Grape Breeding Program at Florida A&M University

Islam El-Sharkawy





Z. Ren
Grape Breeding



A. Darwish
Grape Biochemistry



M. Moniruzzaman
Grape Biotechnology



A. Humphries
Enologist



P. Gajjar, Ph.D.
Grape Phenomics



E. Olaoye, MS
Grape VOC



M. Park
Grape Genomics



A. Ismail
Grape Transcriptomics

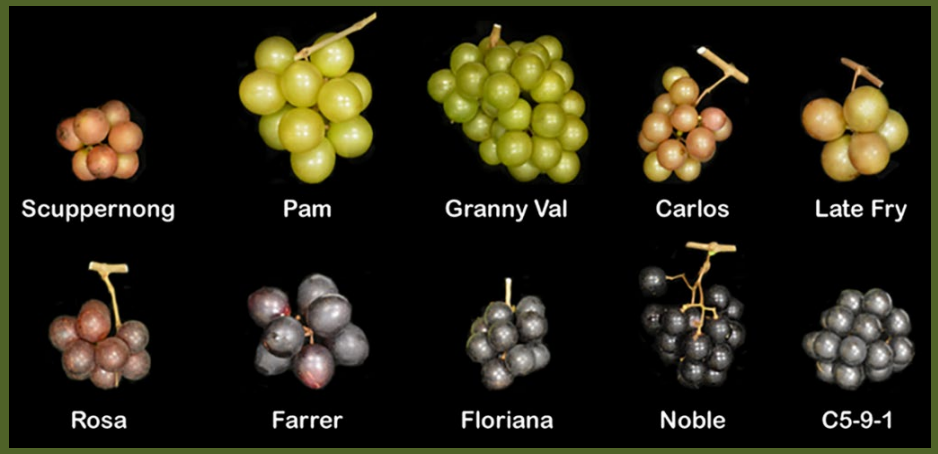
Research Activities

Muscadine beneficial characteristics:

- Anticancer activity (African American Breast Cancer and African American Prostate Cancer);
- Berry color and its relation to antioxidant activity;
- Antimicrobial activity of muscadine grape against ripe rot fungus (*Colletotrichum* sp.);
- Produce large berry seedless muscadine grapes for fresh consumption using CRISPR – technology;
- Biochemical and molecular comparison of aroma profile spectrum in ripe muscadine and bunch grape berries;
- Breeding new high quality Southern grape cultivars for meeting industry demands in Florida.
- Identify molecular mechanisms underlying drought, salinity, and hypoxia tolerance in grapes.

Research Activities

Berry Color & Antioxidant Activity





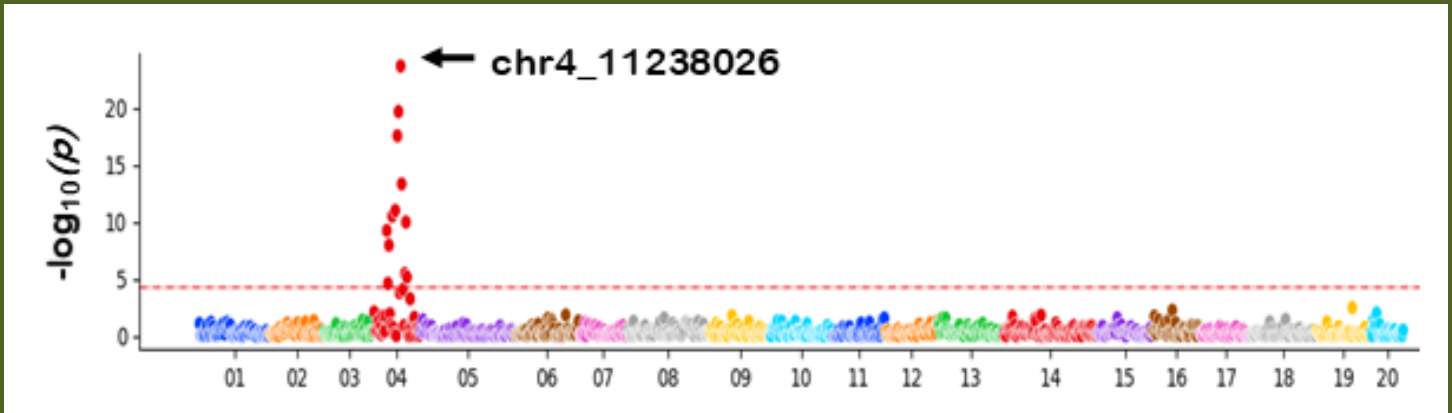
Muscadine berry color:
Purple, Dark-red, Red, Bronze, and Green.

Reason????

