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This issue of the ASEV Technical Update contains interpretive abstracts written by authors of articles published in the third and fourth issues of the *American Journal of Enology and Viticulture*, 2013. A link to the online Journal article appears at the end of each abstract.

Mapping Grapevine (*Vitis vinifera* L.) Water Status during the Season Using Carbon Isotope Ratio ($\delta^{13}\text{C}$) as Ancillary Data

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Vine water status is a major parameter for vine management because it affects both wine quality and yield. It can be modified by adapting management and harvesting practices to vineyard variability. In a previous study, the spatial variation of vine water status, assessed by predawn leaf water potential, was estimated from ancillary data based on vigor measurements in Mediterranean and nonirrigated conditions. The current work aims at establishing a similar spatial model for stem water potential (Ψ_{Stem}) with ancillary data based on vine water status; i.e., carbon isotope ratio ($\delta^{13}\text{C}$). Hence, the model could be used in a broader range of situations, including those where water deficit is moderate and those where vine vigor is possibly impacted by factors other than water deficit; e.g., vine nitrogen status. Stem water potential and $\delta^{13}\text{C}$ were measured for three consecutive years on 96 locations within one vineyard block. A spatial model was created to predict spatial variations of Ψ_{Stem} by using $\delta^{13}\text{C}$ values obtained during a previous year as ancillary data. Ψ_{Stem} maps established with the spatial model proved to be more accurate than Ψ_{Stem} values obtained with a nonspatial model. This study shows that operational maps of vine water status can be obtained by means of a spatial model in which $\delta^{13}\text{C}$ values from a previous season are used as ancillary data. Maps can be updated at any given mo-

ment during the season by carrying out a limited number of Ψ_{Stem} measurements in selected locations. This application is a powerful tool, both to save irrigation water in a period of increasingly scarce water resources and to improve quality, which is adversely affected by both under- and over-irrigation.

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Reactions Involving Iron in Mediating Catechol Oxidation in Model Wine

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Wine is capable of reacting with a considerable amount of oxygen, red more than white since polyphenols are the main reactants. However, polyphenols do not react directly with oxygen but rely on the catalytic intervention of iron and copper, which are invariably present in small concentrations. Iron, in its reduced ferrous state, Fe(II), first reacts with oxygen and is oxidized to its ferric state, Fe(III). This reaction progressively slows as the Fe(III) produced is found to increasingly inhibit the process. It has been proposed that oxygen is reduced in two steps, first to an intermediate hydroperoxyl radical and then to hydrogen peroxide, which goes on to oxidize ethanol. Contrary to previous reports, a model catechol was found not to react with Fe(III) or to alter the rate of reaction of the Fe(II) with oxygen. Consequently, it is proposed that hydroperoxyl radicals, which were thought to react with catechols, are not produced and an alternative mechanism for the oxidation of Fe(II) is proposed. Catechols are oxidized to quinones by Fe(III), but it is confirmed that substances which react with quinones are also required to drive the process forward. Hydrogen peroxide is reduced by Fe(II) and the resulting intermediate free radical oxidizes ethanol to acetaldehyde. However, it is demonstrated that oxygen is also taken up in the process, confirming the existence of this second mechanism for its reduction, which still depends on iron. The ability of Fe(II) to donate and Fe(III) to accept an electron is measured by the reduction potential of the couple, which is determined by substances that bind to the metal. Tartaric acid is shown to determine this reduction potential, and so this acid determines the ability of iron to promote oxidative processes in wine.

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Impact of Dissolved Oxygen at Bottling on Sulfur Dioxide and Sensory Properties of a Riesling Wine

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The contact of wine with air is common during winemaking and results in dissolution of oxygen into the wine. Wine exposure to oxygen results in loss of sulfur dioxide, the main wine antioxidant. Sensory characteristics of the wine are also likely to change in response to oxygen exposure. In white wine, a moderate oxygen exposure is viewed as potentially favorable to avoid reductive off-odors, while excessive oxygen exposure can result in loss of fresh and fruity aromas. Several winemaking operations are known to potentially promote incorporation of atmospheric oxygen into the wine, with a consequent increase of wine dissolved oxygen. Bottling has been indicated as a set of operations potentially resulting in a large increase in wine dissolved oxygen content. With the recent introduction of devices allowing relatively rapid measure of dissolved oxygen during bottling, there is a growing interest in the influence of oxygen at bottling on subsequent wine development. It has been previously shown that the closure has a primary role in determining the degree of oxygen exposure in bottled wine. In this study, a Riesling wine was bottled with three different dissolved oxygen levels and sealed with two different coextruded and one screwcap closure in order to investigate the impact of dissolved oxygen and closure on wine evolution post-bottling. Dissolved oxygen introduced at bottling influenced sulfur dioxide decline during bottle storage, especially during the first three months. Closure oxygen transfer rate also influenced sulfur dioxide loss, and this effect became more important with time in the bottle. Although closure was an important factor influencing sensory attributes of bottled wine, within each closure dissolved oxygen accounted for significant differences across the wines. Wines bottled with high dissolved oxygen showed significantly higher ratings for oxidation, confirming the importance of oxygen management at bottling on wine evolution over time.

