Technical Abstracts

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Technical Abstracts

NOTE: Pages 1-43 constituted the program section of the original printed Program and Technical Abstracts Booklet.

Abstracts are listed in the approximate presentation order as scheduled in the conference program.

2025 Alpha Listing of All Authors with Submitted Abstracts

Wednesday National Conference Oral Presentation Abstracts (Research Papers)

Enology – Wine Chemistry and Phenolic Analysis Session

Effects of Contrasting Cap Management on ORP, Phenolic, and Volatile Outcomes in Pinot noir and Petite Sirah Wines

Dallas Parnigoni, Federico Casassa,* Sean Kuster, Bob Coleman, James Nelson and Jesus Villalobos
*Wine and Viticulture Department - Cal Poly San Luis Obispo, 1 Grand avenue , San Luis Obispo, CA, 93407, (lcasassa@calpoly.edu)

Pinot noir and Petite Sirah wines were produced using five and six cap management protocols: punch-downs (PD, twice daily); pump-overs (PO, two full volumes, twice daily); and gas mixing executed by gas injections into must: air mixing (AirMix, 1 hr, twice daily), nitrogen mixing (N_2Mix; 1 hr, twice daily); ORP-control through air additions (ORPConAir; 10-sec air when ORP < -40 mV); and in Pinot noir only, simultaneous N_2 additions coinciding with ORPConAir (ORPConN_2; 10-sec N_2). Oxidation-reduction potential (ORP), reduced glutathione (GSH), and oxidized glutathione (GSSG) were monitored throughout a 10-day alcoholic fermentation. In both varietals, average ORP values were similar between PD and PO wines; however, PO wines exhibited peaks ≥100 mV during pump-overs, while PD wines maintained a negative ORP at peak fermentation, even during punch-downs. At pressing, N_2Mix wines showed GSH:GSSG ratios of 6.6:1 and 5.0:1, while PD wines showed ratios of 0.7:1 and 1.3:1 in Pinot noir and Petite Sirah, respectively. At pressing, there were no differences in anthocyanin or tannin in any treatment other than AirMix wines in either varietal. Alternatively, AirMix wines showed reductions in total phenolics at pressing of 21% and 30% compared to PD wines in Pinot noir and Petite Sirah, respectively. Compared to PO wines, PD wines had increased flavan-3-ols by 48% and 8% in Pinot noir and Petite Sirah, respectively. Ethyl n-octanoate had the greatest odor activity values (OAV) in all treatments of Pinot noir, ranging from 147 (PO) to 116 (AirMix), while isoamyl acetate was most odorous in Petite Sirah, ranging in OAV from 248 (ORPConAir) to 120 (AirMix). These cap management protocols produced unique ORP evolutions, influenced GSH:GSSG ratios, and differentially affected phenolic and volatile composition, with consistent trends despite varietal differences.

Funding Support: GALLO

In-line Monitoring of the Winemaking Process: Redox Variables and Antioxidant Power

Giona Lo Parrino, Alessandro Tonelli, Giuseppe Floridia and **Valentina Canuti***
*DAGRI - Department of Agricultural, Food, Environmental, and Forestry Sciences and Technologies - University of Florence, via Donizetti, 6, Firenze - 50144, Italy, (valentina.canuti@unifi.it)

In-line monitoring of the winemaking process with a limited number of variables remains a current challenge in wine research, aiming to provide rapid assessment of wine stability, oxidizability, and precise dosing of additives or adjuvants. Two key variables related to wine redox status are redox potential (ORP) and antioxidant power (AP), poorly monitored during wine production due to the complexity of oxidation phenomena, the difficulty of performing current AP assessment tests directly in the winery, and the challenges in measuring and interpreting ORP. This study applied a rapid AP test, the wine antioxidant test (WAT, based on Fe^{3+}/Fe^{2+}), and an in-line multiparameter system for monitoring temperature, ORP, and dissolved oxygen (DO) during fermentation/maceration of Sangiovese red grapes (at 25°C, with replications), to understand the correlation between these variables and propose a new approach for in-line assessment of wine production. ORP and

**indicates corresponding author*

Enology – Wine Chemistry and Phenolic Analysis Session
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DO were measured continuously with probes, while WAT and DPPH were measured daily. Wine color and polyphenol content were analyzed using spectrophotometric indices, CIELab, and high-performance liquid chromatography-diode array detection. ORP was able to describe the evolution of alcoholic fermentation and polyphenol extraction, for the experimental condition applied. All parameters monitored during fermentation/maceration were used to create a predictive model for the AP measured by WAT (R^2 0.97 for the calibration model and R^2 0.76 for the validation model). In particular, WAT results correlated directly with wine polyphenol content, DPPH, and polymeric pigments, and indirectly with ORP. ORP, in turn, correlated with monomeric anthocyanins (R^2 0.9013), polymeric pigments (R^2 0.9013), DPPH (R^2 -0.8210), and DO (R^2 0.9759). This study opens new avenues for research in the field of precision enology, supporting the development of in-line winemaking control.

Funding Support: none

Improved Red Wine Color Stability by the Prefermetation Addition of an Innovative Pomegranate Peel-Derived Tannin

Silvia D'Agostino,* Lorenzo Cecchi, Valentina Civa, Lapo Pierguidi, Bruno Zanoni and Valentina Canuti
*University of Florence, Via Gaetano Donizetti, 6, 50144, Firenze, Italy, Florence/50144, Italy, (silvia.dagostino@unifi.it)

Enological tannins are a class of coadjuvants employed in winemaking for their beneficial effects on must clarification, color, and mouthfeel sensations, while preventing oxidation. These polyphenol-rich extracts are regulated by the International Organization of Vine and Wine, which allows using tannins only from nutgalls, wood, and grape seeds and skins. However, growing attention to sustainability in the wine sector has prompted exploration of by-products from the food industry. Pomegranate peels, an important food industry by-product with ~ 0% discarded biomass of the fruit weight, can be valorized by extracting the tannin fraction for application in winemaking. Under the hypothesis that the unique chemical structure of pomegranate peel hydrolysable tannins, characterized by the gallagyl group, could be effective in preventing oxidation and stabilizing wine color, an innovative extraction method has been developed. Vinification of Sangiovese grapes was carried out, in which the addition of pomegranate peel tannin (PPT) was compared to the addition of nutgall tannin (NGT) and oak-derived tannin (ODT) and to a control (CON), with dosages adjusted according to the purity of the extracts. Polyphenol content, antioxidant activity, color indices, CIELab values, and sensory analysis were conducted at racking, after malolactic fermentation, and 6 mo after bottling. The results highlighted a significantly higher polyphenols content in PPT wines compared to the other treatments, resulting in an increased antioxidant activity comparable to NGT wines. The most notable effects were observed in color parameters: PPT wines had the statistically highest color intensity and presence of polymerized anthocyanins. Surprisingly, the addition of PPT led to significant reduction of wine bitterness. The study provided new practical insights on the advantages in using PPT in winemaking, strongly suggesting the possibility of extending the sources for recovery of effective enological tannins, while applying the principles of circular economy.

Funding Support: University of Florence

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Enology – Wine Chemistry and Phenolic Analysis Session

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Wine Nucleophiles Expedite Structural Changes in Wine Tannins, Reducing Astringency and Altering Phenolic Composition

Danielle Fox, P. Layton Ashmore, Andrew L. Waterhouse and James F. Harbertson*
*Washington State University, 359 University Dr., Richland, WA, 99354, (jfharbertson@wsu.edu)

To understand how tannin structural changes that occur during aging affect wine sensory and chemical composition, a full-factorial design experiment was carried out by adding either an oxidative adjuvant (acetaldehyde) or two reductive adjuvants (sulfur dioxide and glutathione) to Cabernet Sauvignon and Petite Verdot wines adjusted to four pHs (pH 3.25, 3.50, 3.75, and 4.0). The wines were fermented in the fall of 2022, and the adjuvants were added midway through 2023, post-ion exchange, and tracked chemically for 1.5 yr. Descriptive analysis and time intensity analysis were performed a year after the additions on a subset of the wines (pH 3.25, 3.75 Petite Verdot). Chemically, the oxidative treatment strongly depended on pH and primarily affected the color components (anthocyanins and polymeric pigments, both small and large), while the addition of reductive adjuvants was not pH dependent. Due to the Cabernet Sauvignon wine having very low concentrations of both tannins (<300 mg/L) and anthocyanins (0 to 350 mg/L), the trends for polymeric pigment formation and changes in tannin were obscured compared to the Petite Verdot wine, which was rich in tannins (~800 to 1200 mg/L) and anthocyanins (200 to 800 mg/L). Acetaldehyde-treated wine reduced anthocyanins over time, while sulfur dioxide preserved anthocyanins to the extent that they exceeded the control at the end of the study. Glutathione significantly reduced the tannin concentration of the wine. Generally polymeric pigments declined over time and were highest in the acetaldehyde-treated wines, but their change was strongly dependent on pH and treatment. Multifactor analysis combining sensorial and chemical analysis showed that the wines were primarily separated by treatment. The glutathione-treated wines were inversely related to astringency and tannin concentration. Aroma characteristics were only affected by the sulfur dioxide treatment, which were related to the baking spice and earthy ortho-nasal attributes.

