**2022 Progress Report to the Southern Region Small Fruits Consortium**

Project Title: **Alternative Atmosphere Treatments to Extend Shelf-life and Control Postharvest Decay in Muscadine Grapes**

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## Public abstract

In the recent years there has been an increased demand for fresh-market muscadine grapes that are traditionally available from mid-Summer to mid-Fall in the Southeaster US region. Moreover, there exists consumer demand from distant markets which however require appropriate packaging and shipping in order for the fruit to arrive in acceptable condition. Controlled atmospheres have been used historically for shelf-life extension of fresh fruits as additional treatments to traditional cold storage. Gaseous ozone has also been used to suppress microorganisms that proliferate during storage. While both technologies have shown promising results in other crops, little work has been done on muscadine grapes. We investigated the effects of these alternative atmosphere treatments as add-ons to cold storage and documented their effects on the shelf-life and quality retention of Georgia-grown muscadine grapes. For this reason, a set of experiments using two popular varieties (Supreme and Fry) was performed between October and November of 2022. The experiments, sample storage and quality data collection have been completed, however the processing of the frozen samples and the statistical analysis is still pending. We are aiming to finish processing the samples during this winter season, analyze the data and compile the final report in the Spring of 2023.

## Objectives

1. Continue researching the applicability of controlled atmospheres (CA) and the appropriateness of ozone ($O_3$) treatments for the shelf-life extension of muscadine grapes.
2. Investigate and evaluate the efficacy of the combination of CA and $O_3$ treatments in the suppression of postharvest disease incidence.
3. Investigate the phytotoxicity of ozonated air on muscadine grapes.

## Justification and Description

There is an increasing interest by consumers in the consumption of fruits which are good sources of antioxidants. Muscadines (*Vitis rotundifolia*) are rich repositories of high antioxidants such as flavonoids in peel, flesh, and seed, as well as ellagic acid and resveratrol in their juice they are also a good source of potassium, magnesium and calcium (Ector, 2001). Additionally, unlike some other antioxidant fruits such as Aronia, muscadines have a wonderful flavor. Muscadines are thus positioned to become a new superfood if they can be successfully introduced to consumers not familiar with this product. Unfortunately, muscadine marketing is hindered by a brief harvest window which is exacerbated by a relatively short storage ability. This project aims

to find ways to lengthen the storage ability of muscadine fruit so that it can be marketed more successfully and reach consumers throughout the nation.

Muscadine grapes while similar to bunch grapes (*Vitis vinifera*) differ in that their fruit are larger, seeded, thick skinned and usually borne in small clusters of 2-10 berries, and picked as individual berries. Vegetative growth is abundant and fruit generally grow within the thick canopy, rather than hanging down from the vine like bunch grapes, hindering fungicide application for disease control. The southeastern production region also has greater rainfall and humidity, increasing the prevalence of disease, causing fungi growth on the fruit.

Muscadine harvest season is relatively short and limited to about a 45-day window in late summer while its timing can vary widely, depending on summer temperatures and cultivar selection. South Georgia muscadine production usually begins in late July, peaks in mid-August, and ends in mid-September. Northern Georgia, Arkansas, and North Carolina generally have their harvest window shifted back a month later. Improved postharvest storage techniques would increase sales by lengthening the time fruit could be sold and facilitating transport of fruit to regions outside of the production areas.

Muscadine grapes can be stored for a few weeks at 32-40ºF (0-4ºC) under high relative humidity (R.H.) conditions. However, chilling injury is a common problem at such low temperatures which becomes visible in the form of brown or black discoloration in the grape surface upon transfer to ambient conditions. On the other hand, storing fruit at higher temperatures results in rapid quality losses which are usually manifested in the form of weight, firmness and flavor losses and the development of off-flavors. Additionally, latent infections from the field result in the mycelial spread and occasional sporulation of numerous pathogens during storage, hastening fruit deterioration.

Even when cooled down immediately after harvest at ideal temperature and relative humidity conditions, muscadine shelf-life is at best two to three weeks before fruit become soft, shriveled, and unmarketable. It is of interest to muscadine growers to extend the postharvest life of fruit so that they can fill market niches later in the season potentially as late as Thanksgiving. Thus, the target is to achieve storage periods of 12-16 weeks, ensuring high-quality fruit for sale after storage.

It would be of great benefit to the fresh market industry a thorough investigation on the performance of commercial varieties of muscadines [Supreme (black) and Fry or Hall (bronze)] when it comes to their storability under controlled atmospheres (high carbon dioxide and low oxygen) and the potential of ozone treatments to suppress pathogens.