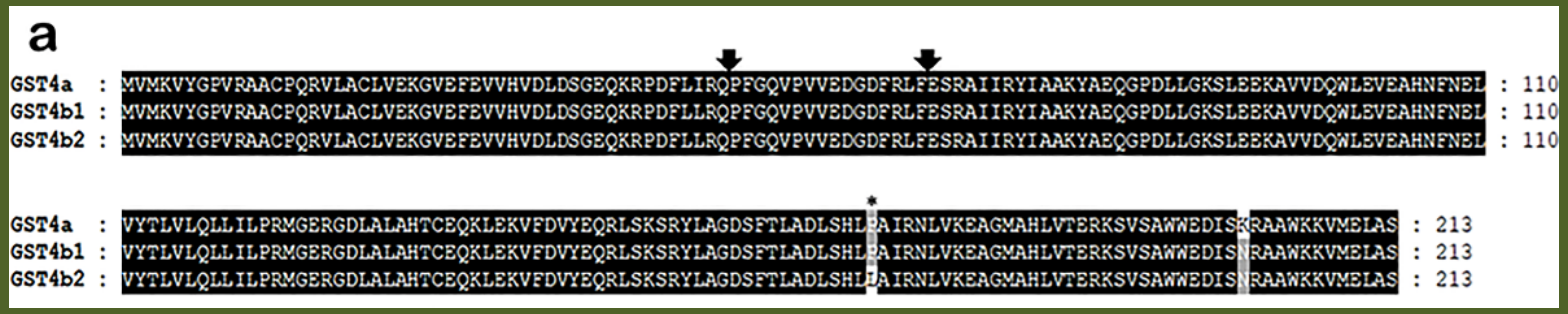
Bunch grape berry color:
Purple, Dark-red, Red, Bronze, Yellow, Gray, and Green.

Reason: MYB

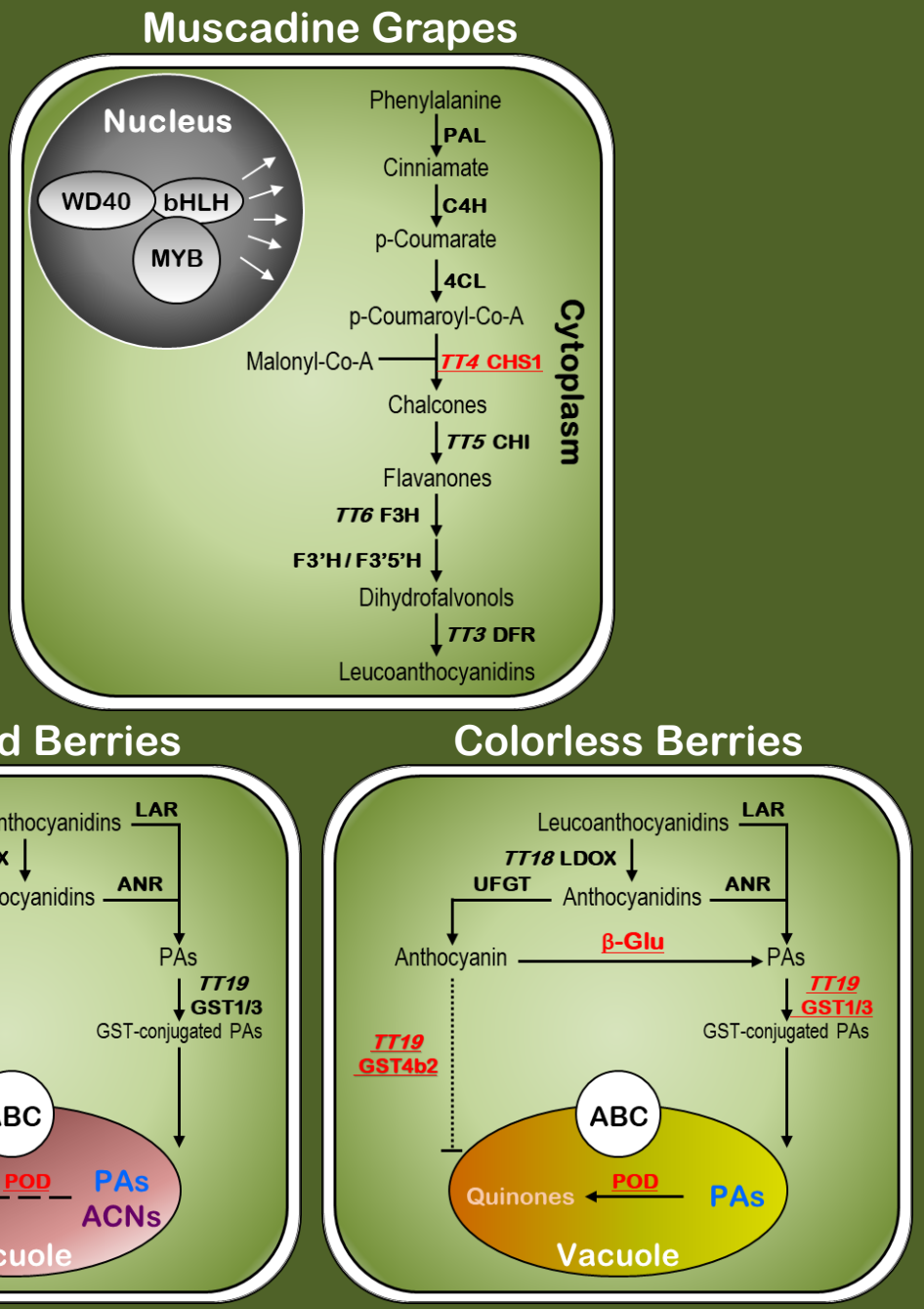
Genome-Wide Association Studies (GWAS) – Color Trait