Funding Support: Washington Wine Commission, Washington Wine Grape Funds

*indicates corresponding author

Enology – Wine Chemistry and Phenolic Analysis Session
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Application of Tannin Fragmentation Fingerprint: A Rapid LC-MS/MS Approach for Structural Profiling and Quantification

Yanxin Lin, Robert (Sui) Qiang, Misha Kwasniewski* and Bruce Pan
*Food Science Department, Penn State University, Penn State University, Rodney A. Erickson Food Science Building, State College, PA, 16803, (mtk5407@psu.edu)

Wine tannins are categorized into condensed tannins (CTs) from grape skins and seeds and hydrolysable tannins (HTs), including ellagitannins (ETs) and gallotannins (GTs), predominantly introduced through oak aging and tannin additives. Both tannin types influence mouthfeel, astringency, and aging potential. However, traditional analytical methods often fail to correlate with perceived astringency and biological activity, particularly in wines with subtle tannin composition differences. This limitation arises because assays such as Folin-Ciocalteu and tannin affinity precipitation provide simplified total phenolic or tannin values, without accounting for structural diversity and polymerization variability. To address these challenges, we developed tannin fragmentation fingerprinting (TFF), an LC-MS/MS method using electrospray ionization in-source fragmentation. This technique enables detailed structural characterization of both CTs and HTs by depolymerizing tannins in the ion source and analyzing their subunit-specific fragmentation spectra. TFF has demonstrated superior analytical capabilities over conventional methods. For CTs, TFF distinguished Noiret wines from the 2022 vintage, with and without exogenous tannin additions (control versus exogenous tannin addition). While traditional methods suggested negligible effect on CT composition, TFF revealed clear separation via principal component analysis and a measurable increase in CT concentration, likely due to the enrichment of specific A-type procyanidins. For HTs, TFF has been optimized for high-throughput quantification, significantly reducing analysis time compared to the previous acid hydrolysis method, while providing precise differentiation between ETs and galloylated tannins (i.e., GTs and galloylated CTs). Analysis of 15 commercial oak products from three regions and five toasting levels showed that French oak had higher ET and GT concentrations than Hungarian and American oak, with higher toasting levels reducing both contents. This advancement enables oak product profiling, aging regime monitoring, and product authenticity verification, and has already been adopted by industry stakeholders for reliable data delivery.

Funding Support: None

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2025 NATIONAL CONFERENCE TECHNICAL ABSTRACTS

Viticulture – Management and Mitigation of Impacts from Grapevine Red Blotch Virus Session

Time Since Grapevine Red Blotch Virus Infection Affects the Extent of Grapevine Red Blotch Disease on Grapes and Wine in *Vitis vinifera* Merlot

Raul Cauduro Girardello,* Cristina Medina-Plaza, Arpa Boghozian, Lik Xian Lim, Catherine Rout, Morgan Rosenberg, Anji Perry, Teresa Erickson, Cristian Olaya, Mysore R Sudarshana and Anita Oberholster
*University of California, Davis, One Shields Avenue, Davis, CA, 95616, (rgirardello@ucdavis.edu)

The impact of grapevine red blotch virus (GRBV) on grape and wine quality is of great concern in the United States. Our research group has demonstrated that grapes infected with GRBV are lower in sugar and anthocyanin concentration when compared with those from GRBV-free grapevines, resulting in wines negatively affected chemically and sensorially. In addition, it was demonstrated that both season and grape variety play an important role in GRBV impacts in grapes and wines. The virus infection is not curable and grapegrowers' first option is generally rouging the infected vines once symptoms are visible to avoid virus spread, as well as to obtain only high-quality grapes in the vineyard. However, it is not known if the time since the grapevine is infected can influence the impact of the disease. This study evaluates the impact of GRBV during multiple years since its infection. Grape berries from *Vitis vinifera* L. Merlot grapevines infected by GRBV in 2016, 2019, 2020, and 2021 were harvested in 2021 in a commercial vineyard in Paso Robles, CA at maturity and analyzed for chemical (total soluble solids [TSS], pH, titratable acidity [TA]) and phenolic composition by reversed-phase high-performance liquid chromatography (RP-HPLC). Wines were made in triplicate using standard winemaking protocols at the Experimental Winery at UC Davis and analyzed for basic chemical composition as well as for phenolic and volatile compounds by RP-HPLC and headspace solid-phase microextraction gas chromatography-mass spectrometry, respectively. Descriptive analyses evaluated wine sensory attributes. Grape composition analysis at harvest (TSS, pH, and TA) demonstrated that the time since virus infection did not affect GRBV's negative impact, except for yeast assimilable nitrogen. However, wine composition was substantially affected, depending on how long the grapevines had been infected by GRBV, especially phenolic and volatile composition. Descriptive analysis also demonstrated that panelists could distinguish wines based on the year of infection.

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Spray-Induced Gene Silencing as a Strategy for Grapevine Red Blotch Virus Control

Christian Mandelli and Laurent Deluc*
*Oregon State University, 1500 SW Jefferson Way, Corvallis, OR, 97331, (laurent.deluc@oregonstate.edu)

The lack of targeted approaches to control grapevine red blotch virus (GRBV) presents a significant challenge to the wine industry. Costly vine removal remains the only practical option, underscoring the urgent need for alternative strategies. RNA interference (RNAi) is a conserved defense mechanism in plants triggered by viral infection; however, the molecular interactions related to RNAi between GRBV and grapevine remain poorly understood. We recently identified nine GRBV genomic "hotspots" targeted by the plant's RNAi machinery during an artificial infection of an infectious clone of GRBV using *Agrobacterium tumefaciens*. Based on these findings,

*indicates corresponding author

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we evaluated hotspot-derived dsRNA (HS-dsRNA) for their silencing efficacy in GRBV(+) tissue-cultured plants, demonstrating a significant reduction in viral gene expression at 12 and 24 days postapplication. Expanding on this, we investigated dsRNA's systemic uptake and silencing potential targeting GRBV in greenhouse-grown plants. RNAi can be enhanced through spray-induced gene silencing (SIGS), which involves applying double-stranded RNA (dsRNA) by foliar spray. This non-transgenic and sustainable approach provides a promising strategy to control viral infection. Fluoro-labeled dsRNA applied via low-pressure spray was detected in the vascular bundles of leaf petioles within 48 hr, with systemic movement observed by 7 days posttreatment. Fluorescence persisted through 14 days, indicating dsRNA sustained transport. To assess silencing efficiency, GRBV(+) plants were treated with naked HS-dsRNA or HS-dsRNA complexed with carbon dots to enhance uptake and stability. Viral gene expression was quantified by qPCR at 1, 2 and 3 mo postapplication, with additional long-term evaluations underway to determine optimal application frequency for sustained suppression of GRBV replication. Our results provide the first experimental validation of dsRNA-induced RNAi for viral suppression in grapevine. Ongoing analyses will refine dsRNA formulation and treatment strategies, advancing the feasibility of SIGS as a sustainable alternative for GRBV control.

Funding Support: Oregon Wine Board

Potassium Application Improves Fruit Total Soluble Solids in Grapevine Red Blotch Disease-Affected Grapevines

Joseph DeShields, Achala KC and Alexander Levin*
*Southern Oregon Research and Extension Center, Oregon State University, 569 Hanley Road, Central Point, OR, Central Point, OR, OR, 97502, (alexander.levin@oregonstate.edu)

Grapevine red blotch disease (GRBD) is characterized by impaired photosynthetic activity, inhibited sugar translocation, and interveinal blotching on the leaves. These symptoms negatively affect fruit quality, resulting in lower sugar and anthocyanin concentrations in the fruit, making mitigation strategies essential. Given the established importance of potassium (K) in phloem loading and transport of sugars, it was hypothesized that soil and/or foliar applications of K could potentially alleviate the negative effects of GRBD on fruit ripening. In 2023 and 2024, two rates of soil-applied K, 56 kg/ha (medium) and 112 kg/ha (high), and a single rate of foliar-applied K (5.2 kg/ha), were evaluated using a split-plot design on grapevine red blotch virus-infected Cabernet franc and Merlot grapevines. A significant increase in sugar per berry (p = 0.024) was observed in response to increased soil-applied K in Merlot only. However, in both years the medium and high rates of soil-applied K increased pH in Merlot by 1.7 and 2.3% and in Cabernet franc by 4.7 and 5.8%, respectively. Both rates of soil-applied K also significantly increased GRBD symptom expression on Merlot at harvest in both years (p = 0.005), but only the high rate had a significant effect in 2024 (+7.7%; p = 0.024). In both years, foliar K had a significant effect on total soluble solids (TSS) in both cultivars. TSS averages increased by 5.8% in Cabernet franc (p = 0.010) and 3.5% in Merlot (p = 0.038). Although negative effects from soil-applied K treatments were observed on GRBD symptom severity in Merlot, this study demonstrates the effect of foliar K on increasing fruit TSS without compromising fruit yield components. However, the effects of these treatments on pH should be considered in cases where high pH levels may already be an issue.

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Enology – Sensory Experiences of Wine Session

A Comparative Study of Sensory Training Methods for Novice Wine Consumers

Deborah Parker Wong*
*California State University, Fresno, 2360 E. Barstow Avenue, M/S VR89, Fresno, CA, 93740, (dparkerwong@mail.fresno.edu)

The wine industry faces a critical juncture in determining the most effective approach to educating young adult consumers about its products. Demographic trends and consumer surveys indicate a preference for hedonic experiences that enhance enjoyment, in lieu of traditional wine education methods. This study examines the responses of 48 undergraduate college students to two training methods for evaluating wine quality. The research focuses on measuring both hedonic and eudaimonic responses to a digital, interactive visualization method and a traditional, analytical rubric and lexicon-based method. The hypothesis suggests that novice students will prefer the visualization training method, leading to increased time and effort devoted to learning and positively affecting their engagement and motivation levels. Two specific methods were employed in the study: the QUINI wine tasting application, a hybrid model combining traditional instructional strategies with an interactive visualization approach, and the systematic approach to tasting (SAT) developed by the Wine & Spirit Education Trust (WSET), representing a traditional, industry-standard method. Following each training session, students completed post-training surveys designed to measure their hedonic and eudaimonic responses. These responses were coded and analyzed using JASP software. Contrary to the initial hypothesis, Bayesian paired t-test analysis supported the null hypothesis, indicating no statistically significant preference for either training method. Over the 14 wk following the training, when given a choice between QUINI and SAT for assignments, 98% of students consistently chose to use the SAT. This result demonstrates a strong preference for the most expedient method of evaluating wine, challenging the assumption that interactive, hedonic-focused approaches would be more appealing to young adult consumers. These findings suggest that traditional analytical approaches still hold value for novice wine consumers. This study contributes to the discussion about effective ways to engage young adults and the complexity of consumer preferences in this domain.

