Evaluating Fruit Quality *of Citrus Varieties in Georgia*

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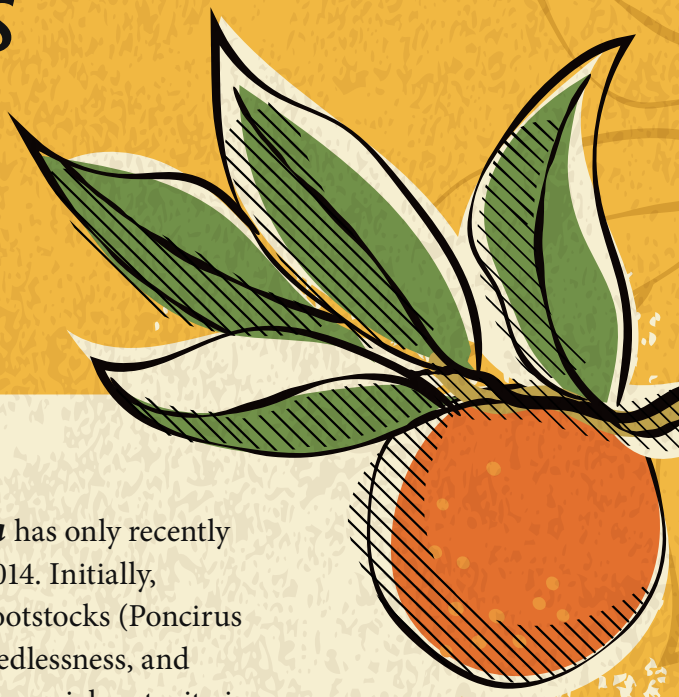

The commercial citrus industry in Georgia has only recently been established, with most groves planted after 2014. Initially, satsuma mandarins (Citrus unshiu) on trifoliate rootstocks (Poncirus trifoliata) were planted for their cold-hardiness, seedlessness, and ease of peeling. Satsuma fruits begin to attain commercial maturity in early November and usually avoid hard freezes in southern Georgia. As of 2022, approximately 75% of the 3,300 acres of citrus planted in Georgia are satsumas, but that proportion is trending downward. To strengthen the new Georgia citrus industry, growers recently have begun to diversify their citrus varieties. Little is known about how these varieties will perform under Georgia weather and soil conditions. Therefore, research is necessary to determine what varieties can best tolerate Georgia's winter weather and to determine cultural norms such as maturation time, fruit quality, and insect and disease tolerance.

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Risks of Citrus Variety Diversification in Georgia

Because few citrus varieties have the documented cold-hardiness of satsumas, diversifying citrus varieties in Georgia comes with risk. Fruit freezing on the trees is possible if varieties are not ready for harvest before hard freezes occur. Therefore, it is important to grow varieties that can be harvested before January. Hard freezes can occur in southern Georgia between the months of November and March, but most commonly occur after January. Recently, some winters have been milder, with low temperatures hovering near 30 °F. If these trends persist, it will be possible to harvest fruit well into the winter months. In general, temperatures of 28 °F that last for several hours can cause fruit damage, but other factors that determine damage to fruit include the location of the fruit on the tree, duration of the freeze, and peel thickness. Growers should review climate data available through the University of Georgia weather network to determine the earliest freeze dates and duration of those freezes in their local region.

Total Soluble Solids (Brix)

Taste panels have revealed that consumers' preference for different citrus fruits is not based on sugar content alone but rather a blend of sugars and acid. The average consumer wants a pleasantly tart or subacid fruit, and this requires certain ratios of sugar to acid (Davies & Jackson, 2022, pp. 250–251). For this reason, total soluble solids (TSS), which are mostly sugars, and the TSS-to-acid ratio are important parameters to consider when determining whether citrus fruit is ready to harvest. Citrus does not continue to ripen after harvest, so the fruit must be allowed to reach peak maturity on the tree (Tucker et al., 2006, p. 271).

In addition to sugars, TSS include certain organic acids (largely citric acid), vitamins, potassium, very small amounts of inorganic salts, and organic compounds that are responsible for the characteristic flavors of various citrus fruits (Davies & Jackson, 2022, pp. 250–251). The *Brix scale* is a measure of TSS dissolved in the juice. Sugars constitute about 80% of the Brix value. Brix is measured in *degrees Brix*, which is equivalent to a percentage. Brix levels rise as fruit matures during the season.

Percent Acid

Citric acid is the primary acid found in citrus fruit, but fruit may also contain small amounts of malic, succinic, and tartaric acid. Acid levels decrease the longer the fruit remains on the tree. The ratio of Brix to acid helps to determine the quality of the fruit. To calculate the ratio, the percentage of Brix is divided by the percentage of acid. For example, juice with a Brix of 10 and acid level of 0.9 has a Brix/acid ratio of 11.1.

