berries sampled per genotype.

DFP varied nearly two fold among muscadine genotypes. The highest DFP occurred among genotypes like 'Cowart', GA 5-1-28, and 'Nesbitt' with soft pulps similar to *Vitis labrusca* berries. The highest DFP occurred among UGA selections and releases like 'Lane', GA 6-1-219, and GA 4-3-147 which were selected for firm flesh. Notably, GA 4-3-147 had a DFP similar to the *vinifera* table grapes. Lowest MF among muscadine genotypes was recorded in GA 4-3-147 at nearly 8 N and highest MF was 12.5 N for 'Nesbitt'. However, even the lowest MF for the muscadine genotypes was still over twice that of the *vinifera* table grapes.

DFP was correlated with berry firmness initially and after 14 days of storage, but was not significantly correlated after longer periods of storage (Table 3). This suggests that firm berry flesh types do not necessarily correlate with retention of berry firmness after long term storage.

Table 3. Pearson correlation coefficients between berry firmness and flesh crispness as measured by deformation at first peak in muscadine berry after various storage periods.

Day 0	Day 14	Day 17	Day 28	Day 31
-0.784	-0.72	NS	NS	NS

Conclusions:

Berry firmness varied widely over cultivars but differences largely disappeared after storage, especially after storage for four days at room temperature. The one notable exception to this was the cultivar 'Supreme' which seems to maintain a higher berry firmness than the other cultivars. Sulfur dioxide generators produced no ill effects on berries, but produced only minor improvements in berry quality or reductions in rot. The results produced here do not warrant further trials with these generators. Texture analysis of muscadine showed a wide range for both DFP and MF. Selections chosen for firm flesh resulted in DFP similar to *vinifera* table grapes. While there was good variation for MF among muscadine genotypes, much improvement still needs to have skin tenderness comparable to *vinifera* berries.

Impact Statement:

This study suggests that retention of berry firmness after storage is a relatively rare trait. The cultivar 'Supreme' was superior to all other selections and should be preferred by growers wishing to store berries for long periods. This cultivar should also be considered the standard to compare to when testing new selections for storage ability. In addition, this cultivar will be used as a parent in the breeding program with the goal of improving storage ability. Sulfur dioxide generators of the type used in this experiment do not appear to hold much promise to significantly improve muscadine storage ability. Texture analysis indicated that improvement is being made in the breeding program for improved berry texture. These tests were relatively simple to carry out and will be used in the future to evaluate all selections in the breeding program. The adoption of a unbiased testing method should allow the breeding program to more efficiently breed for improved fruit texture.