Sulfur dioxide has been used for years as an effective way to control decay during storage of muscadines, often causing bleaching damage, which further reduces the marketability of the product (Ballinger and Nesbitt, 1982). An alternative approach is the use of high carbon dioxide (15%), low oxygen (5%) which has been reported to extend muscadine shelf-life to 6 weeks at 34ºF (1ºC) (Mercer and Smittle, 1990). In this case, chilling injury could be induced in fruit held below 41ºF (5ºC), in the form of increased decay incident upon transfer to room temperature conditions after 4 weeks storage at 34ºF (1ºC) (Saunders et al., 1981). Previous studies (Perkins-Veazie et al., 1999) found that muscadines held at 36ºF (2ºC) with 15% $CO_2$ and 10% $O_2$ reduced decay incidence but increased incidence of brown lesions which could be either a chilling injury symptom or due to expression of impact damage as these fruits were collected by shaking rather than hand harvest.

In the past years there has been an increased interest in the utilization of ozone ($O_3$) as an alternative to traditional sanitizers in many crops including grapes (Sarig et al., 1996) Ozone is a strong oxidizing agent (1.5 times stronger than chlorine) and is effective over a much wider spectrum of microorganisms. Ozone treatments can extend the shelf-life of many products as they can guard against mold and bacteria growth during cold storage at very low concentrations. Despite the use of ozone in many crops, the potential and limitations of effective use of ozone for postharvest treatment of muscadines have not been fully documented and should be further studied.

Our laboratory is currently performing an experiment using Supreme and Fry varieties that were sourced from Griffin, GA in late September. The resuWe propose to investigate the effects of controlled atmosphere (high $CO_2$ and low $O_2$) with the addition of ozone ($O_3$) during cold storage on the overall fruit quality as well as their potential to shelf-life extension. Additionally, we would like to evaluate the effects of the above treatments on postharvest disease incidence during cold storage and after the transfer of muscadines in ambient conditions. The aim would be for the methods to be incorporated at current facilities using low-cost modifications, offering possible methods for extending the muscadine shelf-life to 8-12 weeks.

## Materials and Methods

Muscadine grapes were obtained from a commercial grower in Brooks, GA (Ison's Vineyards) and stored for up to 5 weeks at low temperature storage. The grapes were collected after the fruit have passed through the commercial cooling, grading and packing lines to ensure that standard industry procedures were followed. The common commercial cultivars Supreme (black) and Fry (bronze) were used for this experiment. Fruit were transported immediately to the Postharvest facility at the Vidalia Onion Research Laboratory, University of Georgia, Tifton Campus, and placed immediately at 40ºF (4ºC) at 90-95% R.H.

### Postharvest treatments

Postharvest and physiochemical attributes were measured initially (immediately after harvest) by evaluating berry size, weight, total soluble solids content (º Brix), titratable acids content, pH and for defects (bruises, pedicel separation/tears), and decay incidence. These same evaluations were also performed after cold storage.

Firm muscadine berries of uniform color were stored in one-pint polyethylene clamshells and held at 40ºF (4ºC) with high R.H. in closed cardboard boxes with vented polyethylene liners for up to 16 weeks. The experimental design was a randomized complete block, with three replications (with 3 clamshells per replication) and four treatments:

1) Cold storage [Control (no CA/ozone application)]
2) Cold storage + CA storage (15% $CO_2$/5% $O_2$)]
3) Cold storage + 0.5 ppm $O_3$
4) Cold storage + [CA (15% $CO_2$/5% $O_2$) plus 0.5 ppm $O_3$]

Fruit were subsampled every week for weight loss, and presence or absence of decay, shriveling, and firmness determined with a FirmTech 2 Fruit Firmness Tester, which is a sensitive equipment featuring a lever elevating mechanism. To determine chilling injury, a subset of clamshells held at 40ºF (4ºC) was pulled and rated each week from low temperature storage. Three replicates of 5 muscadine berries were placed in jars at 68ºF (20ºC) and headspace sampled for presence of ethylene and to measure their respiration rates using a gas chromatograph and a portable Bridge 900141 $O_2$/$CO_2$ analyzer. Berries free of decay were be frozen and held at -80ºC before and after storage treatments, for compositional analysis.

Compositional analysis

Subsamples of fruit, consisting of 10 to 20 grapes per sample, were juiced. The soluble solids content will be measured by placing approximately 1 mL of juice on a digital refractometer. The pH of the puree will be determined using a pH meter, and amount of acidity determined by a Mettler-Toledo titrator. Three to five mL of puree will be extracted with methanol for anthocyanin and phenolic determination using methods of Giusti and Wrolstad (1999) for total anthocyanins, and those of Singleton et al. (1999) for total phenolics.

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