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Wine Cuality – A New Method for the Assessment of Wine Sensory Quality by Experts

Jean-Xavier Guinard,* Lik Xian Lim and Anita Oberholster
*UC Davis, 392 Old Davis Road, Department of Food Science and Technology, Davis, CA, 95616, (jxguinard@ucdavis.edu)

Wine quality has traditionally been evaluated by experts on a 100-point scale. Even though such a quality rating may provide reliable information about the overall quality of the wine, an indication and/or justification of how that rating or number was reached is not usually provided. And yet, sensory quality is a multidimensional concept that encompasses many aspects of a wine's sensory profile, such as trueness to style, the absence of defects, and the presence of desirable sensory attributes and more holistic concepts such as balance and complexity. Inspired by our approach to deconstructing and understanding hedonic (liking) ratings by consumers, and the Coffee Cuality method (https://www.coffeecuality.com/) we developed to evaluate specialty coffee, we designed Wine Cuality scorecards to assess white and red wines. Those combine an overall quality rating on a 100-point scale with just-about-right ratings for select attributes, a check-all-that-apply task

**indicates corresponding author*

Enology – Sensory Experiences of Wine Session—CONTINUED

from a list of 20 to 30 sensory and holistic attributes, and some open comments. Through a suite of statistical tools and word analysis, the quality rating on the 100-point scale can be deconstructed and justified and the performance of the experts can be evaluated. The method also accounts for the stage at which a wine is tasted and rated, i.e., postfermentation, post-barrel aging (finished wine), or in the context of a wine judging. We tested our Wine Cuality method with a group of 100 wine experts, using a set of experimental wines from our smoke taint research and commercial wines. The experts consistently discriminated among the wines on the basis of sensory quality and provided a thorough understanding of the positive and negative drivers of sensory quality for both the white and red varietals in this study.

Funding Support: Jackson Family Wines, USDA Agricultural Research Service

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Exploring Consumer Perceptions of Alternative Wine Packaging: Environmental and Recyclability Impacts

Mark Walker Bartz, Lawton Lanier Nalley, Brandon McFadden, **Renee Threlfall*** and Shelby Rider
*University of Arkansas, 2650 N. Young Ave, Fayetteville, AR, 72704 (rthrelf@uark.edu)

Sustainability initiatives are increasingly emphasized in the grape and wine industry. Wine packaging accounts for 34 to 41% of the total carbon footprint of wine production, primarily due to the widespread use of glass bottles. To reduce this footprint, alternative packaging materials such as aluminum, polyethylene terephthalate (PET), and multilayer flexible pouches are emerging. However, consumers often perceive glass as the optimal packaging material for wine, associating wine in alternative packaging materials with lower quality. An online discrete choice experiment was conducted with 2000 United States wine consumers and purchasers to assess willingness-to-pay (WTP) for wines packaged in aluminum, PET, or flexible bags relative to glass. Participants were randomly assigned to information groups highlighting the carbon footprint and recyclability of the materials. Consumers discounted wines in alternative packaging, with price reductions ranging from $4.37 to 8.09 for aluminum, $8.01 to 11.42 for PET, and $10.57 to 15.49 for flexible bags compared to glass. WTP was lowest in the no-information group ($22.36) and highest in the carbon-footprint-only group ($25.37). Similarly, market share for alternative packaging ranged from 27.22% in the no-information group to 34.40% in the carbon-footprint group. Consumers consistently preferred aluminum over PET and flexible bags among alternative options. These findings underscore the potential of consumer education on the environmental benefits of alternative packaging to enhance adoption and WTP. Promoting the lower carbon footprint of alternative materials could help shift consumer perceptions and drive sustainability in the grape and wine industry.

Funding Support: The University of Arkansas System Tyson Endowed Chair in Food Policy Economics

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Enology – Sensory Experiences of Wine Session—CONTINUED

Modeling the Extraction of Aroma Compounds as a Function of Grain Type, Surface Area, and Toast Intensity in Model Wines

Mackenzie Aragon,* Robert Coleman, Roger Boulton and Thomas S. Collins
*WSU, 2455 George Washington Way, Apt. F230, Richland, WA, 99354, (mackenzie.aragon@wsu.edu)

Oak alternative products are more quickly extracted than traditional oak barrels. Our prior work in this area demonstrated that the overall surface area and more importantly, the amount of end grain, affect the extraction rate of aroma compounds from alternative forms. The end grain in alternatives plays an increasingly important role in smaller alternative pieces, for which the end grain becomes a large percentage of the overall surface area. This study extends the prior work to include the role of toasting intensity on extraction rate by evaluating American oak adjuncts of differing intensities—light, medium, and heavy toasts. Segments measuring 23 cm x 2.6 x 2.0 cm in length were sequentially cut in half by length (23 cm, 11.5 cm, 5.75 cm, 2.87 cm, and 1.44 cm). This process resulted in treatments with the same total mass and oak volume, but increased surface area and end-grain to cross-grain ratio for the shorter segments due to the exposure of two additional end-grain surfaces for each cut. All treatments used a dosage rate of 20.0 g/L and were extracted in model wine (15% v/v ethanol) for 90 days. Samples were analyzed for content of furfurals, guaiacol, and oak lactones using gas chromatography-mass spectrometry. The extraction rate and concentration increased as the SA and end-grain to cross-grain rose. At each toast intensity, individual compound classes exhibited different behaviors. Additionally, changes in the concentration of individual compounds at each toasting intensity also influenced the overall extraction kinetics. A first-order kinetic model was fitted to the raw data for each compound across all toast intensities at various SA and grain ratios using the Differential Evolution parameter estimation routine (Peterson and Ulrich 2011). This model's results highlight the significance of the grain ratio and toasting intensity on the extraction rate and concentration.

Funding Support: Scott Laboratories

*indicates corresponding author

Enology – Sensory Experiences of Wine Session—CONTINUED

Enological Measures to Improve the Sensory Quality of Dealcoholized Wines

Ulrich Fischer,* Lisa Käppler, Katrin Oster and David Töpfer
*Institute for Viticulture & Enology, Dienstleistungszentrum Ländlicher Raum-Rheinpfalz, Breitenweg 71, Neustadt an der Weinstrafle / 67435, Germany, (ulrich.fischer@dlr.rlp.de)

Worldwide wine consumption is decreasing, and consumers behave more consciously regarding alcohol. The wine industry has the choice to complain about alcohol criticism, or proactively develop attractive dealcoholized wines, which serve both the objective to reduce personal alcohol consumption and fulfill the passion for an artisanal drink made from well-defined geographic origins and highly acclaimed grape varieties. However, removing ethanol, with its sensory potency, often leads to a boring and dull palate; lack of varietal flavor; and emergence of unpleasant stale, green, and cooked notes. Thus, clever strategies are needed to overcome these sensory shortcomings. In many technological and sensory experiments, we demonstrated that winemaking which enhances flavor in the starting wines also yielded dealcoholized wines with pronounced varietal aroma. Additionally, the green, stale flavor of fusel alcohols that remains in the dealcoholized wines due to their high boiling points, was masked successfully. Dealcoholization shortly after fermentation keeps many varietal flavors in their non-volatile, bound form, which prevents loss by vacuum-distillation. Using aromatic grape juices instead of sucrose to overcome increased sourness offers a reservoir of additional attractive varietal notes that can be released into the dealcoholized wine by ß-glucosidase enzymes. Use of oak enhances the vinous character and strong carbonation supplies mouth-coating irritation, which may even distract consumers from noticing the missing alcohol at all. Skin-fermented white wines are a source of highly bioactive polyphenols and, due to the concomitant loss of bitterness and astringency, they provide a smooth structure to dealcoholized wines. Targeted winemaking offers the chance to produce expressive dealcoholized wines with varietal character, providing a sophisticated alternative for traditional wine drinkers, but also opening the world of wine to consumers who never touched wine before, as they perceive wine as being too alcoholic, bitter, and astringent.

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Viticulture – Measuring and Managing Vine Water Status Session

To Shed or Not to Shed: Different Responses of Cabernet Sauvignon and Malbec Vines to Drought-Induced Leaf Shedding

Caetano Albuquerque,* Alexander Levin and Andrew McElrone
*California State University, Monterey Bay, 100 Campus Center, Seaside, CA, 9355, (calbuquerque@csumb.edu)

Water deficits and other factors can induce abscission of basal, older leaves on grapevine shoots. While leaf removal is a common practice to improve fruit quality and reduce disease pressure, when excessive it can lead to berry sunburn. Understanding when vines start to shed their leaves during water stress, whether wine grape varieties differ in this response, and the cause of this phenomenon, is useful for irrigation management to match production goals and variety-specific responses to improve berry quality and yield. We hypothesized that Cabernet Sauvignon and Malbec would have different thresholds for water-stress induced leaf shedding and that petiole xylem embolism would drive these responses. We measured leaf shedding and midday leaf water potentials (Y_w) of vines grafted onto 1103P grown at the UC Kearney Station. We also scanned petioles of intact plants of both varieties across a dehydration range using synchrotron-based microcomputed tomography (microCT) to directly observe xylem embolism. Leaf shedding started in the field around Y_w = -1.3 MPa for both varieties and Malbec vines shed more leaves than Cabernet Sauvignon with this difference increasing with greater water stress. Malbec petioles were more susceptible to drought-induced embolism than Cabernet Sauvignon, which can be attributed to pith capacitance. The pith cells of Cabernet Sauvignon dried quickly after embolism initiation, while pith cells of Malbec petioles were full of water until severe water stress. Petiole shrinkage had a linear response to water stress for both varieties. These findings show that winegrape varieties show different vulnerabilities to drought-induced leaf shedding, embolism, and pith capacitance. Water released from drying pith cells of Cabernet Sauvignon likely contributed to more resistance to drought-induced embolism. Combined with petiole shrinkage, these data can be used to develop new technologies to track vine water stress for improved irrigation management.

Funding Support: Allocated Beamtime at the Advanced Light Source (ALS) US Department of Energy Henry Jastro Scholarship (UC Davis)

Impact of Extra Irrigation During Heatwaves on the Performance of Cabernet Sauvignon and Riesling Vines

Charles Obiero* and Markus Keller
Washington State University, 24106 N. Bunn Road, Prosser, WA 99350, Prosser, WA, 99350, (charles.obiero@wsu.edu)

Grapegrowers often apply extra irrigation water during heatwaves to mitigate heat stress. However, it is uncertain whether this extra irrigation water improves vine performance, and the practice also risks jeopardizing the benefits of the grower's regulated deficit irrigation (RDI) program. We evaluated Cabernet Sauvignon and Riesling winegrapes to determine the impact of extra irrigation applied before or during predicted heatwaves on vine water status, growth, and productivity. From 2022 to 2024, field trials were conducted in a WSU drip-irrigated research vineyard near Prosser, WA. Extra irrigation water was applied for 24 hours (hr) immediately before or 4 hr daily during heatwaves. The outcomes were compared with standard RDI (control). Extra water before or during the heatwaves increased leaf water status compared with the control. However, 4 hr of extra irrigation daily during heatwaves

**indicates corresponding author*

increased plant water status more than the 24 hr of extra irrigation once before heatwaves. In both varieties and all seasons, shoot growth did not stop, especially in the 4-hr daily extra irrigation treatment. On average, extra irrigation increased berry weight by 8% compared with the control. In Cabernet Sauvignon, but not Riesling, extra irrigation increased yield by 16% and pruning weight by 20%. In both varieties, extra water did not alter fruit total soluble solids, titratable acidity, or pH compared with the control. Thus, 24 hr of extra irrigation ahead of heatwaves or 4 hr of daily extra irrigation during heatwaves lowered plant water stress but did not influence the basic fruit composition in Cabernet Sauvignon and Riesling vines compared with RDI without extra irrigation. However, shoot growth did not stop in vines that received 4 hr of daily extra irrigation during heatwaves. This might jeopardize growers' overall goal of using RDI as a canopy management tool.