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Cluster Thinning Reduces the Economic Sustainability of Riesling Production

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Cluster thinning is practiced to reduce grapevine crop load and advance ripening parameters, such as Brix, which may or may not lead to higher quality wine. Cluster thinning is often implemented in the field with little or no specificity, and its practicality has been questioned because of increased production costs and

lost yields. New analytical methods were applied to a field study of Riesling grown in the Finger Lakes at three different crop levels (1, 1.5, and 2 clusters per shoot) over a three-year period. The results of wine sensory analysis showed that consumers were able to discern aromatic difference among wines made from varying crop levels. Economic analysis illustrated that grower financial net return per hectare was highest at the higher crop levels and that the only way financial losses associated with cluster thinning could be recouped would be from substantial increases in base market price for grapes.

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Effects of Ethanol, Tannin, and Fructose Concentrations on Sensory Properties of Model Red Wines

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The complex nature of interactions among wine constituents is thought to produce sensory and chemical changes in wine. The current study investigated the simultaneous effects of ethanol, tannin, and fructose and their interactions on the aroma, taste, flavor, and mouthfeel properties of wine. To our knowledge, there have been no published studies on the impact of these components on sensory properties of wines using a full-factorial experimental design. Using a trained sensory evaluation panel, the effect of ethanol (0, 8, 10, 12, 14, and 16% v/v), tannin (500, 1000, and 1500 mg/L), and fructose (200 and 2000 mg/L) on 20 sensory attributes of model wines was investigated. Analysis of variance showed few significant interaction effects and was dominated largely by the main effects. Generally, increase in ethanol concentration significantly affected ($p \leq 0.05$) the majority of the attributes by either increasing (chemical, woody, spicy aroma and flavor, bitter taste, burning sensation) or decreasing (fruity, floral, caramel aroma and flavor) perceived intensity. Similarly, tannin concentration induced significant effect on some ($p \leq 0.05$) but not all attributes. Increasing tannin concentration tended to increase woody aroma and flavor, bitter taste, and burning sensation and reduced fruity and spicy aroma and flavor. However, all of the sensory attributes were not significantly influenced by varying fructose concentration ($p > 0.05$), suggesting that this was the least important wine component among the studied variables. These findings provide further information to better understand the changes in the sensory properties of wines produced by modifications in wine components.

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Effect of Sunlight Exclusion at Different Phenological Stages on Anthocyanin Accumulation in Red Grape Clusters

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The influence of sunlight exclusion from grape clusters at different phenological stages on berry composition, especially anthocyanin accumulation in berry skin, was investigated. Sunlight was excluded from clusters at three different stages: fruit set to about 1 week preveraison, about 1 week preveraison to about 1 week postveraison, and about 1 week postveraison to maturity for the red grape cv. Jingxiu (*Vitis vinifera* L.) over two seasons and three cultivation conditions (in the field in 2011 and in the greenhouse and rain shelter in 2012). Sunlight exclusion at the different stages did not consistently affect berry weight, soluble solids content, or titratable acidity at maturity. However, sunlight exclusion from fruit set to 1 week preveraison consistently significantly increased anthocyanin content both at 1 week postveraison and at maturity, compared to the clusters exposed to sunlight throughout fruit development (control). Clusters with sunlight excluded from 1 week preveraison to 1 week postveraison accumulated less anthocyanins than control clusters at 1 week postveraison, while re-exposure to sunlight resulted in recovery of anthocyanin synthesis to a similar total content to control clusters at maturity. The absence of sunlight from 1 week postveraison to maturity did not significantly affect anthocyanin content compared to the control. The increase of anthocyanin content by sunlight exclusion from fruit set to 1 week preveraison might have a practical application for production of more anthocyanins in red grape berry skin.

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Regional Differentiation of New Zealand Pinot noir Wine by Wine Professionals Using Canonical Variate Analysis

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Pinot noir is the most widely planted red grape variety in New Zealand and is a premium wine product based on its retail price by volume. Wine commentators have noted differences in wines from different regions (Central Otago, Marlborough, Martinborough, and Waipara) in informal evaluations, but no scientifically rigorous evaluation has been undertaken to date. Descriptive analysis by untrained wine professionals in a statistically designed replicated trial found that Pinot noir from the four wine regions were differentiated according to aroma, in-mouth flavor,

and mouthfeel attributes. Marlborough wines were characterized with greater intensity of red cherry and raspberry aromas, greater red fruit in-mouth flavor, and greater balance and finish length mouthfeel. Martinborough wines were characterized with greater intensity of black cherry, oak, and spice aromas and greater oak tannins mouthfeel. Waipara wines were characterized by greater intensity of barnyard, herbal, and violet aromas and greater fruit density/concentration in-mouth flavor. Central Otago wines were intermediate between the other three regions. Additionally, it was found that the results were generally reliable and that untrained but experienced wine professionals could be used for sensory evaluations of this nature.

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Purification and Structural Characterization of a Type II Arabinogalactan-Protein from Champagne Wine

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Some arabinogalactan-proteins (AGPs) isolated from red wine have interesting physicochemical and sensory properties. An AGP was isolated from a Champagne wine by anion-exchange, affinity, and size-exclusion chromatography. Glycosyl residue analysis showed that it included arabinose (12.8%), galactose (68.5%), glucuronic acid (5.9%), and trace rhamnose (0.7%). The protein part of the AGP primarily contained hydroxyproline, serine, alanine, glutamic acid, and threonine. Methylation analysis revealed that the carbohydrate moiety of the glycoprotein had a highly branched structure. The Champagne AGP core consisted of 3-linked β -D-galactopyranose units carrying side chains of 6-linked β -D-galactopyranose, partly substituted in position 3 and 4 by L-arabinofuranosyl residues. Size-exclusion chromatography with multiangle laser light scattering of the Champagne AGP revealed apparent average molecular weight mass of 1.1×10^5 g/mol, characterized by a narrow polydispersity index (M_w/M_n 1.09), with a very low intrinsic viscosity ($[\eta] = 0.1$ dL/g).