Loss of color in muscadine is associated with a SNP in GST4b encodes glutathione S-transferase gene, resulting in change P_{171} (c**c**g) to Leu (c**t**g).



- CHS and GST4 enzymes control pigment intensity among colored muscadines;
- Homozygote muscadine genotypes for GST4 have more anthocyanin levels than heterozygote genotypes;
- Non-colored muscadines are due to a mutation that made the mGST4 not able to transport anthocyanins into vacuole.
- The cytoplasmic anthocyanins are converted into proanthocyanidins that can be transported to the vacuole by GST1 and GST3.



Ismail et al., 2023 Communications Biology

Questions

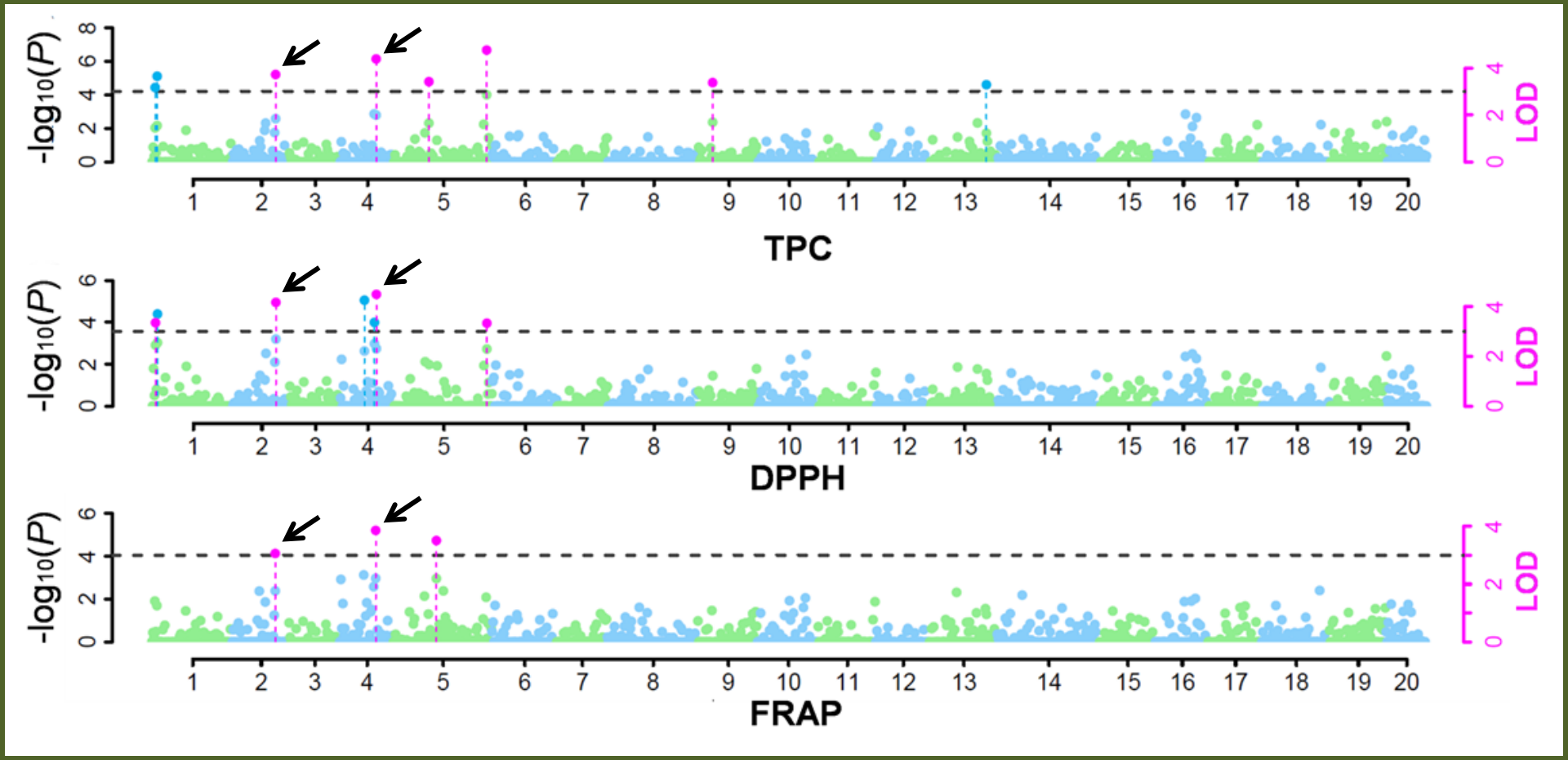
Is anthocyanin is positively involved in antioxidant activity? Yes