Funding Support: 1. USDA Northwest Center for Small Fruits Research 2. Washington State Grape and Wine Research Program

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Drip Irrigation or Vine Cooling: Which is the Best Strategy for Heatwave Mitigation in Cabernet Sauvignon?

Pietro Previtali,* Thomas Giagou, Luis Sanchez and Nick Dokoozlian
*GALLO, 600 Yosemite Blvd, Modesto, CA, 95354,
(Pietro.Previtali@ejgallo.com)

The frequency of heat days (T_{max} > 38°C) and heatwaves (>2 consecutive heat days) has increased steadily over the past decades. In California, unprecedented heat has been recorded in vintages such as 2017, 2020, 2022, and 2024. Heat extremes cause yield losses and negatively shift wine composition toward higher alcohol and lower color, mouthfeel, and aroma compounds. Increased irrigation during heatwaves mitigates heat effects on yield, fruit composition, and wine chemistry of Cabernet Sauvignon, and the intensity of this effect is dependent on irrigation timing and intensity. In 2024, we compared drip irrigation treatments with canopy cooling systems in Cabernet Sauvignon in Sonoma, CA. Six drip irrigation treatments, combining three timings (0, 1, and 2 days prior to the heatwave) and two amounts (50% and 100% more than the control), and four cooling systems, were compared to a control with standard drip irrigation and no cooling. Vine cooling treatments received the control irrigation and were automatically triggered at T > 35°C. The 2024 season was exceptionally hot, with 14 heat days and heatwaves across all summer months. Both drip irrigation and cooling reduced canopy temperature during heatwaves and improved vine water status. Lower air temperature in the fruit zone was only recorded for cooling treatments and to a different degree depending on the system used, up to 10°C. Both standard irrigation and vine cooling improved yield components and fruit composition at harvest. Greater improvements in yield (+4 kg/vine) and berry weight (+0.3 g) were observed in drip irrigation treatments. Fruit quality parameters were maximized with cooling systems, including lower sugar levels and off-flavors and improved anthocyanins and mouthfeel-related phenolics. These findings show that drip irrigation and vine cooling can be used to mitigate the effects of heatwaves and preserve yield and quality under heat extremes.

Funding Support: GALLO

Wednesday National Conference Oral Presentation Abstracts (Research Papers)

2025 NATIONAL CONFERENCE TECHNICAL ABSTRACTS

Viticulture – Measuring and Managing Vine Water Status Session—CONTINUED

Rootstock Drought Tolerance or Vigor Control? A Quandary for Cool Climate Dry-farmed Vineyards

Patricia Skinkis,* Grace Lilly and Abigail Sriram
*Oregon State University, 2750 SW Campus Way, 4017 Ag & Life Sci Bldg., Corvallis, OR, 97331, (patricia.skinkis@oregonstate.edu)

Pairing rootstock traits with desired winegrape growth responses is an important consideration for vineyard owners as they seek environmental and economic sustainability. While rootstocks have been used in Oregon's Willamette Valley for 30 years, the focus had been on vigor-reducing rootstocks that lack drought tolerance. The seasonal climate has changed since that time, with warmer and drier growing seasons. Growers seek rootstocks to match climate, soils, and production goals, with the most important parameters being increased drought tolerance for no-till, no-herbicide use, suitability to restrictive soils, and balanced vine vigor to reduce vineyard inputs while achieving desired yields and quality. To address these concerns, vine growth, water stress, and fruit composition were evaluated in a mature vineyard from 2020 to 2024. The trial was established as a split-plot design with cultivar as the main plot and rootstock as the subplot. Pinot noir was grafted to 18 rootstocks and Chardonnay and Pinot gris were grafted to nine rootstocks of varying parentage. Results show that rootstocks have the greatest effect on vine vegetative growth and yield. Vines with the most vegetative vigor were on 5BB, 1103P, 420A, and 140R and had 1.5- to 3-fold higher pruning weights than vines on vigor-reducing rootstocks (101-14, 3309C, Schwarzmann, 44-53, and Riparia Gloire). Vines with larger canopies also had higher yields, while Riparia Gloire, Schwarzmann, and 44-53 had 1.4- to 2-fold lower yields than average. We hypothesized that larger vine size and fruit yield could reduce drought tolerance, but the most vigorous vines had the least plant water stress. Vines on 101-14 and Riparia Gloire had the most drought stress. However, there were differences in cultivar response by rootstock. Differences in fruit composition by harvest were primarily explained by vine vegetative vigor, with the weakest vines having the most advanced ripeness compared to the largest vines with highest yields.

Funding Support: Oregon Wine Board and Northwest Center for Small Fruit Research

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Evaluating Machine Learning for Spatial-Temporal Prediction of Grapevine Water Status Using Landsat 8 Imagery

Eve Laroche-Pinel, Vincenzo Cianciola, Khushwinder Singh, Gaetano Vivaldi and **Luca Brillante***
*Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740, (lucabrillante@csufresno.edu)

Climate change exacerbates drought and heat stress in vineyards, increasing the need for efficient water management. This study evaluates using Landsat 8 imagery and weather data to predict grapevine water status through a gradient boosting machine (GBM) model. Midday stem water potential (Ψ_{stem}), net assimilation (AN), and stomatal conductance (g_s) were measured over two seasons in a *Vitis vinifera* cv. Merlot vineyard in Central California. Spatial and temporal predictive accuracy was assessed using block-out and date-out cross-validation. Machine learning accurately predicted vine water status spatially within training dates, with low normalized root mean square errors ($NRMSE_{\Psi stem}$: 2.7%; $NRMSE_{gs}$: 16.2%; and $NRMSE_{AN}$: 11.2%) and high accuracy ($R^2 > 0.8$). However, forecasting for new dates is more challenging, with NRMSE reaching 17.7% for Ψ_{stem} and 72.5% for g_s.

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Viticulture – Measuring and Managing Vine Water Status Session—CONTINUED

Incorporating prior ground data at a single location improves model performance, reducing NRMSE to 6.8% for Ψ_{stem} (R^2 = 0.90), 53.4% for g_s (R^2 = 0.74), and 25.5% for AN (R^2 = 0.78). These findings highlight the importance of validation methods that account for spatial-temporal dependencies in agricultural data sets. By integrating remote sensing with machine learning, this study provides a scalable approach to monitoring vine water status, enhancing decision-making in precision viticulture under climate change.

Funding Support: American Vineyard Foundation; Bronco Wine Co. Chair in Viticulture

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Boosting Soil Water Retention and Vineyard Sustainability: Effect of Biochar and Hydrogels

Ashraf El-kereamy,* Alaaeldin Rezk, Lauren Hale and Maha Afifi
*UCR, 900 University Ave., Riverside, CA, 92521, (ashrafe@ucr.edu)

Soil water retention is a critical factor influencing plant growth, soil management, and drought resilience. Organic matter plays a key role in soil moisture retention, with its ability to absorb up to 20 times its weight in water. Changes in temperature further impact evapotranspiration, soil infiltration, and groundwater recharge. Enhancing soil water retention is essential to mitigate the effects of drought, particularly in agricultural systems. Hydrogels, a class of polyacrylamide-based amendments, improve soil water-holding capacity and plant growth by increasing water availability. Similarly, biochar, a carbon-rich material derived from biological residues, enhances soil moisture retention due to its porosity and large surface area. While hydrogels have demonstrated effectiveness in improving soil water retention in Scarlet Royal grapes, the potential of biochar in table grape production remains underexplored. A 3-yr study examined the effects of hydrogel and biochar on the productivity and quality of two table grape varieties, Great Green (Sheegene 17) and Allison (Sheegene 20), grown in clay and sandy soils under limited water supply (60% ET_c). Applying hydrogel at 260 or 520 lb/acre and biochar at 5 or 10 tons/acre mitigated yield losses and improved berry size, weight, color, and firmness, with higher application rates proving more effective, particularly in sandy soils. Additionally, treatments enhanced soil microbiome activity and improved overall soil health. Ongoing trials are assessing lower application rates. This presentation will highlight the findings and explore the feasibility and costs associated with hydrogel and biochar applications in table grape production.

Funding Support: California Table Grape Commission

Thursday National Conference Oral Presentation Abstracts (Research Papers)

Enology – Characterization and Mitigation of Smoke Taint in Wine Session (research reports)

Oak aging Mitigates the Effect of Grape Smoke Exposure on the Sensory Profile of Different Red and White Wine Matrices

Lik Xian Lim,* Cristina Medina-Plaza, Catherine Routt, Jean-Xavier Guinard and Anita Oberholster
3072 Woods Circle, Davis, CA, 95616, (lxlim@ucdavis.edu)

The wildfires that swept through Napa Valley in 2020 caused an estimated USD$3.7 billion economic loss to the grape and wine industry. During a wildfire event, volatile phenols (VPs) are released in fresh smoke from burning wood (lignin) and are absorbed through the grape berry skin, where they are rapidly glycosylated. The wines made from smoke-impacted grapes are characterized sensorially as medicinal, smoky, and possessing a retro-nasal ashtray character. However, there are matrix differences among varieties and winemaking styles that can affect smoke expression as well as the synergistic effects among VPs. In this study, serial dilutions of non-impacted and impacted (intentionally smoked postharvest) wines were used to create wines with differing levels of smoke impact across varietals (Cabernet Sauvignon, Zinfandel, and Chardonnay). The influence of oak aging on smoke impact mitigation was also studied (12-mo new oak-aged and stainless steel control). Gas chromatography-mass spectrometry and liquid chromatography-triple quadrupole mass spectrometry were used to quantify free and total VPs, and individual bound glycosides, respectively. Descriptive analysis was used to evaluate sensory characteristics of wines. There was a linear relationship between the amount of VPs and glycosides present in a blend and the amount of smoke-impacted wine present. Wines with high VP levels determined by chemical analysis also had higher smoke ratings determined by the descriptive panel. Generally, wines that underwent barrel aging for 12 mo had less “ashy aftertaste” and smoke-related attributes in all three varieties. Stainless steel control wines were more fruity, but also more smoky, across all smoke-related attributes. These findings contribute to our understanding of grape smoke exposure at different levels of taint and the potential use of barrel aging to mitigate overall smoke perception in wine across these taint levels.

