Electronic Nose Evaluation of Grape Maturity

Study demonstrates why a conducting, polymer-based electronic nose may be an objective tool for evaluating grape maturity, according to authors.

Bruce W. Zoecklein, Ahmad I. Athamneh and Kumar Mallikarjunan*

***WBM* Senior Technical Editor's note:** Winemakers know that the most usual metrics we use for grape ripening—Brix, pH, TA, color, etc.—don't predict wine quality. Zoecklein et alia contend that measuring the volatile compounds in grapes, a fancy way of saying grape aroma, is better at predicting final wine quality. As the authors note, the so-called "electronic nose" is a reliable, simple and objective way of determining fruit maturity.

WE INVESTIGATED THE ability of an electronic nose to measure Cabernet Sauvignon (*Vitis vinifera* L.) fruit maturity over several seasons. Grape maturity is a critical attribute impacting potential wine quality. As all winemakers know, maturity evaluation is difficult, due to the many interrelated factors that impact physical and chemical changes, and limitations in the understanding of those factors. Currently, grape maturity evaluation often includes measurements such as berry weight, sugar content (Brix), pH, titratable acidity, malic acid and color, used individually or in combination. These assays may be influenced by sampling method and accuracy, and sample processing variations. Additionally, specific levels of fruit sugar, acidity, pH and color are not always strongly correlated to potential wine quality.

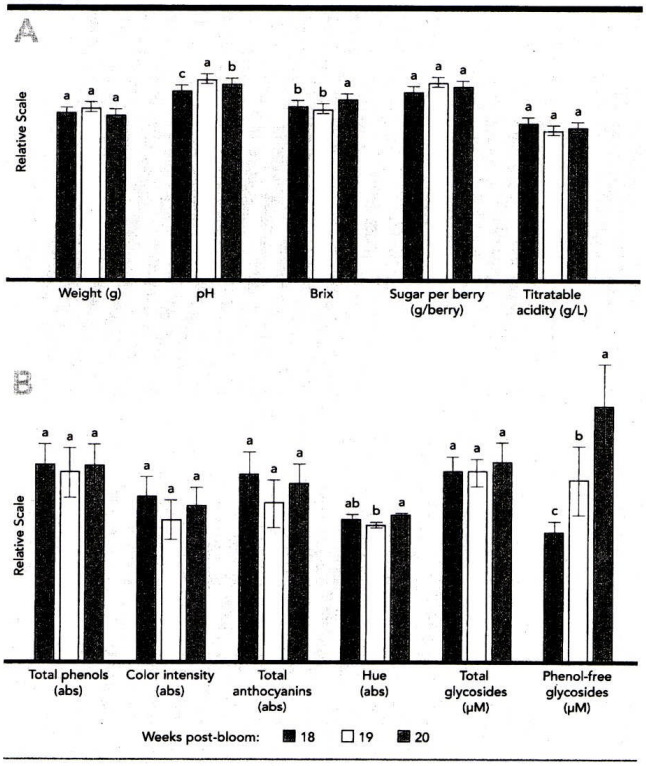
Grape-derived varietal aroma, on the other hand, is a very important wine attribute correlated to wine quality. Free volatiles may contribute directly to odor while some non-volatile conjugates represent aroma precursors that may be released during winemaking and aging. The pool of free aroma components and their precursors increases rapidly in the advanced stage of fruit maturity, referred to as engustment (Coombe and McCarthy, 1997). For that reason, many winemakers sensorially and subjectively evaluate juice aroma as a maturity gauge. Because of the difficulties associated with sensorial evaluation, we believe there is a need for a reliable, simple and objective technique for evaluation of fruit maturity, based on fruit volatiles.

TECHNOLOGY SIMULATES HUMAN OLFACTORY SYSTEM

The electronic nose is a relatively new technology utilized in a variety of applications in the medical and food industries. It is, in part, a simulation of the human olfactory system, which can aid in decision-making when volatile compounds correlate with sample attributes. In the wine industry, the electronic nose has been suggested as a tool to monitor toasting homogeneity of oak barrels and for regional wine discrimination, among other applications. Our studies over the last two vintages evaluated the capacity of a conducting polymer-based electronic nose to monitor Cabernet Sauvignon (*Vitis vinifera* L.) fruit maturity by analyzing headspace volatiles.