Red muscadines has more antioxidant activity the bronze muscadines? Not necessarily

Why wine generated based on colored muscadine berries is healthier than wine generated based on unpigmented berries?

Why muscadines exhibit diversity in antioxidant activity?

Genome-Wide Association Studies (GWAS) – Antioxidant Trait



- chr2_1446718: UDP-glycosyltransferase enzyme positively associated with high antioxidant activity.
- chr4_16491374: 4-hydroxy-4-methyl-2-oxoglutarate aldolase involved in gallic acid degradation. Gallic acid is a key metabolite player involved in antioxidant activity in muscadine grapes.

Park et al., 2022 Frontiers in Plant Science

Produce large berry seedless muscadine grapes for fresh consumption using CRISPR –technology

Fruit set programs in bunch grapes



Seeded/Female

Seeded/Perfect

Parthenocarpy seedless

Fruit set programs in bunch grapes



Seeded

Stenospermocarpy seedless

Parthenocarpy seedless

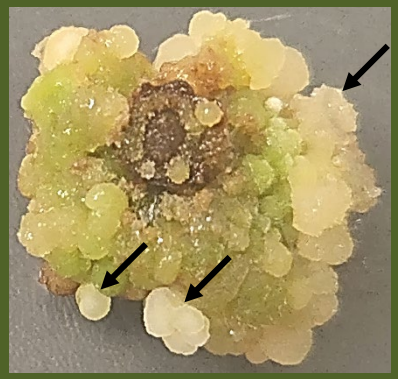
- Our target is to generate muscadine grapes exhibiting stenospermocarpy fruit set.
- Introducing the trait by conventional breeding with bunch grapes is not possible due to differences in chromosomes number between the two species.
- Several research groups were able to identify a potential gene candidate underlying the trait.
- We decided to use the gene-editing technology to generate a non-GMO large seedless muscadine berry suitable for fresh consumption.

Problems

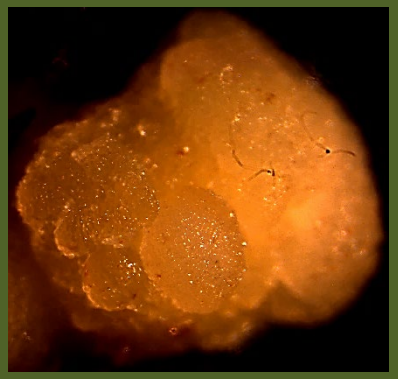
- Grapes are transformed by using somatic embryos as a gene delivery system. Highly efficient regeneration protocol has been developed at the CVSFR for the purpose of this project.

- The CRISPR technology can interrupt the gene either by insertion or deletion. However, we wanted to investigate the option of nucleotide substitution.

CRISPR technology for improving muscadine grapes



Pre-embryonic callus



Somatic embryos



Somatic embryos propagation



Somatic embryos transformation







Plants development in a selection media



Adaptation

Breeding new high quality Southern grape cultivars for meeting industry demands in Florida

Blanc Du Soleil

- Wine aroma of ‘Blanc Du Soleil’ is comparable to ‘Pinot Gris’ with pear, apple, peach, and pineapple notes.
- Wine exhibit medium acidity compared to ‘Stover’ (low) and ‘Blanc Du Bois’ (high), which makes it versatile for sparkling, still, and dessert style wines.
- Wine has a superior color characteristics compared to Blanc Du Bois and Stover. It is lighter in color than Blanc Du Bois and less brown/pink than Stover, which gives it better quality for white wine production.
- Plants will be available by the end of 2023 from Double A Vineyard, Fredonia, NY.





Scheiner et al., 2023 HortScience