Funding Support: USDA Agricultural Research Service, California Department of Food and Agriculture, Jackson Family Wines

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Effect of Smoke Exposure on Different Varieties of Red Grapes and Related Wines: A Case Study

Francesco Maioli,* Chen Liang, Arran Rumbaugh and Ron Runnebaum
*UC Davis, Hilgard Lane RMI North, Davis, CA, 95616, (fmaioli@ucdavis.edu)

In recent years, exposure of vineyards to smoke from wildfire events has been shown to directly affect grape composition and, subsequently, wine quality. Smoke taint has emerged as a significant concern for the global wine industry. In 2020 alone, the United States suffered an estimated $3.7 billion in damages due to wildfires and tainted grapes and wines. The industry needs tools and methods to determine smoke impact in a vineyard after a wildfire. This case study examines the impact of the 2024 Lake Fire in Santa Barbara County on nearby vineyards during the early stages of red grape ripening. The smoke-exposed grape samples and the resulting wines were collected from five different red grape varieties: Cabernet Sauvignon (n = 5), Cabernet franc (n = 1), Merlot (n = 2), Malbec (n = 1), and Pinot noir (n = 1). Grapes were cultivated at varying altitudes but within ~5 km of the fire. Smoke-exposed grapes were fermented and wines were produced according to local winery

**indicates corresponding author*

protocols. The effect of smoke on both the grapes and the wines was assessed by quantifying volatile phenols and their glycosylated forms by GC-MS/MS and LC-MS/MS analysis, respectively. Environmental data, including local air quality measurements and satellite images, were collected to track the movement and concentration of smoke and correlate with grape and wine composition. The study revealed how different red grape cultivars respond to smoke exposure, particularly during early stages of ripening (preveraison). It also demonstrated how this exposure translated into the wines produced and provided insights into how winemaking influences the release of volatile phenols from glycosylated forms.

Funding Support: USDA

Advancing Smoke Taint Mitigation: The Potential of Sulfur-Based Nutritional Approaches

Olivia Jefferies and Elizabeth Tomasino*
*Oregon State University, 100 Weigand Hall, Corvallis, OR, 97331, (elizabeth.tomasino@oregonstate.edu)

Wildfire smoke presents an ever-growing challenge for the wine industry, threatening grape quality and winemaker livelihoods. When grapes in the vineyard are exposed to smoke, the resulting wines often develop an ashy, smoky flavor that compromises sensory quality. The underlying cause of this ashy flavor has been linked to a combination of smoke-related compounds, specifically thiophenols and volatile phenols. While much is already being explored about these compounds and their impact, there is a growing need for practical solutions that can mitigate smoke exposure's effects during winemaking. Sulfur-containing nutrients, widely recognized for their role in enhancing varietal thiols—key aroma compounds in Sauvignon blanc—may offer a potential avenue for addressing smoke taint in wine. Previous studies demonstrated that increasing sulfur-based nutrients can promote production of thiols, raising the question of whether these same nutrients could influence the formation of smoke-related thiophenols during fermentation. This research aims to explore that possibility by investigating the effect of sulfur-based nutrient additions on the concentration of smoke-derived compounds in wine. Smoke-exposed Pinot noir grapes from Oregon were processed through microfermentations with a variety of nutrient additions: glutathione, Glutastar, and diammonium phosphate (DAP). Two controls were included—one using smoke-impacted grapes without nutrients and another using clean, non-smoke-exposed grapes. Advanced analytical techniques like GC-MS/MS and LC-MS/MS were used to measure free phenols, phenol-glycosides, and thiols. All fermentations proceeded successfully, with no adverse effects from the nutrient treatments, demonstrating that these additions are viable for winemaking processes. While nutrient additions did not appear to directly alter the concentration of smoke-related compounds, this study provides valuable insight into how winemakers might approach the challenge of smoke exposure.

Funding Support: Specialty Crop Research Initiative Grant #2021-51181-35862/project accession #1027470 from the USDA National Institute of Food and Agriculture and USDA-Agricultural Research Service (ARS) project number 2072-21000-057-00D

Thursday National Conference Oral Presentation Abstracts (Research Papers)

2025 NATIONAL CONFERENCE TECHNICAL ABSTRACTS

Viticulture – Regenerative Viticulture and Soil Health Session (research reports)

On-Farm Assessment of Long-Term Effects of Regenerative Management on Vineyard Soil Health

Lauren Picone, Corinne Butler, Cristina Lazcano and Charlotte Decock*
*Grimm Family Center for Organic Production and Research, California Polytechnic State University, San Luis Obispo, CA, 1 Grand Avenue, San Luis Obispo, CA, 93407, (cdecock@calpoly.edu)

This study assessed the effects of long-term, stacked regenerative management practices on soil health across 87 vineyard blocks in California with diverse management histories, microclimates, and soil types. Soil health indicators including aggregate stability, mineralizable carbon, and soil organic carbon were analyzed to develop region-specific rating curves. Soil health indicator average values trended lower than established framework values, emphasizing the need for commodity- and region-specific rating systems. Long-term cover cropping (≥10 yr), particularly when combined with other practices, significantly improved soil health scores. The integration of livestock emerged as a practice capable of accelerating soil health improvements, yielding benefits in less than 10 yr. Findings highlight the importance of tailoring practice combinations to specific soil types and climactic conditions to achieve soil health goals. These results contribute to the growing body of evidence supporting the need for comprehensive, yet adaptable, soil health rating systems.

Funding Support: Foundation of Food and Agriculture Research California Department of Food and Agriculture Specialty Crops Block Grant

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Effects of Stacking Regenerative Management Practices on Soil Health, Vine Quality, and Yield in a Sonoma, California Vineyard

Paige Davis,* Axel Herrera, Connie Wong, Amanda Rodriguez, Kerri Steenwerth and Cristina Lazcano
*UC Davis, 1 Shields Ave, Davis, CA, 95616, (pedavis@ucdavis.edu)

Regenerative management practices in vineyards are gaining traction as we shift to building self-regulating systems that need fewer synthetic inputs and disturbances to soil and vines. While regenerative practices have been studied individually, this study looks at the effects of stacking these practices in a vineyard in Sonoma, California. The 17-yr-old vineyard is planted with Cabernet Sauvignon on a 101-14 rootstock with a Positas Gravelly Loam soil type. The regenerative practices included a reference with conventional management (RF) and combinations of compost (C), no-till (N), and grazing (G): C, N, GC, NC, and GNC, with three replicates for each treatment. Treatments were applied for two growing seasons from 2022 to 2024. We hypothesized that stacking of practices would increase soil and vine health. Vine row and tractor row soil samples were collected in 2024 at two depths (0 to 15 cm and 15 to 30 cm). Soils were analyzed for bulk density, aggregate stability, gravimetric water content, EC, pH, water holding capacity, total carbon and nitrogen content, microbial respiration, permanganate oxidizable carbon, microbial biomass carbon, potentially mineralizable nitrogen, ammonium and nitrate levels, and phosphorus. Leaf samples were collected at veraison and analyzed for macronutrient (N, P, and K) and micronutrient (Zn, Fe, B, and Cu) content. Grape yield was recorded and grape quality was analyzed for juice and berry phenolics and a range of basic chemistry properties (glucose, fructose, total soluble solids, etc.). We will use analysis of variance to compare soil health indicators across treatments, providing evidence of how regenerative management affects different aspects of vineyard soil function. A

**indicates corresponding author*

correlation analysis will evaluate the relationships between soil health indicators and leaf nutrients to better understand the effects of regenerative agriculture. Integrating soil, vine, and yield analyses will provide insight into potential benefits or tradeoffs of regenerative management, such as changes in grape quality.

Funding Support: Foundation for Food and Agriculture Research California Department of Food and Agriculture

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Ideal Vineyard Soils from Grower Perspectives Ddiverge from Traditional Soil Health Paradigms

Noelymar Gonzalez-Maldonado,* Kerri Steenwerth, Mallika Nocco, Erika Yao, Luisa Robles and Cristina Lazcano
*USDA-ARS and UC Davis, 1110 Plant & Environmental Sciences Building, LAWR Department, One Shields Ave, Davis, CA, 95616-8627, (ngonzalezmaldonado@ucdavis.edu)

Soil health is essential for sustainable winegrape production. However, soil health metrics and guides designed from annual cropping systems may not correspond to needs and goals for winegrape production. The traditional soil health paradigm promotes organic matter accumulation and turnover to enhance nutrient cycling and maximize crop yield, while vineyard management focuses on balancing vine vigor and optimizing grape quality. This study aimed to identify soil health indicators associated with growers' desired vineyard outcomes, while accounting for soil properties, management, and sampling variability. Soil samples were collected from 16 grower-identified ideal and 16 challenging vineyard soils. Soils were rated based on their ability to regulate vine vigor and produce high grape quality in Napa Valley. Samples from vine rows and tractor rows (0 to 20 cm depth) were analyzed for total carbon (TC), permanganate oxidizable carbon (POXC), mineralizable C (Min C), microbial biomass C (MBC), dissolved organic C, total N, plant-available N (NO_3^--N, NH_4^+-N), potentially mineralizable N (PMN), pH, EC, bulk density, wet aggregate stability (WAS), penetration resistance, and infiltration rate. Soil texture was a key factor influencing soil health indicators and growers' differentiation between ideal and challenging soils. Ideal soils had slightly lower levels of clay and silt content and lower TC, POXC, TN, EC, and WAS indicators. Higher soil health levels were observed in tractor rows with vegetative cover compared to bare vine rows, suggesting that soil samples should be taken from both zones. No-till practices enhanced TC, Min C, and NH_4^+-N. Enhancing these properties could support soil structure and resilience to extreme weather conditions. These findings emphasize the value of integrating growers' perspectives into defining soil health with respect to distinctive winegrape production goals, highlighting the need to adapt traditional soil health frameworks to better serve perennial vineyard systems.