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Impact of Malolactic Fermentation on the Color and Color Stability of Pinot noir and Merlot Wine

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Many factors can impact red wine color, but one area that has received little attention is the impact of malolactic fermentation (MLF). MLF is an integral step in red winemaking, and in this study, the impact of MLF on red wine color and the ability of *Oenococcus oeni* to degrade compounds important to the development of polymeric pigments were investigated. Pinot noir and Merlot wines were produced where a portion of the wines underwent simultaneous alcoholic and malolactic fermentations.

At dryness, all wines were pressed prior to sterile filtration, and wines that had not undergone malolactic fermentation (MLF-) were then either inoculated with one of three strains of *O. oeni* (MLF+) or pH-adjusted to the same pH as MLF+ wines. Malolactic fermentation resulted in a reduction in red color and polymeric pigment formation in Pinot noir and Merlot wines and a corresponding higher concentration of monomeric anthocyanins. Color loss was observed when alcoholic and malolactic fermentations were performed simultaneously and also when the MLF was conducted after the alcoholic fermentation. Color loss was independent of the pH change caused by MLF, and no differences among the three strains of *O. oeni* were observed. Strain *O. oeni* VFO demonstrated hydroxycinnamic acid esterase activity by converting caftaric acid to caffeic acid and coumaric acid to *p*-coumaric acid. This conversion did not impact color due to copigmentation as no differences were noted for this value between any of the wines that had or had not undergone MLF. Wines that underwent MLF contained lower concentrations of acetaldehyde and pyruvic acid than wines that did not undergo MLF, and this may explain the differences in polymeric pigment content as these compounds are involved in the formation of stable polymeric pigment compounds.

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Postveraison Application of Antitranspirant Di-1-*p*-Menthene to Control Sugar Accumulation in Sangiovese Grapevines

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Global warming is affecting the onset of phenological stages in the grapevine, and quite often ripening occurs much earlier than in the past. Too early ripening can be associated with too high alcohol and untypical flavor. The effectiveness of a postveraison application of the antitranspirant Vapor Gard (VG) was investigated as a technique to delay grape ripening and reduce sugar accumulation in the berry. VG was applied at 2% concentration to the upper two-thirds of the canopy and it significantly lowered leaf gas exchange. The study was carried out over the 2010-2011 seasons, and in both years, VG treatment reduced the pace of sugar accumulation in the berry as compared to control vines, scoring a -1.2 Brix at harvest and wine alcohol content at -1%. The application of VG at postveraison above the cluster zone is an effective, simple, and viable technique to hinder berry sugaring and obtain less alcoholic wines. To be effective, spraying should be performed at ~14 to 15 Brix, making sure that the lower leaf epidermis is fully wetted by the chemical. The application can be mechanized and combined with pest sprays to increase its economic sustainability.

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Application of a New Organic Yeast Immobilization Method for Sparkling Wine Production

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In traditional sparkling wine production, yeast lees removal is a labor-intensive and time-consuming process, and the use of immobilized yeasts has been investigated in order to reduce and simplify the riddling and disgorging procedures. The use of immobilized yeasts in bottle fermentation made it possible to decrease two-fold the area of production facilities and reduce the net cost of this stage by 80%. Yeast immobilization consists of the introduction into the bottle of a certain amount of beads containing cells. While the cells grow, they remain trapped in the beads and wine clarity is preserved. Immobilization supports suitable for the wine industry have prerequisites, such as food-grade purity, low cost, abundance, nondegradable nature, and suitability for low-temperature fermentation. This study examines the efficiency and effectiveness of a new immobilizing yeast format to produce sparkling wines by the traditional method. The innovative cell entrapment organic system, named biocapsules, was accomplished by the natural and spontaneous co-immobilization of a *Saccharomyces cerevisiae* strain and a filamentous fungus (*Penicillium chrysogenum*). The behavior of this immobilization method was compared with the activity of the same yeast strains in free cell format and immobilized in calcium alginate beads. Two *Saccharomyces cerevisiae* strains were used as starters and two different base wines were tested. This new immobilization system has shown good fermentation effectiveness and the resulting sparkling wine has a slightly better foam quality than batches made with free cells. Otherwise, no relevant differences in enological or sensory analyses were observed compared with traditional fermenting methods. The results suggest that biocapsules might be a low cost, natural, and suitable yeast immobilization method for sparkling wine production.

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Kinetics of Oxygen Ingress into Wine Bottles Closed with Natural Cork Stoppers of Different Qualities

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The contact between wine and oxygen is of critical importance for wine conservation and bottle aging processes. The sealing performance of closures is strictly related to their permeability properties. Cork, a natural cellular material, remains the most

used closure for quality wines. However, the natural variability of cork regarding its oxygen permeability has not been adequately measured because all previous studies had limited samplings for each type of closure. The time evolution of oxygen ingress into bottles closed with natural cork stoppers was investigated one year after bottling by a nondestructive colorimetric measurement method using the oxidation of an indigo carmine solution. The natural variability of cork was tested using a large sample of 600 natural cork stoppers from different quality classes and produced from corkboards of different thickness. Despite the variability of the absolute amount of oxygen entering the bottle, the kinetics of oxygen ingress was similar in all cases and could be adjusted to logarithmic models. There was a quick and high oxygen ingress in the first days after bottling, with an initial high rate, followed by decreasing rates during the first month and later on, until stabilizing at a low and rather constant ingress rate from the third to the twelfth month. Significant differences were found between stoppers produced from the thinner and thicker corkboards, suggesting that the variation of oxygen ingress is a consequence of the natural differences in the cell dimensions and air volume within the stopper. These results can be used to establish and characterize the sealing performance quality classes of cork stoppers regarding oxygen ingress.