Brix/Acid Ratio

The Brix/acid ratio is more important in determining acceptable flavor when the Brix levels are low than when the Brix levels are high. As the fruit matures, the Brix and acid percentages change until an acceptable ratio is reached. As fruit maturity progresses, the ratio can become higher as the sugar rises and acid drops. This high ratio may lead one to believe the fruit quality is increasing, but very high ratios—over 20, for example—result in insipidly sweet juice without tartness, which is not desirable.

Georgia does not currently have maturity standards for citrus, but in some states, the law requires a minimum Brix level and a minimum Brix/acid level for each classification of fruit and stage of maturity. In Florida this

is determined by the Florida Department of Citrus and the Florida Citrus Commission. Florida has five major marketing classifications: orange, grapefruit, tangerine, tangelo, and other varieties that may be given a separate identity. Each classification has specific standards. For example, Florida regulations state that Murcott honey tangerines require that acid not exceed 1% unless the Brix/acid ratio is 12 or higher. For processing, the ratio is a minimum of 10 with no requirement for acid. For tangelos there is a more extensive chart that specifies Brix/acid ratios that decrease as the Brix rises and depend on whether fruit are for fresh consumption or processing.

Examples of Brix/Acid Ratios from Georgia

On November 8, 2021, 60 fruit from 'Owari 874' satsumas on 'US-942' rootstocks growing in Valdosta, GA, were juiced and evaluated for Brix and acid. The trees were planted in 2014 and had a Brix of 10.2 and acid level of 0.92. The Brix/acid ratio was 11.1, which indicates a quality fruit. For comparison, the commercial-standard Brix-to-acid ratio for satsumas in Louisiana is 10.

Having a minimum Brix level is important. If fruit has both low Brix and acid levels, the Brix/acid ratio could appear acceptable but the ratio would be misleading. An example of this is when 'Miho Wase' satsumas on 'Rubidoux' rootstock were juiced on October 20 in Valdosta, GA, from trees planted in 2016. The Brix from 30 juiced fruit was 7.0 and the percent acid was 0.65. The ratio of 10.8 normally would indicate a quality fruit, but the taste was poor because of the low Brix level.

Fruit with both high Brix and acid levels, such as 'Sugar Belle' mandarins, may have a low Brix/acid ratio but still have a pleasing flavor because of the higher Brix level. For example, 40 random fruit were picked and juiced from 'Sugar Belle' mandarin trees on four different rootstocks in Valdosta, GA, on January 4, 2022. The Brix level of the juice was 14.2 and the acid was 1.5152. The Brix/acid ratio of the 'Sugar Belle' juice was 9.4, but the juice's flavor was considered outstanding.

Evaluation of 29 Georgia-Grown Citrus Varieties

In December 2021, five citrus fruits (exceptions are noted in the table) were picked and juiced into one sample from each variety/rootstock combination represented in Table 1. All plantings were from Lowndes and Lanier counties except for 'Pink Frost' grapefruit (UGA) and 'Grand Frost' lemon (UGA), which came from a planting in Tift County. For each sample, the Brix was tested using an Atago 3810 digital pocket refractometer and the acid was derived using a Mettler Toledo automatic titrator. Photos were taken of two to four of the fruit from each sample prior to juicing to show the exterior and interior of the fruit. Table 1 provides data on:

- varieties currently being grown in Georgia
- when they were planted
- the rootstocks on which they were grafted
- measured TSS levels
- measured titratable acidity (TA)
- TSS/TA ratios

The values in the table provide information that may assist growers in choosing which varieties to plant and when they may mature.

Table 1. Characteristics of 29 varieties and 40 variety/rootstock combinations collected from five fruits on December 15, 2021 (unless otherwise noted).