Funding Support: American Vineyard Foundation Western SARE USDA ARS

Viticulture – Regenerative Viticulture and Soil Health Session (research reports)—CONTINUED

CIP Implementation in Wineries to Reduce Water and Chemical Use

Brooke Fanale,* David Block, Robert Coleman and Ron Runnebaum
*UC Davis, 1 Shields Ave, Davis, CA, 95616,
(bmfanale@ucdavis.edu)

Reduction in water and cleaning chemistry use has become essential in the wine industry, given water scarcity and the cost of wastewater treatment. Clean-in-Place (CIP) technology, using a central fixed in place cleaning system, is a potential solution. In other allied industries such as dairy processing, biopharma, and brewing, CIP has been able to reduce the use of cleaning chemistries and water, while automating cleaning to reduce labor and improve worker safety—all while improving cleaning. This study examined incorporating CIP systems into the wine industry, focusing on fermentation and storage vessels, where automated cleaning has not yet been widely incorporated but represents a significant portion of resource allocation. This was accomplished by examining hydrocyclones, understanding CIP wastewater composition, and assessing nanofiltration for recycling of cleaning chemistries and water. Hydrocyclones, a potential economical and energy-efficient option to remove relatively small particle solid waste from liquid streams, were assessed in single stages and in series to determine the recovery of solids. Wine lees collected from white fermentation tanks were used, allowing assessment of the necessity for further clarification prior to water re-use. Composition of cleaning wastewater produced in a winery (i.e., typical "dirt") was also examined to understand what is typical. Samples were collected on six 2000-L tanks during typical cleaning cycles using the installed CIP system. Samples were taken at each stage of cleaning at the tank inlet and outlet and examined using a combination of high-performance liquid chromatography, Lowry protein assay, and potassium probe to quantify levels of acids, sugars, alcohols, protein, potassium, and polysaccharides expected to be present in a postfermentation wine tank. With alternative cleaning chemistries (potassium hydroxide, hydrogen peroxide, and potassium bisulfate), nanofiltration of the cleaning solutions was evaluated. Up to 95% of the cleaning solutions could be recovered.

Funding Support: UC Davis, Foley Family, and Treasury Wine Estates

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Modulation of Malic Acid by *Saccharomyces cerevisiae* Strains: Development of Novel Acidifying Starters

Ana Hranilovic,* Charlotte Vion, Julia Capitanio, Chantal Mansour, Margaux Bernard, Maitena Muro, Philippe Marullo, Joana Coulon, and **Lisa Strid**
*Laffort, 11 Rue Aristide Berges, Floirac, 33270, France,
(ana.hranilovic@laffort.com)

Insufficient acidity in grapes due to warming climates requires costly adjustments throughout winemaking. During alcoholic fermentation (AF), acidity can be reduced further by yeast metabolism, as most *Saccharomyces cerevisiae* strains partially consume malic acid. This study describes the development of novel *S. cerevisiae* strains capable of producing malic acid through QTL-assisted breeding. The resulting 'ACIDIC' strains produced >3 g/L malic acid under winemaking conditions, leading to pH reductions exceeding 0.5 units. In parallel, a distinct group of 'DEMAL' strains capable of consuming up to 80% of the initial malic acid was obtained. Extensive phenotypic characterization, in terms of fermentation performance, production of primary and secondary metabolites, and sensory effect, highlighted the ability of

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Enology – Microbial Impacts in Winemaking and Cellar Management Session (research reports)

these strains to modulate wine acidity under various enological conditions. It also delivered two starters for broader application in the wine industry, which were further evaluated in a series of winemaking trials. Detailed chemical and sensory profiling of the obtained wines validated their acidifying capacity, with increased malic acid post-AF and/or lactic acid post-FML (up to 1 g/L and 0.7 g/L, respectively). The decreased pH and increased titratable acidity were in line with the yeast-derived modulation of malic acid and accompanied by lower ethanol content (<0.5% vol.) and enhanced glycerol production. Analysis of yeast-derived flavor compounds further revealed distinct metabolic fingerprints, contributing to an overall 'fresher' wine profile. Together, these findings broaden the intrinsic capacity of *S. cerevisiae* to modulate malic acid during fermentation, provide insights into the underlying regulatory mechanisms, and offer new microbial tools to manage acidity and differentiate wine styles.

Funding Support: Laffort

Effect of Different Strains of *Lachancea thermotolerans* Yeast on Acids and Sugars during Chambourcin Wine Fermentations

Renee Threlfall* and Amanda Flemming
*University of Arkansas, 2650 N. Young Ave, Fayetteville, AR, 72704, (rthrelf@uark.edu)

There is increased interest in using non-*Saccharomyces* yeasts such as *Lachancea thermotolerans* to enhance wine complexity and resolve acidity issues. In 2023, 252 kg of Arkansas-grown Chambourcin (*Vitis* hybrid) grapes were hand-harvested, randomized into batches, crushed, and destemmed. Seven inoculation treatments were conducted in duplicate using *Saccharomyces cerevisiae* (SC) and three strains of *L. thermotolerans,* including a commercial strain (LAK) and two experimental strains (LT1 and LT2). *L. thermotolerans* treatments received sequential *S. cerevisiae* inoculations after 24 or 48 hr. All treatments were co-inoculated with malolactic bacteria 24 hr after *S. cerevisiae*. Total sugars, pH, titratable acidity (TA), and total organic acids of the grapes/must/wines were evaluated during fermentation at 21°C (0, 3, 6, 9, and 12 days) and at bottling. At harvest, grapes had 20.36% total sugars, pH 3.77, 0.61% TA, 0.37% malic acid, and 1.19% total organic acids. All treatments completed alcoholic fermentation by day 6 (total sugars < 0.3%), though by day 3 SC wines finished. At day 3, lactic acid ranged from 0.22% (LAK-SC-24 hr) to 0.42% (LT1-SC-48 hr). By day 6, SC wines had the highest pH (3.89), while other treatments ranged from 3.58 to 3.74. By day 12, LT2-SC-48 hr wines had the highest TA (0.84%) and lactic acid (0.35%), while malic acid remained slightly unfinished in all wines (0.04 to 0.06%). At bottling, SC wines had the highest pH (4.00), while other treatments ranged from 3.82 to 3.87. LT1-SC-48 and LT2-SC-48 wines had the highest lactic acid (0.43 to 0.46%) and total organic acids (0.91 to 0.92%) compared to SC wines (0.25% and 0.72%, respectively). *L. thermotolerans* strains in mixed inoculation with *S. cerevisiae* produced Chambourcin wines with lower pH and higher TA and lactic acid. This fermentation approach offers a natural way to enhance acidity, stabilize microbial balance, and address winemaking challenges in warm-climate regions.

Funding Support: Lallemand Oenology

Enology – Microbial Impacts in Winemaking and Cellar Management Session (research reports)—CONTINUED

Effect of Nutrient Additions and Wine Lees on Biogenic Amine Production by *Pediococcus*

Jaewoo Choi, Liping Yang and **James Osborne***
*Oregon State University, 100 Wiegand Hall, Oregon State University, Corvallis, OR, 97331, (james.osborne@oregonstate.edu)

This study investigated the effect of wine lees and nutrient additions on biogenic amine production by *Pediococcus.* Initial experiments assessed production of biogenic amines by *Pediococcus* in Merlot, Pinot noir, and Chardonnay wine. Of the four isolates tested, only *Pediococcus inopinatus* OW8 increased the concentration of biogenic amines, with all wines into which OW8 was inoculated containing significantly higher histamine than the control wine. Differences between wines were also noted. Pinot noir wines inoculated with OW8 contained the most histamine, followed by Merlot and then Chardonnay. The lower histamine concentration in Chardonnay wine may have been due to the initial slower growth of *P. inopinatus* OW8 in this wine compared to Merlot and Pinot noir. However, *P. inopinatus* populations still reached >107 CFU/mL in the Chardonnay wine. Additional factors that could affect biogenic amines were also explored. Three different nutrient treatments were applied to a Chardonnay juice prior to fermentation. The three treatments were control, high diammonium phosphate (DAP), and high organic N. After completion of alcoholic fermentation, wines were cold-settled and dimethyl-dicarbonate was added to eliminate background microorganisms. After cold settling, wines were racked or not racked to create lees or no lees treatments and either *P. inopinatus* OW8 or *Pediococcus parvulus* WS9 was inoculated into the wines. Nutrient addition and lees treatments significantly affected the concentration of biogenic amines in the wine. The addition of either organic nutrients or DAP resulted in significantly higher histamine in treatments inoculated with P. inopinatus OW8. DAP additions resulted in significantly more histamine than organic nutrients. Aging on the lees also increased production of histamine by P. inopinatus OW8, but only if nutrients had been added. Overall, the addition of DAP and aging on lees resulted in the greatest concentration of histamine in treatments inoculated with *Pediococcus.*

Funding Support: Northwest Center for Small Fruits Research

*indicates corresponding author

Enology & Viticulture Joint Session – Influence of Vineyard Conditions and Practices on Wine

Foliar Nitrogen Supplementation: A Tool to Manipulate Fruit N Status

Pierre Davadant, Nataliya Shcherbatyuk, James A Harbertson, Lee A Kalcsits and **Markus Keller***
*Washington State University, 24106 N Bunn Road, Prosser, WA, 99350, (mkeller@wsu.edu)

Grapegrowers in dry regions face challenges with low nitrogen (N) in harvested grapes, affecting winemaking due to insufficient yeast assimilable nitrogen (YAN). Foliar N application at veraison may enhance grape and wine composition without inducing excessive vigor, yet its effect on phenolic compounds and plant N partitioning remain unclear. We conducted a 3-yr field trial and two separate pot experiments in arid eastern Washington to test whether foliar-applied N moves to the fruit and other plant organs, enhancing berry ripening and quality, and potentially replenishing the available N pool to support next year's crop. In a field trial with own-rooted Syrah, we applied liquid urea ammonium nitrate (0, 22.5, 45, 90 kg N/ha) to the soil at bloom or foliar urea (15 kg N/ha) at veraison. We also tested the impact of supplementing a foliar urea spray at veraison (87 g N/L) on potted Cabernet Sauvignon vines that had received four different rates of soil N at bloom (0 to 3.75 g N per pot). Finally, using potted Riesling vines, we applied ^{15}N-labelled urea at veraison on whole canopies, leaves only, or clusters only to trace N partitioning at harvest.