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Use of Zirconium Dioxide during Fermentation as an Alternative to Protein Fining with Bentonite for White Wines

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White wines are commonly stabilized by removing the heat unstable proteins through adsorption by bentonite. Bentonite fining is not an efficient wine processing step and can also remove other wine components. Alternative absorbents are thus sought, and zirconium dioxide (zirconia) is recognized as a promising candidate. The aim of this project was to determine the effectiveness of zirconia when added during fermentation in removing proteins and its effect on fermentation rate and on the chemical parameters of the resulting wines. Zirconia in pellet form was enclosed in a metallic cage, added at 25 g/L rate to three fermenting juices (Riesling, Sauvignon blanc, and Semillon), and left in contact with the juice/wine for 3 days before being removed. This addition resulted in a great protein reduction, with the resulting wines being heat stable, thus confirming zirconia as a viable alternative to bentonite fining for protein removal from juice and wine. Its application during fermentation represents a significant improvement from a previously proposed use of zirconia in wine, since the 3 to 5 days of stirring required is replaced by natural mixing during fermentation. Other key advantages of using zir-

conia in fermentation are that the fermentation rate is increased and, most importantly, that the wines produced are fully heat stable with no loss of wine as lees, since the cage with the pellets can simply be removed and regenerated several times with the washing procedure proposed in previous research. The main drawback of using zirconia in fermentation is the high dosage required, but its ability to be regenerated reduces this negative aspect. In addition, since the protein removal was almost complete with two days of contact, it is likely that addition of lower dosages for longer times would represent a more feasible solution, so to allow the uptake and development of zirconia-based solutions for the wine industry.

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Simplified Method for Free SO₂ Measurement Using Gas Detection Tubes

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The aeration-oxidation (A-O) method is widely used for measurement of free sulfur dioxide (SO₂) in wines. We describe a modification to A-O which uses inexpensive SO₂ gas detection tubes developed for the mining industry in place of a receiver flask filled with peroxide solution. Samples are prepared in a similar fashion to A-O: a 20 mL wine sample is added to a flask and acidified with 10 mL 25% phosphoric acid. An antacid tablet is then added to the flask to evolve CO₂ in situ and the gas flow directed to a SO₂ gas detection tube. The length of tube that changes color is linearly proportional to the original free SO₂ concentration. The accuracy of the method was evaluated by measuring free SO₂ concentrations in 16 wines (seven whites, nine reds) using both the SO₂ tube method and an A-O reference method. Free SO₂ concentrations for individual wines measured by each method were within ± 2 mg/mL, indicating that the new method could achieve acceptable accuracy. The limit of detection of the SO₂ tube method was 3.3 mg/L in wine. The SO₂ tube method has several advantages over A-O, including requiring less time per analysis and no specialized glassware or equipment. The cost per analysis is roughly \$1.00 to 2.00 per sample, with the major consumable cost being the detection tubes. However, tubes can be conserved in exchange for precision by using smaller sample sizes.

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Indirect Evaluation of Microbial Spoiling Activity in Grape Marcs by Near-Infrared Spectroscopy

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Grappa is an alcoholic beverage produced in Italy from the distillation of grape marcs. Such material, composed mainly of skins and seeds that remain after grape crushing and removal of must, is conveyed from wineries to distilleries where it is stored in big piles for a period varying from a few to many weeks. Fermentations that take place during this period of storage produce ethanol and other volatile molecules that are then extracted and concentrated during the distillation process. The period preceding the arrival of marc to the distillery is crucial for the quality of this raw material, since microbial populations can grow rapidly, consuming sugars and producing ethanol that is lost in the atmosphere. In addition, the contact with oxygen can induce further microbial populations and oxidative reactions leading to production of molecules that can generate off-flavors in the distillate. The method presented in this work allows a rapid estimation of the levels of reducing sugars, ethanol, and acetic acid by samplings that can be done easily and rapidly by a portable NIRS instrument endowed with a wired probe that can be repeatedly inserted in many points of the marc mass. This method allows a rapid evaluation of the grape marc when it arrives at the distillery, allowing operators to determine its microbial deterioration and thus make the most appropriate decision regarding its technological transformation.

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Effect of pH and Alcohol on Perception of Phenolic Character in White Wine

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Winemakers have recently shown a greater interest in incorporating phenolics into their white wines in an attempt to produce more “textural” wines. What tastes and textures do phenolics contribute to white wines, and how does wine pH and alcohol influence these? This research demonstrates that in addition to contributing to astringency and bitterness, white wine phenolics also contribute to perceived viscosity and hotness. Phenolics contributed more to these tastes and textures when alcohol levels were lower, probably resulting from alcohol's direct contribution to these or similar tastes and textures. Phenolics had less of an effect on the astringency of low pH wines compared with those of moderate pH. Whether these textural dimensions afforded by phenolics are desirable is dependent on wine style and individual taste preferences. However, greater textural diversity resulting from higher phenolics was less apparent in higher alcohol wines.

