

Survey of Sensing Methods for Detection of Freeze Damage in Oranges

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The goal of this project is to develop and test a field method for using an ethanol sensor to measure whether a sample of oranges contains a threshold level of freeze-damaged fruit. The citrus industry is seeking an objective alternative to the manual inspection method used by CDFA inspectors to determine freeze damage in navel oranges.

Previous research showed that freeze damaged fruit produces ethanol and an inexpensive, hand-held, battery-operated ethanol detector was effective in measuring the ethanol (etoh) produced by freeze-damaged oranges. This year's research evaluated the effectiveness of a method for identifying freeze damaged oranges using two navel varieties (Atwood and Washington), with and without preharvest gibberillic acid (GA) treatment and with fruit harvested over the potential frost period from December through March.

Each week during the test period, navel oranges from the Lindcove Field Station were harvested and immediately sent to UC Davis for laboratory testing. Fruit were inspected, and damaged fruit was discarded. Fruit was then weighed and a few pieces were juiced for soluble solids measurement with a bench top refractometer. Some of the fruit was held at 41°F during the testing and used as a non-frozen control. The remainder of the fruit was placed in a 20°F freezing chamber for 8 or 16 hours.



Fruit was thawed at room temperature for about 24 hours and then tested for headspace ethanol concentration. Each piece of fruit was placed in a one-quart Ziplock plastic bag for a one-hour. After equalization the bag was sampled for ethanol with an Alcosensor IV (Intoximeters, Kansas City, MO). The sensor was factory modified with a hypodermic needle probe allowing the bag to be sampled. Fruit was then manually evaluated for freeze damage using the USDA procedure for recently frozen oranges.

Discriminant analysis statistics were used to determine the optimum ethanol threshold for distinguishing between lots of frozen and non-frozen fruit. A lot of 6 or 7 fruit was considered frozen if one fruit was determined to be freeze-damaged. Data for each week's test were pooled, with variety and GA treatment separated in the analysis.

The best discrimination between frozen and non-frozen lots was obtained by setting the etoh threshold at 0.03 mg/l for GA treated fruit and 0.00 mg/l for fruit not treated with GA (see table). Assuming these thresholds, the etoh method agreed with the USDA method in 92% and 94% of the Washington variety lots and 86% and 78% of the Atwood lots. Preliminary analysis indicates that the discrimination accuracy is not very sensitive to etoh threshold, and overall accuracy may not be reduced much by using one threshold for GA and non-GA treated oranges.

The ethanol method is inexpensive, requiring one-quart Ziplock bags (they can be reused by taping over the hole caused by the hypodermic needle) and an \$850 ethanol sensor. The sensor calibration is very stable, we did not need to recalibrate it during the season. The sensor can measure ethanol concentration in about 15 seconds, allowing 100 fruit to be tested in less than one hour.

Variety	Preharvest Treatments	
	No GA (freeze damage if etoh>0.03 mg/l)	Treated with GA (freeze damage if etoh>0.00 mg/l)
Washington	92%	94%
Atwood	86%	78%

Table 1. Percent agreement between headspace ethanol and USDA manual methods for determining freeze damage to lots of navel oranges.

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