Results showed that foliar N application at veraison significantly increased YAN in field-grown Syrah and pot experiments. Higher YAN found in Cabernet Sauvignon-harvested berries was negatively correlated with skin tannins but not seed tannins. ^{15}N applied on Riesling fruit remained in the clusters, while ^{15}N applied on leaves was translocated to the perennial plant organs for storage. Pot experiments highlighted that the greatest relative increase in YAN from foliar N treatment occurred in vines with the lower N status.

Funding Support: USDA-NIFA Specialty Crop Research Initiative (award number 2020-51181-32159), Washington State Grape and Wine Research Program, Ste. Michelle Wine Estates (in-kind)

Thursday National Conference Oral Presentation Abstracts (Research Papers)

2025 NATIONAL CONFERENCE TECHNICAL ABSTRACTS

Enology & Viticulture Joint Session – Influence of Vineyard Conditions and Practices on Wine—CONTINUED

Vineyard Nitrogen Application Effect on Grape and Wine Phenolic Composition and Sensory Profile

Juliana Pazos, Ryan Doyle, Markus Keller, Nataliya Shcherbatyuk, Pierre Davadant and James Harbertson*
*WSU Wine Science Center, 359 University Dr., Richland, WA, 99354, (jfharbertson@wsu.edu)

It was hypothesized that nitrate-based fertilizer treatments would lower fruit and wine phenolics due to increases in vine vigor and phenolic biosynthesis inhibition. 0, 20, 40, and 80 lbs nitrogen/acre were soil-applied to Syrah vines representing the Control, Low, Medium, and High treatments. In addition, a fifth treatment of foliar urea application (15 lbs N/acre) was included to contrast with the soil nitrate treatments. Treatments were applied to three different rows in a randomized block design. The experiment was repeated for three vintages (2022 to 2024). Wines were made respecting the block design (15 wines per vintage: five treatments, three replicates). Skin and seed tannin content, size, and composition were analyzed using protein precipitation and phloroglucinolysis. Sensory analysis was performed in the 2022 vintage using descriptive analysis. Eleven aroma, three taste, and three mouthfeel descriptors were evaluated in triplicate (tasting each treatment nine times) using a 15-person panel. Basic grape chemistry was not consistently altered by the vineyard treatments. Yeast assimilable nitrogen increased with the High and Urea treatments. Grape anthocyanins content, skins and seed tannin content, size, and composition were unaltered by the field treatments. However, High and Urea treatment wines presented significantly lower concentration of tannins than the Control and Low treatments. In addition, the High and Urea treatment wines had the lowest tannin size, although subunit composition was unaltered. Preliminary protein analysis using the BCA method suggests that higher soil nitrogen or foliar urea applications could lead to an increase in protein content, which could be binding to the larger tannins and remove them from the wine. Despite the significant differences in chemistry, panelists were unable to find significant differences between the wines.

Funding Support: Specialty Research Initiative High Resolution Vineyard Nutrition Project and Washington State Wine Commission

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Determination of Abiotic Stress-Induced Off-Flavors in White Wine by GC/Olfactometry and Sensory Reconstitution Studies

Caterina Szmania, Jochen Vestner and **Ulrich Fischer***
*Institut for Viticulture & Enology, Dienstleistungszentrum Ländlicher Raum-Rheinpfalz, Breitenweg 71, Neustadt/67435, Germany, (ulrich.fischer@dlr.rlp.de)

Due to increasing abiotic stress, the atypical aging note (ATA) emerged in the late 1980's, being reminiscent of naphthalene, floor polish, wet wool, fusel alcohols, and acacia blossom. Although 2-aminoacetophenone (2-AAP) was postulated as the molecular marker for the ATA taint, it only accounts for the "acacia blossom" scent, while the molecular base of the other off-flavors remains unknown. To fill this knowledge gap, 38 German white wines were analyzed, of which 21 were rejected due to an ATA off-flavor and 17 were approved. Descriptive analysis (DA) and non-targeted GC-analysis revealed significant differences between cohorts. GC/olfaction revealed

*indicates corresponding author

Enology & Viticulture Joint Session – Influence of Vineyard Conditions and Practices on Wine—CONTINUED

overall 56 odor active volatiles, of which seven occurred at higher concentrations in rejected wines (negative contributors). Model wine and varietal wines (Riesling, Pinot blanc, and Müller-Thurgau) were either spiked solely with 2-AAP or a mix of all seven negative contributors at their greatest occurring concentration. DA showed that sole 2-AAP addition enhanced "acacia blossom" exclusively, while the attributes "ATA", "fusel alcohol", and "stressed" increased significantly only by adding all seven negative contributors. A sensory omission test revealed that among the seven negative contributors, only 2-methyl-propanol, 3-methyl-butanol, and methionol had a significant effect, which coincides with their highest odor activity values of 1111, 78, and 122, respectively. When adding only those three compounds to the model and varietal wines, DA reported equal "stressed", "fusel alcohol", and "ATA" intensities as if all seven negative contributors were added. Thus, the "classic" 2-AAP driven ATA-taint "acacia blossom" should be differentiated clearly from the stress-induced "fusel alcohol", "atypical aging", and "stressed" off-flavors caused by higher alcohols. They coincide with diminished fruitiness in the wines due to sensory masking and lower ester concentrations, which were presumably diminished by nitrogen/amino acid deficiency during grape maturation and in juices.

Funding Support: German Ministry for Economics and Climate Protection Research Council Food Industry (FEI), AIF 21 095 F

Effect of Biofungicides on Grape and Wine Chemistry, Fermentation, and Sensory Attributes of Wines from California

Qun (Kristy) Sun,* Quinn Cahoon, Shunping Ding and Shijian Zhuang
*California State University, Fresno, 2360 E Barstow Ave., Fresno, CA, 93740, (qsun@csufresno.edu)

Controlling common vineyard fungal pathogens such as *Erysiphe necator* (powdery mildew) and *Botrytis cinerea* (gray mold) is a significant concern for the grape and wine industry, particularly as these pathogens have developed varying degrees of resistance to synthetic fungicides. Biofungicides, which use other organisms to combat these pathogens, present a promising alternative. We evaluated the effects of biofungicides on grape and wine chemistry, wine fermentation, and sensory attributes. Chardonnay and Carignan from California's Central Valley, along with Pinot noir and Chardonnay from the Central Coast, were treated with biofungicides in the vineyard and subsequently vinified during the 2023 and 2024 growing seasons. Treatments included three biofungicides: *Bacillus subtilis* strain QST 713 (Serenade ASO), *Streptomyces lydicus* strain WYEC 108 (Actinovate AG), and an extract of *Reynoutria sachalinensis* (Regalia). Two control treatments were used: one with a synthetic fungicide and one without any fungicide. All treatments were conducted in quadruplicate following a randomized complete block design. Berry and wine chemical components were measured comprehensively. Sensory evaluation was performed by a panel of 10 individuals consisting of students and staff from the Fresno State Viticulture and Enology department. Disease severity had the most significant affect. When disease pressure was minimal at a vineyard site, biofungicides were a viable alternative to synthetic fungicides, with their primary effect being on wine phenolic composition.

Funding Support: CDFA and ARI System

Wednesday & Thursday National Conference Poster Presentation Abstracts (Research Papers)

2025 NATIONAL CONFERENCE TECHNICAL ABSTRACTS

Enology and Viticulture Research Report Posters

Rapid Detection and Risk Assessment of Smoke-Derived Volatile Phenols: A Chemometric Approach using Spectrofluorometry

Brandt Bastow,* Adam Gilmore, William Drayton and Anita Oberholster
*University of California, Davis, 677 Laugenour Dr., Woodland, CA, 95776, (bpbastow@ucdavis.edu)

The 2020 wildfires on the United States West Coast highlighted the urgent need for rapid, cost-effective methods to assess smoke exposure in wine. Analytical laboratories were inundated with samples, delaying results by over a month—an impractical timeframe for harvest decisions. Current assessment methods rely on mass spectrometry, which is accurate, but time-intensive and costly. To address these challenges, this research explores absorbance-transmission and excitation-emission matrix (A-TEEM) spectroscopy combined with chemometric modeling as a rapid alternative to quantify smoke-derived volatile phenols and their associated sensory risks. The study involves analyzing wine samples from multiple Northern California vineyards, spanning 10 varietals and several vintages. Sample preparation includes linear dilutions of severely smoke-affected grapes and wines to enhance detection of trace absorbance and fluorescence spectral signatures. Sensory analysis was conducted to determine the levels of various "smoke taint" attributes present in the wine. Single and multi-block chemometric models, employing multivariate and machine learning techniques, are currently being constructed by regressing A-TEEM spectral data against mass spectrometry and sensory analysis reference values. Statistical approaches under evaluation include gray classical least squares, parallel factor analysis, multivariate curve resolution, partial least squares, locally weighted regression (LWR), and extreme gradient boosting. Preliminary results demonstrate strong predictive correlations, with a LWR model achieving an R^2 of 0.997 for free guaiacol. A-TEEM demonstrates high instrumental repeatability (RSD < 2%), supporting the method's robustness. This research aims to establish the efficacy of spectrofluorometry as a reliable, cost-effective tool for smoke taint risk assessment, enabling producers to make timely, informed decisions during wildfire-affected harvests.