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Seasonal and Regional Variation of Green Aroma Compounds in Commercial Vineyards of *Vitis vinifera* L. Merlot in California

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A field study was conducted from 2007 to 2010 to look at regional and seasonal variability of the main compounds responsible for green aromas in grapes and wines: 3-isobutyl-2-methoxypyrazine (IBMP) and C₆ compounds. Sixty-nine commercial *Vitis vinifera* L. Merlot vineyards located in three distinctly different winegrape growing regions within the Central Valley of California were sampled at commercial harvest; fruit samples were analyzed for green aromas and standard chemometrics and various weather parameters such as growing degree days and rainfall. Seasonal variation was found to be more important than regional variation, but similar trends among regions were found within each season. In contrast to previous findings, cool growing conditions did not necessarily equate to higher levels of fruit green aromas at harvest. Instead, warm regions and warm seasons showed a tendency toward fruit with increased levels of IBMP and C₆ compounds at harvest. Rainfall during the dormant season was also associated with levels of green aromas at harvest, but contrary to common belief, the driest season recorded the highest levels of green aromas at harvest. This was attributed to an earlier irrigation start date and a higher volume of water applied during the spring. These results suggest that temperature during the spring, a period of active growth, is likely the most influential driver of fruit green aromas, probably due to a positive interaction with vine vigor and therefore fruit shading.

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Influence of Fruit Maturity, Maceration Length, and Ethanol Amount on Chemical and Sensory Properties of Merlot Wines

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The purpose of these experiments was to evaluate the impact of grape maturity on winemaking practices, with an emphasis on how seed maturity influences extraction of seed tannins. The experiment used higher ethanol concentrations and extended maceration to evaluate the extraction of seed tannins and was conducted over two seasons in the field and winery with one vintage of wine sensory. Merlot grapes were harvested with ~20.3 and ~24.9 Brix over two seasons 33 days (2011) and 34 days apart (2012) to achieve the target Brix. Half of the low Brix musts and half of the high Brix musts were adjusted before fermentation to

emulate the Brix of the other harvest. Each of the adjusted musts were additionally subjected to 10 days (control wines) and to 30 days (EM wines) of skin contact to evaluate the chemical and sensory effects of grape maturity and different EtOH concentrations under two contrasting maceration protocols. Control wines had significantly higher anthocyanin content, saturation, and red color component, whereas EM wines had enhanced tannin extraction from seeds, lower anthocyanin content, lower saturation, higher hue, and higher large polymeric pigment content. EtOH differences up to 2.7% (v/v) showed no significant effect on tannin and anthocyanin extraction, suggesting a minor role of this solvent under standard winemaking conditions. We also found that tannin extraction during extended maceration is independent of maturity and EtOH concentration for a single season, but may vary seasonally. Extrapolation of these results in Merlot to commercial practices such as delaying harvest to achieve seed browning suggests that the visual ripeness of seeds may be a relatively lesser factor affecting tannin extraction during maceration. Sensory evaluation of wine found significant differences, and, interestingly, ethanol from chaptalization and increased grape maturity removed veggie aromas, suggesting that within the range studied (~12 to 14.4%), ethanol had a significant positive impact on the sensory profile of the final wines.

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Determining the Methoxypyrazine Biosynthesis Variables Affected by Light Exposure and Crop Level in Cabernet Sauvignon

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Methoxypyrazines are sensorially potent volatile compounds responsible for herbaceous/vegetal attributes in wines made from certain grape varieties. The biosynthesis of these compounds in grape berries is known to occur via a pathway that involves the methylation of hydroxypyrazine intermediates. Certain viticultural management regimes can be used to alter methoxypyrazine concentrations in the fruit of those varieties that have the genetic capability of producing them. This study explored the effect of light exposure and crop level on 3-isobutyl-2-methoxypyrazine (IBMP) concentrations in Cabernet Sauvignon fruit to better understand the effect of these variables on the concentration of the precursor 3-isobutyl-2-hydroxypyrazine (IBHP) and the expression of a methyltransferase gene (*VvOMT3*) responsible for the final step in methoxypyrazine biosynthesis. Light was found to reduce the expression of *VvOMT3* and the concentration of IBHP, suggesting that a combination of these factors reduces IBMP concentration when fruit has greater light exposure. In contrast, reducing the crop level of vines to less than half of that of controls did not have a significant effect on IBHP concentration or *VvOMT3* expression, despite the treatment causing a significant increase in IBMP concentration. IBMP appears to be synthesized in the flesh of the berry, which suggests that differences in berry size may explain the crop level effect on IBMP concentrations.

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Increasing Bioactive Phenolic Compounds in Grapes: Response of Six Monastrell Grape Clones to Benzothiadiazole and Methyl Jasmonate Treatments

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Grapes are one of the most important sources of polyphenols for humans through their consumption as fresh fruit or in red wines. In the effort to find mechanisms for improving the phenolic content of grapes, the results obtained using elicitors, phytochemicals primarily designed to improve plant pathogen resistance, has opened a novel field of interest. Elicitors do not kill pathogens themselves but trigger the mechanisms that plants possess to improve pathogen resistance; among them, an increase in the levels of phenolic compounds. However, studies have shown that the exact response of plants to elicitors depends both on the variety and clone. In the present study, two different elicitors (benzothiadiazole and methyl jasmonate) were applied in a vineyard where a collection of the six selected clones of Monastrell grape variety were planted to determine whether any observed effect is clone-dependent. The analysis of anthocyanins, flavonols, stilbenes, and seed and skin tannins showed that, in general, both elicitors increased the levels of phenolic compounds in the treated plants, although the extent of the response differed among the different clones. This general improvement of phenolic compounds in treated grapes indicated that such treatments could be an interesting tool for improving grape and wine color while also increasing resistance to some microorganisms. However, a preliminary exploratory study should be made since the extent of the observed response may vary between clones from the same variety and also between campaigns, since clone-environment interactions may also exist.