Berry samples were randomly collected from both the east and west sides of north-south oriented, open-Lyre trained vines at 18, 19 and 20 weeks post-bloom for a total of 15 replicates per week for physical, chemical and electronic nose analysis. We used a Cyranose 320 (Cyrano Sciences, Pasadena, CA), hand-held electronic nose system with 32 polymer-based sensors. Electronic nose measurements were compared with 11 physical/chemical indices used to evaluate fruit maturity: berry weight, pH, Brix, titratable acidity, total phenols, color intensity, hue, total anthocyanins, and total and phenol-free glycosides. We compared these indices with laboratory electronic nose analysis of berries and with non-destructive electronic nose measurements of clusters on the vine. Sixteen

FIGURE 1



Physical and chemical analyses for Cabernet Sauvignon grapes sampled 18, 19, and 20 weeks post-bloom, one season. Means associated with different letters are significantly different, a = 0.05, by least significant difference. Error bars represent 95% confidence intervals.

intact clusters were randomly selected per week, wrapped in polyethylene bags for 45 minutes, followed by electronic nose headspace analysis.

In one study, Brix, pH, hue and phenol-free glycosides were found to be highly significantly different among the three fruit sampling dates (FIGURE 1). The large differences in phenol-free glycosides with advanced maturity may reflect the increases in the pool of potential aroma and flavor compounds with advanced fruit maturity (Zoecklein et al., 2000). This change appeared to be correlated with engustment.

Discriminate analysis plot of physical and chemical data showed clustering according to sampling week (FIGURE 2A). The separation indicated the similarity within a sampling group and the difference among the three dates as expected. Electronic nose data on berries collected and performed in the laboratory, and the enose data from intact clusters measured in the field, produced similar separations. With one measurement, both the laboratory enose and the field enose measures favorably compared to those based on the 11 physical and chemical indices. Samples were classified according to sampling week, indicating the ability of the electronic nose to differentiate among the maturity groups. Cross-validation analyses indicated 91 percent of samples were correctly classified based on physical and chemical data, compared to 100 percent and 98 percent based on laboratory and field electronic nose data measurements, respectively. This study was conducted over two seasons with similar results.

DIFFERENTIATING FRUIT FROM DIFFERENT CANOPY LOCATIONS

In a related effort, we used an electronic nose to help differentiate fruit from different canopy locations. Fruit on different sides of the canopy may vary in maturity due to variations in solar exposure (Smart and Robinson 1991, Downey et al. 2006). We know that variation in aroma and flavor maturity may not be reflected in differences in berry weight, Brix, pH, titratable acidity and other common physicochemical indices used by winemakers. In this study, berry weight, Brix, sugar per berry, pH and titratable acidity measured on fruit samples from east and west canopy sides of north and south, Lyre-trained rows, at 18, 19 and 20 weeks post-bloom were not significantly different (FIGURE 3A). However, the electronic nose was able to differentiate between samples from east vs. west canopy side, likely due to variation in fruit volatile compounds (FIGURE 3).

In our studies, a conducting polymer-based commercially available electronic nose was used to differentiate fruit maturity based on one nondestructive measurement of grape volatiles. The electronic nose was able to differentiate between maturity groups. The success of this approach is likely due to the vast number of volatile compounds that contribute to grape varietal character, most of which are generally not considered in maturity analyses. We believe this research demonstrates the potential for this relatively new technology to be used as a rapid and objective tool for evaluating grape maturity, which may contribute to maximizing wine quality with minimum cost. **wbm**

Professor Bruce W. Zoecklein (bzoeckle@vt.edu), associate professor Kumar Mallikarjunan and graduate student Ahmad I. Athamneh are with the Enology-Grape Chemistry Group at Virginia Tech in Blacksburg, Virginia.