Variety	Rootstock	Date planted	TSS* (Brix)	Titratable acidity (TA)	TSS/TA ratio
SWEET ORANGES					
Southern Frost Navel (UGA)	Flying Dragon	2017	11.7	0.64	18.3
Glen Navel	Sour Orange	2014	9.4	0.84	11.2
Glen Navel	US-852	2017	10.2	0.75	13.6
Cara Navel	US-897	2018	9.5	0.73	13.0
Washington Navel	US-852	2017	10	0.65	15.4
Marr's Orange	*Poncirus trifoliata*	2009	10.7	0.84	12.7
Ambersweet Orange	US-852	2009	8.1	0.52	15.6
Sweet Bessie Orange	US-852	2017	6.7	0.66	10.2
Early Gold Orange	16-6	2008	8.1	0.63	12.8
Moro Blood Orange	US-942	2019	9.7	1.07	9.1
Hamlin Orange	US-812	2016	9.4	0.69	13.6
MANDARINS					
Sugar Belle Mandarin	US-942	2018	13.1	1.62	8.1
Sugar Belle Mandarin	US-897	2018	13.3	1.78	7.5
Sugar Belle Mandarin	US-852	2018	12.7	1.48	8.6
Sugar Belle Mandarin	Rubidoux	2018	13.7	1.65	8.3
Sugar Belle Mandarin	X-639	2015	12.1	1.53	7.9
Sugar Belle Mandarin	Goutou	2017	12	1.11	10.8
Tango Mandarin	US-852	2020	9.6	0.88	10.9
Tango Mandarin	X-639	2018	10.9	0.92	11.8
Kishu Mandarin	US-852	2017	8.7	0.51	17.1
Kishu Mandarin	Rubidoux	2019	10	0.64	15.7
Shiranui Mandarin	US-942	2019	11.0	1.01	10.9
Shiranui Mandarin	US-852	2018	11.7	1.30	9.0
Shiranui Mandarin	US-897	2016	13.5	1.38	9.8
Shiranui Mandarin	Swingle	2015	11.8	1.57	7.5
Early Pride Mandarin	X-639	2017	11.1	0.88	12.6
Orange Frost Mandarin	Own roots	2017	10.6	0.97	10.9
Artic Frost Mandarin	Own roots	2015	12.2	0.97	12.6
Keraji Mandarin	US-942	2018	10.7	0.48	22.3
US Superna (88-2)	US-852	2019	14.4	0.82	17.6
Sweet Frost Changsha (UGA)	Rubidoux	2016	12.9	0.91	14.2
Poncan Mandarin	Rubidoux	2010	12.2	0.64	19.1
Owari Satsuma Mandarin	Kuharski Carrizo	2014	11.4	0.78	14.6
Fairchild Mandarin	Flying Dragon	2009	16.1	0.93	17.3

Variety	Rootstock	Date planted	TSS* (Brix)	Titratable acidity (TA)	TSS/TA ratio
GRAPEFRUIT					
***Golden Grapefruit	Flying Dragon	2009	9.0	1.01	8.9
**Pink Frost Grapefruit (UGA)	*Poncirus trifoliata*	2009	7.6	1.38	5.5
LEMONS					
**Grand Frost Lemon (UGA)	*Poncirus trifoliata*	2010	6.3	3.46	1.8
Meyer Lemon	Own roots	2009	7.1	4.94	1.4
TANGELOS					
Page Tangelo	US-852	2018	12.6	0.96	13.1
Minneola Tangelo	US-897	2018	10.9	1.18	9.2

*TSS = Total soluble solids

**Sample collected on January 9, 2022; each sample included three fruits.

***Two fruits sampled for this variety.

SWEET ORANGES

Southern Frost Navel

Glen Navel

Cara Navel

Washington Navel

SWEET ORANGES

Marr's Orange

Ambersweet Orange

Sweet Bessie Orange

Early Gold Orange

Moro Blood Orange

Hamlin Orange

MANDARINS

Sugar Belle Mandarin

Tango Mandarin

Kishu Mandarin

Shiranui Mandarin

Early Pride Mandarin

Orange Frost Mandarin

MANDARINS

Artic Frost Mandarin

Keraji Mandarin

US Superna (88-2) Mandarin

Sweet Frost Changsha Mandarin

Ponkan Mandarin

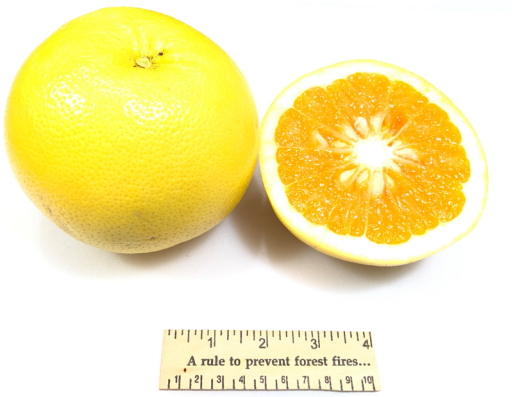
Owari Satsuma Mandarin

MANDARINS

Fairchild Mandarin

Bumper Mandarin

GRAPEFRUITS



Golden Grapefruit

Pink Frost Grapefruit

LEMONS

Grand Frost Lemon

Meyer Lemon

TANGELOS

Page Tangelo

Minneola Tangelo

References

Davies, F. S., & Jackson, L. K. (2022). Harvesting, maturity, and grade standards and marketing. In *Citrus Growing in Florida* (5th ed.). University Press of Florida. https://upf.com/book.asp?id=9780813068855

Tucker, D. P. H., Roger, S., Stover, E. W., & Ziegler, M. R. (2006). Fruit quality. In *Florida Citrus: A Comprehensive Guide*. University of Florida IFAS Communication Services. http://ifasbooks.ifas.ufl.edu/p-206-florida-citrus-a-comprehensive-guide.aspx

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