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Morphological, Physiological, and Biochemical Changes in *Vitis* Genotypes in Response to Photoperiod Regimes

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The purpose of this study was to identify morphological, physiological, and biochemical changes in *Vitis* genotypes in response to photoperiod regimes. Experiments were conducted under greenhouse conditions using cold-sensitive Cabernet franc (*Vitis vinifera*) and cold-tolerant Couderc 3309 (3309C, *V. riparia* x *V. rupestris*) and Concord (*V. labruscana*). Potted vines were exposed to short day (SD) (8 hr) or long day (LD) (16 hr) for 4, 6, and 8 weeks. Shoot growth, periderm formation, dormancy, freezing tolerance (lethal temperature that kills 50% of primary buds:

LT50), and soluble sugar concentrations in leaf and bud tissues were examined. Shoot growth slowed in all cultivars under SD, accompanied with increased periderm formation and dormancy depth. Concord initiated these changes first, followed by 3309C, then Cabernet franc. The three cultivars did not show differences in freezing tolerance under LD, with LT50 ranging between -6.1 and -8.1°C. However, freezing tolerance increased by 0.7, 2.0, and 2.7°C after 4, 6, and 8 weeks under SD, respectively. Freezing tolerance of Concord increased after 4 weeks of SD treatment, whereas that of 3309C and Cabernet franc did not increase until after 6 weeks of SD treatment. Among all sugars, raffinose had distinctive responses associated with photoperiod, remaining low and similar (0.5 to 2.3 mg/g dry weight) under LD. Under SD, raffinose concentration was generally higher, ranging from 2.2 to 5.7 mg/g dry weight in leaves and 1.6 to 3.7 mg/g dry weight in buds, with cold-tolerant 3309C and Concord accumulating higher concentrations compared to cold-sensitive Cabernet franc. These results suggest that raffinose accumulation might be an early step in response to photoperiod coinciding with slowed shoot growth, the induction of endodormancy, and the initial acquisition of freezing tolerance.

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Pulsed Electric Field-Assisted Cold Maceration of Cabernet franc and Cabernet Sauvignon Grapes

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The effect of pulsed electric field (PEF) treatment on the cold maceration (6 days at 6°C) of Cabernet franc (CF) and Cabernet Sauvignon (CS) grapes was investigated. The qualitative parameters of extracts (pH, Brix, color intensity), their anthocyanin and total polyphenol content, and free radical scavenging activity were determined during the whole period of cold maceration. The high PEF treatment (5 kV/cm, 1 ms, 48 kJ/kg) significantly enhanced extraction of flavonoid components (quercetin 3- β -D-glucoside and epicatechin gallate) after the cold maceration of red grapes. Such PEF treatment also enhanced the color intensity of the grapes (75% for CF and 68% for CS) and increased the anthocyanin content of the extract (from 87 to 172 mg/L for CF and from 168 to 269 mg/L for CS). The moderate PEF treatments (400 and 800 V/cm, duration 50-100 ms) were less effective for polyphenol extraction but consumed less energy (3 to 40 kJ/kg). The wines obtained from PEF-treated Cabernet franc and Cabernet Sauvignon grapes had higher phenolic content and color intensity during the alcoholic fermentation period than wines obtained from the untreated grapes.

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Preharvest Prediction of Yeast Assimilable Nitrogen in Finger Lakes Riesling Using Linear and Multivariate Modeling

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Wine yeast requires nitrogen to efficiently convert sugars into alcohol during primary fermentation. Often the yeast assimilable nitrogen (YAN) of must is limited, but testing requires specialized equipment or the inconvenience of waiting for results from external labs. Subsequently, winemakers often add supplemental nitrogen prophylactically without must analysis. This study was conducted to determine whether early YAN values can be used to predict YAN at harvest, allowing winemakers to send samples for testing at external laboratories and have results before harvest. A survey of 62 Riesling vineyards in the Finger Lakes region of New York State was made at three time points: veraison, two weeks prior to harvest, and harvest. Three types of regression models were used to develop an equation that winemakers could use to predict harvest YAN from their own preharvest numbers. The simplest model used only preharvest ammonia nitrogen (AMM) measurements and had a cross-validated R^2 (Q^2) of 63.26%, while the model using preharvest YAN had improved prediction power (Q^2 = 69.51). More complicated models required more data input but had increased accuracy; the best regression model had a Q^2 of 73.57% and included six terms (veraison AMM, preharvest YAN, preharvest TA, preharvest pH, harvest TA, and harvest pH), and the partial least squares regression model with the best cross-validated regression coefficient (Q^2 = 74.18) also included six terms (preharvest pH, preharvest TA, preharvest AMM, preharvest YAN, harvest pH, and harvest TA). Use of any of these prediction models will allow winemakers to more closely estimate YAN at harvest, resulting in more accurate additions of supplemental nitrogen and avoiding excesses that may result from prophylactic additions.