Literature Cited

COOMBE, B.G. and MCCARTHY, M.G. (1997) Identification and naming of the inception of aroma development in ripening grape berries, *Australian Journal of Grape and Wine Research*, 3, 18-20.

DOWNEY, M. O., DOKOOZLIAN, N. K. and KRSTIC, M. P. (2006) Cultural practice and environmental impacts on the flavonoid composition of grapes and wine: A review of recent research, *American Journal of Enology and Viticulture*, 57, 257-268.

SMART, R. and ROBINSON, M. (1991) *Sampling into Wine*. Adelaide, South Australia: Winetitles.

ZOECKLEIN, B.W., DOUGLAS, L.S. and JASINSKY, Y.W. (2000) Evaluation of the phenol-free glycosyl-glucose determination, *American Journal of Enology and Viticulture*, 51, 420-423.

FIGURE 2

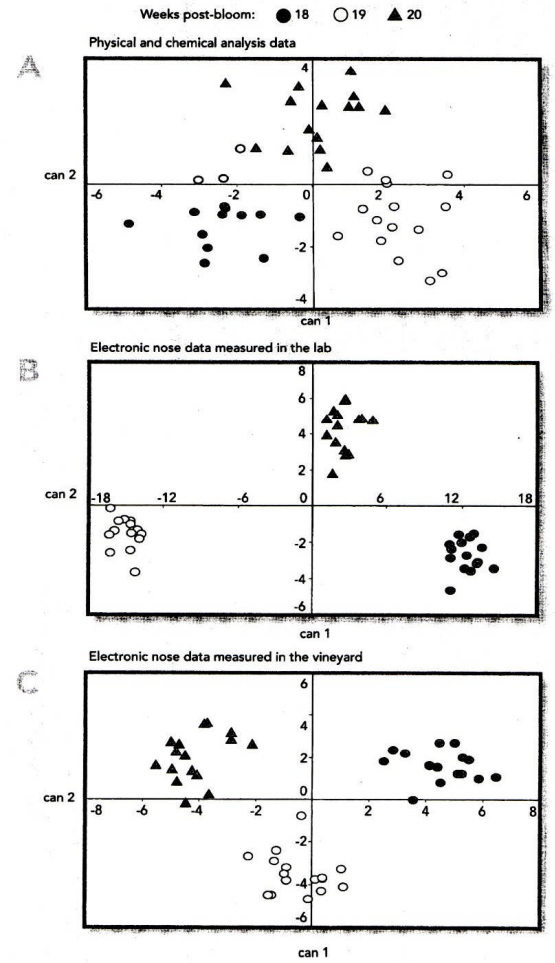


Figure 2. Canonical plot summary of (a) physical and chemical analyses data, (b) electronic nose data measured in the laboratory, and (c) electronic nose data measured in the vineyard, for Cabernet Sauvignon grapes sampled 18, 19, and 20 weeks post-bloom in season 1.

FIGURE 3

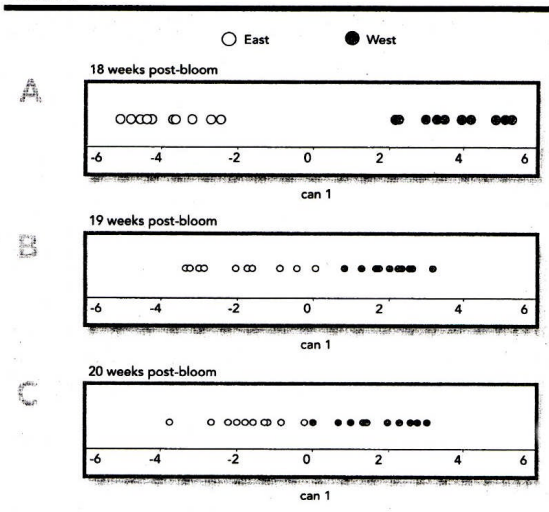


Figure 3. Canonical plot analysis cross-validation summary of electronic nose measurements of Cabernet Sauvignon fruit from east vs. west canopy side at (a) 18, (b) 19, and (c) 20 weeks post-bloom.