

Relationships of Brix, Titratable Acidity, and pH with Time during Ripening above and below Temperature Thresholds

Jeremy Weiss*, University of Arizona Cooperative Extension
 Jesse Noble, Merkin Vineyards

*presenting author, jlweiss@arizona.edu

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As temperatures continue to trend higher, winegrape growers and winemakers in warm-climate viticultural regions will increasingly be challenged by the many effects temperature has on fruit composition. Warmer ripening conditions in recent years for such growing regions around the world have resulted in higher sugar concentrations, less acidity from declines in malic acid, higher pH, and changes in aromatic and phenolic compounds, all of which can be particularly affected by daytime maximum or nighttime minimum temperatures.

For analysis, we use measures of Brix, titratable acidity (TA), and pH for several varieties across multiple vintages from a warm-climate vineyard in the Willcox AVA in southeastern Arizona. **Red varieties** include Grenache, Mourvèdre, Sangiovese Grosso, and Tempranillo. **White varieties** include Chardonnay, Malvasia Bianca, and Sauvignon Blanc. Vintages span 2016 through 2020.

We correlate these measures with accumulated hours of temperatures greater than values between 30 and 40 °C (86 to 104 °F) and less than values between 10 and 20 °C (50 to 68 °F), ranges encompassing thresholds reported in previous studies (e.g., Rienh et al. 2016). Temperature

Results suggest that duration of both heat and cold exposure influence Brix and TA of white varieties as a group. We expected negative Brix-accumulation and positive TA-accumulation relationships for cold exposure, but not for heat exposure. The degree of heat or cold at several temperature thresholds is linked to these relationships. Neither duration nor degree of heat or cold seem to affect fruit composition of red varieties as a group, perhaps indicating more inter-varietal differences.

Information that helps identify and minimize these impacts and aids production of well-balanced wines in these regions is needed. Here, we evaluate fruit composition at harvest in the context of time spent during ripening above and below temperature thresholds to test our hypothesis that duration and degree of heat and cold exposure correlate to composition values.

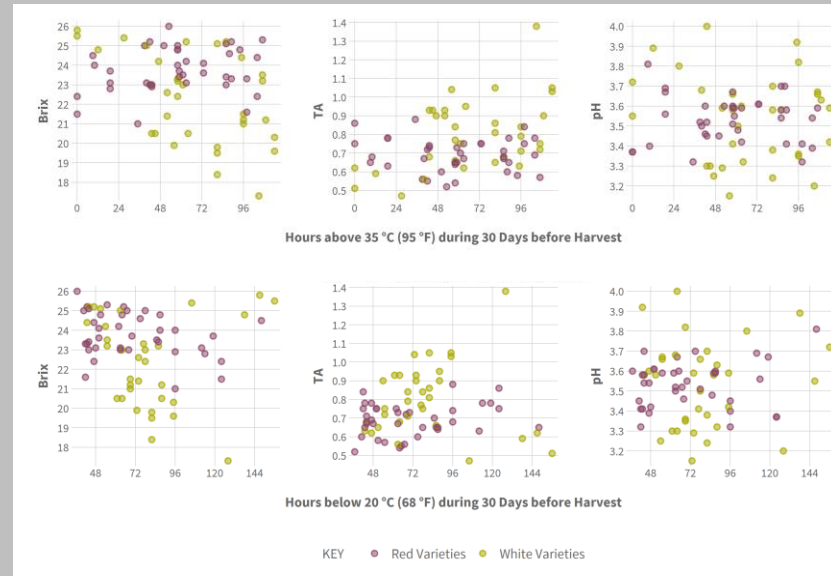
accumulations are over the 30 days leading up to harvest and based on data collected at a meteorological station located approximately one kilometer (0.6 mile) from the vineyard.



American Viticultural Areas (AVAs) in Arizona

By determining how exposure to heat and cold during ripening potentially has influenced fruit composition in recent vintages, our work provides an initial model for growers and winemakers in this and other warm-climate viticultural regions with which to predict impacts of temperature conditions in future growing seasons and to consider vineyard and winery adaptations for production of quality fruit and balanced wines under continued regional warming.

Fruit Composition versus Temperature



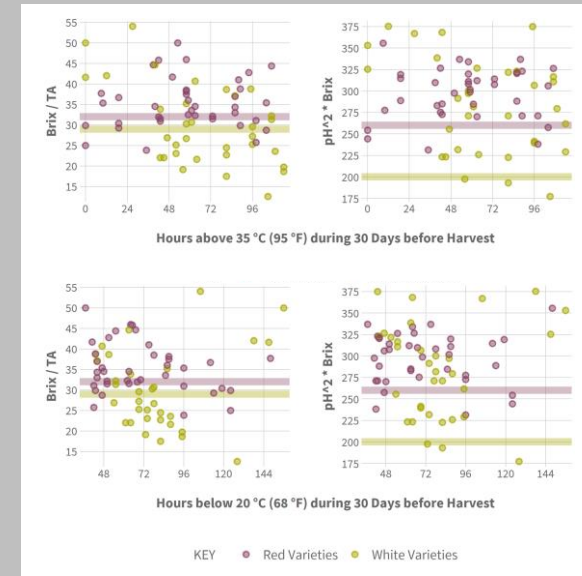
These example scatterplots show how values of Brix, titratable acidity (TA), and pH relate to temperature accumulations above 35 °C (95 °F; top row) and below 20 °C (68 °F; bottom row). Temperature data are from the AZMET Willcox Bench station (cals.arizona.edu/azmet).

Correlations for Red Varieties

	Below (°C)										Above (°C)											
	10	11	12	13	14	15	16	17	18	19	20	30	31	32	33	34	35	36	37	38	39	40
Brix	NA	NA	NA	NA	-	+	-	-	+	-	-	+	+	+	+	+	+	+	+	+	+	+
TA	NA	NA	NA	NA	+	-	+	+	+	+	+	-	-	-	-	-	+	-	-	-	-	+
pH	NA	NA	NA	NA	-	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+
Brix / TA	NA	NA	NA	NA	-	+	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+
pH ² * Brix	NA	NA	NA	NA	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Table entries represent Kendall's Tau rank correlation coefficients. Positive (+) and negative (-) relationships between fruit composition or balance and temperature accumulation that are statistically significant (p-value < 0.05) are shaded. NA values indicate no accumulation of temperature relative to a particular threshold.

Fruit Balance versus Temperature



Like the figure to the left, but for fruit balance values (Gallander 1983; Amerine and Joslyn 1970). Thick horizontal lines matching the colors of red and white varieties are respective target values.

Correlations for White Varieties

	Below (°C)										Above (°C)											
	10	11	12	13	14	15	16	17	18	19	20	30	31	32	33	34	35	36	37	38	39	40
Brix	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TA	NA	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
pH	NA	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+
Brix / TA	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
pH ² * Brix	NA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Like the table to left, but for white varieties.