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Cold-Active Acid Pectinolytic System from Psychrotolerant *Bacillus*: Color Extraction from Red Grape Skin

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Pectinases are enzymatic systems able to break down pectic polymers of grape skin cell walls. In the winemaking process, pectinases yield considerable benefits: faster fermentation start, higher must yield, easier pressing, quicker and more complete clarification, and an enhanced extraction of aromatic and polyphenol compounds from grape skins. This work focuses on polyphenols extraction by pectinases from red grape skins. Some of these polyphenols, anthocyanins, are the pigments responsible for the color

of red wines. The grape skin cell wall constitutes a barrier to diffusion of polyphenols. However, permeability to these compounds can be increased by partial hydrolysis of their structural polysaccharides (like pectin), a process that can be facilitated by maceration enzymes, as pectinases. Enological pectinases are enzymatic preparations with high pectinolytic activity and they are obtained mainly from fungi. However, the *Bacillus* genus is a great producer of exocellular substances, such as pectinases. In addition, these bacterial strains produce pectinases in shorter time and with lower production costs than fungi. Therefore, the aims of the current study were (1) to characterize the pectinolytic system produced by a *Bacillus* sp. strain and (2) to evaluate its effect on the extraction of pigments and total polyphenols from red grape skins in a short maceration at low temperature in order to examine its potential as a cold-active acidic pectinase source. The bacterial pectinolytic system showed significant enzymatic activity at acidic pH and low temperature (20°C), conditions similar to those in vinification processes with low maceration temperatures. According to results obtained after short macerations, the bacterial pectinolytic system allowed a rapid extraction of anthocyanin compounds, resulting in musts with better chromatic characteristics than those obtained with commercial pectinases. Consequently, the use of this “cold-active” pectinolytic preparation compensates the limited color extraction in macerations of red grape skins conducted at low temperature. Further experiments under real vinification conditions are currently being carried out to confirm these effects and to propose the potential use of this pectinolytic preparation to improve color extraction in red winemaking at low temperature. Considering the advantages of *Bacillus* strains over fungi with respect to the enzymatic production at industrial scale and the results obtained in the present study, *Bacillus* sp. CH15 could be an alternative microbial source of cold-active acidic pectinases for potential use in red winemaking.

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Sensory Impact of Extended Maceration and Regulated Deficit Irrigation on Washington State Cabernet Sauvignon Wines

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The sensory effects of extended maceration and four different regulated deficit irrigation (RDI) treatments and some of their interactive effects were studied under winemaking conditions comparable to those of a commercial scale. While the application of the different RDI treatments primarily produced differences in color, astringency, and bitterness in the resulting wines, the effect of the two contrasting maceration treatments affected all

sensory attributes. Thus, under our experimental conditions, the maceration treatments had a comparatively higher impact than the RDI treatments in the sensory and chemical profile of the wines. Chromatic attributes were significant in the 25% ET_c control treatment and were also highly correlated with the flavonol and anthocyanin derivatives and small polymeric pigments. Red and black fruit aroma attributes were favored in the controls of the 70% ET_c and 25/100% ET_c treatments. These results suggest that moderate RDI protocols such as 70% ET_c and 25/100% ET_c positively impact the fruity component of wine aroma, possibly by favoring accumulation of norisoprenoids, whereas more severe RDI protocols such as 25% ET_c increased perceived color saturation, astringency, and bitterness. Extended maceration resulted in wines with comparatively lower fruit-based aromas and perceived wine color saturation, but enhanced the perception of bitterness and astringency, with the latter possibly arising from the concurrent effect of a high concentration of flavan-3-ols and oligomeric proanthocyanidins in these wines. Thus, the application of extended maceration for 30 days or more appears to have limited merit as a winemaking practice. If wines with high tannin content are sought for stylistic or blending purposes, practices such as prefermentation runoff (saignée) would be a more rational option in light of optimizing winery logistics.

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Cover Crops and Tillage in a Mature Merlot Vineyard Show Few Effects on Grapevines

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Permanent cover crops are commonly used in vineyard floor management because of their beneficial effects to soil and vine health, but studies evaluating their competitive effects on vines have been conducted primarily in nonirrigated vineyards. Future air quality regulations could mandate the use of no-till floor management practices in California's Central Valley. We evaluated the combined effects of cover crop type (oats alone or oats grown with legumes) and tillage on soil nutrient availability, vine nutrition, growth, yield, and juice characteristics of *Vitis vinifera* cv. Merlot grown under regulated deficit irrigation in a commercial vineyard from 2008–2010. Cover crops combined with tilled or no-till treatments had little effect on grapevine growth and nutrition. In this case, grapevine responses suggest that annual variability in climate and vine balance influenced vine attributes more than cover crop and tillage treatments, at least in the initial three years of the study.

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Cover Crop Water Use in Relation to Vineyard Floor Management Practices

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A trial was conducted in a 2-year-old Sangiovese (*Vitis vinifera* L.) vineyard to compare soil evaporation (E_s) versus cover crop (*Festuca arundinacea* var. barfelim) evapotranspiration (E_{cc}) and to investigate the effect of mowing in reducing cover crop E_{cc} , and, hence, its below-ground competitiveness. Our study showed that E_s and E_{cc} were similar after a rainfall event when the soil surface was wet. When the shallow soil layers dried out, E_s dropped quickly, becoming 35 and 48% lower than mowed and unmowed cover crop E_{cc} , respectively. Our results showed that mowing was effective at reducing E_{cc} . Immediately after mowing, the percentage of E_{cc} reduction ranged from 35 to 49%, depending on the amount of clipped biomass. Thus, under our experimental conditions, including nonlimiting soil water, mowing was not a viable alternative to bare soil management practices as a means to reduce ground water loss. However, an accurate scheduling of mowing frequency and timing could be used as a short-term soil water conservation technique during summer periods of decreased water availability.

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Increase in Cytokinin Levels during Ripening in Developing *Vitis vinifera* cv. Shiraz Berries

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Grape berry development and the response of berries to their environment are largely controlled by the action of plant hormones. Understanding which hormones are present in developing grape berries, at what times and at what levels, is an important step toward better understanding berry development. This knowledge is essential to efforts to manipulate berry development in ways useful to the grape industries. This paper describes the quantification of the plant hormones abscisic acid (ABA) and its metabolites and a range of cytokinins and gibberellic acid species in the same grape (*Vitis vinifera* L.) berry pericarp (skin plus flesh) developmental series. ABA has been implicated in the response to stress and is seen as a positive regulator of berry ripening while gibberellic acids are involved in berry growth. The biologically active gibberellic acids 4 and 7 (along with precursor and inactive forms) were present before veraison, during the period of cell division and expansion, but at very low concentrations after veraison.

ABA levels, in line with the proposed role of ABA in ripening, increased at veraison and peaked shortly afterward. The analysis of the concentrations of certain cytokinins provided some previously unreported and surprising results, as the concentration of one cytokinin species, isopentenyladenine, increased rapidly at veraison and remained at elevated levels throughout ripening. The reason for this phenomenon is unknown, but a similar increase in the concentrations of some cytokinins has recently been observed during kiwifruit development. The accumulation of a cytokinin during berry ripening suggests it has a role in controlling berry development. Possible roles for the observed increase in cytokinin levels include the control of sugar accumulation, berry expansion, and tissue aging. Controlling these processes is important to the berry, and changes to any of these processes would have important impacts on berry composition.

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Characterization of Selected Organic and Mineral Components of Qvevri Wines

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Traditional winemaking in qvevris (amphora-like clay vessels) is one of the oldest known methods of wine production, originating in the current territories of Georgia. The organic and mineral components of 20 qvevri wines from selected wineries throughout Europe were evaluated to gain insight into this method of wine production. Important chemical parameters for assessing wine quality such as pH, residual glucose, acidity (titratable acidity), specific organic acids (acetic, lactic, malic, and tartaric acids), phenolics (total phenolics and anthocyanins in red wines), total antioxidants, and selected minerals (phosphorus, calcium, magnesium, manganese, potassium, and zinc) were measured in each sample. The data were also compared with previously reported values for conventional wines. Qvevri wines were less acidic than conventional wines, containing higher levels of acetic and lactic acids but lower levels of tartaric acid. They also contained higher levels of antioxidants and total phenolics, the latter being up to 10 times more abundant in the white wine varieties than in conventional wines. Despite fermentation in clay vessels, the mineral content of qvevri wines was within the normal reported range, although the levels of phosphorus were slightly higher. This is one of only a few studies that have considered the compositional nature of qvevri wines.

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Genetic Identification and Origin of Grapevine Cultivars (*Vitis vinifera* L.) in Tunisia

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Nine DNA markers were used to characterize 35 wild grapevines (*Vitis vinifera* subsp. *sylvestris*) prospected from northwestern Tunisia and 64 cultivated accessions (*Vitis vinifera* subsp. *vinifera*) maintained in the repository of the Arid Land Institute of Medenine (Tunisia). All the analyzed DNA markers were found to be informative and revealed 62 distinct genotypes, including 31 cultivated accessions and 31 wild ones. Some cases of synonymies (different names for the same cultivar), color sports, and homonymies (same name for different cultivars) were detected. Some matches were found with previously analyzed Tunisian samples and with international cultivars, allowing verification of cultivars or establishment of new synonyms. The analysis of the chloroplast genome gave clues to the origin of the grapevines. Chlorotype A (typical of southwestern Europe) was most abundant in wild samples (65%), whereas chlorotypes C and D (common in the Near East) were more frequent in cultivated genotypes (45% and 23% respectively). DNA analysis of Tunisian wild and cultivated accessions showed that both sets of samples maintain high levels of genetic variation, but there has been a low gene flow between cultivated and wild forms. Thus, most cultivated accessions do not derive directly from the local wild populations but could correspond to materials introduced from different locations during historical times or derived from spontaneous hybridizations among them. However, we could not discard the hypothesis that a few analyzed samples, such as Bezzoul Kalba Bidha or E Rways-siya 3, could arise from hybridization events between wild and cultivated grapevines.

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Earthy and Fresh Mushroom Off-Flavors in Wine: Optimized Remedial Treatments

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Geosmin and 1-octen-3-one are the causal agents of earthy-muddy and fresh mushroom off-flavors. Several products are available to remove these off-flavors and are commonly used at different steps of winemaking for various applications. This research evaluated and compared the efficiencies of those commercial products, including activated carbons, chitosans, zeolites, and filtrations, on white wine. Several formulations of activated carbon provided good efficiencies for geosmin removal, as well as a filtration dedicated to off-flavor removal. On the other hand, chitosans and zeolites were generally not able to reach a satisfactory level. Activated carbons were also able to reduce the concentration of 1-octen-3-one.

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