Funding Support: CDFA 2021 Multi-State Specialty Crop Program

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Non-Contact Postfermentation Wine Processing to Remove Thiol-Related Smoke Compounds

Lik Rong Lim and Elizabeth Tomasino*
*Oregon State University, 100 Weigand Hall, Corvallis, OR, 97331, elizabeth.(tomasino@oregonstate.edu)

Global warming and climate change have increased the number of wildfire events during the grapegrowing season. The smoke-exposed grapes can result in smoke-tainted wines, which are perceived poorly by the consumer. Volatile thiophenols contribute to the ashy and smoke-tainted off-flavors in wine. Traditional sulfur mitigation methods for wine include adding copper sulfate as a fining agent which partly remains in the wine after bottling. However, copper sulfate is traditionally used on reductive related sulfur compounds and has yet to be thoroughly evaluated for removing volatile thiophenols in wine. It is also known to alter other wine aroma compounds. This work was done on a benchtop scale, with the goal of removing thiols without having the product come in contact with the wine and selectively removing only smoke compounds. An inert closed-loop system was devised, where thiophenols could be removed from the initial solution using a separate flask containing a thiol-selective trapping compound, - 5,5'-dithiobis(2-nitrobenzoic acid)

**indicates corresponding author*

(DTNB). This system ensured the trapping solution would not mix with the initial solution/wine. Previous work investigated the parameters suspected to influence trapping efficiency, including the concentration of thiol, the concentration of DTNB, the size and number of bubbles, the buffer solution used, and the temperature. The system is now being evaluated with a model wine spiked with smoke thiols to evaluate the trapping feasibility of the system. Future work includes testing on smoked-out wines and conducting sensory evaluations to determine if removing volatile thiophenols improves the perceived overall quality of the wine by consumers.

Funding Support: the USDA-Agricultural Research Service (ARS) project number 2072-21000-057-00D.

Wildfire Smoke-Taint Amelioration in Red Wines using Y Zeolite

Connor Patton*
*University of California, Davis, 2949 Portage Bay West, Apt 125, Davis, CA, 95616, (cqpatton@ucdavis.edu)

Wildfire smoke exposure of winegrapes leads to wines with an unappealing, ashy flavor and aroma. The ashy flavor and aroma is caused by absorption of smoke-related volatile phenolic compounds into the body of the grapes. Treatment of smoke-tainted wines involves introduction of Y-zeolite, a microporous, adsorptive aluminosilicate. The Y-zeolite is intended to selectively adsorb volatile phenolic compounds such as guaiacol, syringol, phenol, and cresol while limiting the removal of wine matrix compounds necessary to preserve the wine's natural flavor, aroma, color, and texture. Addition of Y-zeolite to smoke-tainted California red wines for 1 hr with stirring resulted in 49 to 95% removal of free guaiacol, 4-methylguaiacol, *o*-cresol, 4-ethylguaiacol, *p*-cresol, *m*-cresol, 2,3-dimethoxyphenol, 4-ethylphenol, syringol, and 4-methylsyringol, and 18% removal of free phenol. The glycosidically-bound phenolics were only reduced in concentration by 36% reduction or less. Ethanol content of Y-zeolite treated wines only dropped by 0.4%, indicating limited competitive adsorption between ethanol and the volatile phenols. Future research will investigate the effect of Y-zeolite treatment on other volatile compounds in wine. The current findings indicate the potential of Y-zeolite as a viable material for smoke-taint amelioration. Further research will be performed to assess the viability of modifying the zeolite structure and composition to increase the adsorptive capacity and selectivity of the zeolites. These modifications include adjusting the silica/alumina ratio, loading the zeolite with metal atoms, and adjusting the pore and supercage sizes. For the research to be applicable in an industrial setting, the smoke-taint amelioration process will have to be continuous and capable of scaling up to an industrial volume. The findings of this study will demonstrate the capability of Y-zeolite to remove the smoke effects from wildfire smoke-tainted wines and the potential for doing so on an industrial scale.

Funding Support: California Department of Food and Agriculture

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Enology and Viticulture Research Report Posters—CONTINUED

Barrier Spray Analyses for Mitigation of Smoke-Related Volatile Phenols in Cabernet Sauvignon Grapes

Gauthier Lagarde*
*UC Davis, 595 Hilgard Ln, Department of Viticulture and Enology, Davis, CA, 95616, (glagarde@ucdavis.edu)

Wildfires are a growing concern for the wine industry, as smoke-derived volatile phenols can significantly alter the sensory profile of wine, imparting undesirable smoky aromas and an ashy aftertaste. Smoke-tainted wines are thus compromised in flavor, typicity, and consumer acceptance. This study evaluates the effectiveness of Kaolin and GM3E as barrier sprays against smoke exposure. Whole grape bunches from 10 potted Cabernet Sauvignon vines were immersed in the respective spray solutions for 30 sec, with the sprays also applied to the leaves. Water was used for two control groups. The following day, three groups of vines (Kaolin, GM3E, and one control) were subjected to 4 hr simulated smoke exposure. The remaining control group was not exposed to smoke (negative control). One week after exposure, the grape bunches were collected and cleaned with water. The washed grapes and cleaning water were stored at -20°C. Free and total volatile phenols in the grapes and cleaning water were quantified by gas chromatography-mass spectrometry, while individual glucoside-bound volatile phenols were measured by liquid chromatography-mass spectrometry. Preliminary results show distinct differences between Kaolin and GM3E. GM3E treatment resulted in higher concentrations of free volatile phenols (337 µg/L) compared to the smoked control (184 µg/L). Kaolin showed lower levels (144 µg/L) than the smoked control, but still higher than the non-smoked control (34 µg/L). The distribution of volatile phenols also varied by treatment. For total volatile phenols, GM3E exhibited 9% of 2,3-dimethoxyphenol, while other treatments had less than 0.6%. Cleaning water contained more total volatile phenols in the GM3E treatment (53 µg/L) than in Kaolin (34 µg/L), smoked control (24 µg/L), or control (9 µg/L). These results suggest barrier sprays can alter the concentration and distribution of smoke-related phenols, providing insights into mitigating wildfire smoke effects on wine quality.

Funding Support: California Department of Food and Agriculture (CDFA)

Empacts of Methyl Jasmonate and Benzothiadiazole on Glycosylated Phenols in Grapes Exposed to Smoke Marker Compounds

Chen Liang,* Arran Rumbaugh, Ron Runnebaum and Francesco Maioli
*University of California, Davis, 595 Hilgard Ln, RMI North, Davis, CA, 95616, (chelian@ucdavis.edu)

During a wildfire event, smoke-exposed grape berries can uptake volatile phenols (VPs) such as guaiacol, cresols, and syringol. These smoke-taint related compounds can be metabolized into their glycoconjugates (Gly-VPs), transported, and stored in the grape cells. The Gly-VPs can be hydrolyzed during fermentation, wine aging, and consumption, releasing the VPs. The hydrolysis of Gly-VPs in mouth was reported to relate to the "smoky", "ashy" off-flavor. Variations in grape Gly-VPs after smoke exposure were reported to improve evaluation of smoke taint risk. This study investigates the effects of human interventions in the vineyard after smoke exposure on Gly-VPs variation in grapes, seeking a way to mitigate smoke taint accumulation in grapes. Glycosylation of the VPs is a detoxification process of the grapevine. Application of natural or synthetic compounds can enhance plant defense responses and affect secondary metabolic pathways. Two such compounds are methyl jasmonate (MeJ) and benzothiadiazole (BTH). Both compounds were found

**indicates corresponding author*

to increase the phenolic content of grapes. This metabolic change could increase glycosylation of VPs, the same as for anthocyanin formation. Alternatively, formation of Gly-VPs could be decreased due to increasing glycosylation of endogenous phenols. To study the effects of MeJ and BTH on Gly-VPs variation in grapes, Cabernet Sauvignon grape clusters were exposed to aqueous mists of smoke marker compounds (guaiacol, *p*-cresol, syringol) at early postveraison. MeJ and BTH spray mists were applied one day after exposure, alone and in combination. Berry samples were collected at three time points. The glycosylated smoke marker compounds of each VP were detected in berries at harvest. The concentrations and changing dynamics of Gly-VPs in berries with MeJ and BTH applications will be reported and preferential uptake of the exposed three VPs will be documented.

Funding Support: USDA-ARS

Validation of Protocols for Acid Hydrolysis of Smoke-Related Glycosides

Julie Hilland,* Thomas Collins and Robert Coleman
*Washington State University, 359 University Drive, Richland, WA, 99354, (julie_hilland@wsu.edu)

Wines produced from smoke-exposed grapes can exhibit undesirable sensory and palatable characteristics. The negative financial impact on a global scale for both grape and wine quality requires reliable methods to measure “free” volatile phenols (VP) and “bound” (VP-glycosides) in grapes and wine when evaluating smoke impact severity. Many analytical methods exist for gas chromatography-mass spectrometry (GC-MS) to quantify volatile phenols. These can also be applied to measuring VP-glycoside samples subjected to acid hydrolysis. However, there is currently no standard protocol for acid hydrolysis. This has contributed to inconsistent analysis results as protocols vary in application of acid, temperature, and duration. This project will develop and validate an acid hydrolysis approach to quantify VP and VP-glycosides in smoke-affected wines. A 30-L batch of model wine containing 5g/L KHTA and 14.75% alc (v/v) and adjusted to pH 3.30 was prepared. The amount of acid required to adjust samples to pH 1.0 and the amount of base to bring samples back to pH 3.5 was determined. Ten volatile phenols were added at 50 ug/L concentration each to the 30-L batch. VP-model wine samples were divided into two main categories: control and acid hydrolyzed. Samples were further divided into two subgroups: heated/non-heated and covered (watch glass)/uncovered. A hot water bath set at 80°C was used as the heating source. Unheated samples were placed on the laboratory counter at room temperature. Hydrolysis was conducted over a 4-hr period. Volatile phenol recovery using GC-MS was used to quantify and evaluate method success based on percent recovery. All tests were conducted in triplicate. The extent of variability across treatments will be used to improve acid hydrolysis protocols. Once validated, establishment of optimal pH, temperature, and time parameters by characterizing the hydrolysis reactions of known glycoside concentrations can be determined.

Funding Support: USDA/SCRI

Enology and Viticulture Research Report Posters—CONTINUED

Examining the Role of Frost Damage on Leaf Composition to Unravel the Mystery of the "Frost Taint" Wine Phenomenon

Mitchell Davey, Markus Keller, Zilia Khaliullina, Danielle Fox and James Harbertson*
*Washington State University, 359 University Drive, Richland, WA, 99354-1671, (jfharbertson@wsu.edu)

Previous work demonstrated that frost-damaged leaves added to must prior to fermentation cause atypical floral aromas and floral aftertaste in Cabernet Sauvignon wines. The phenomenon is anecdotally referred to as "rose" or "frost" taint. In this work, leaf volatile composition was measured using untargeted solid-phase microextraction gas chromatography-mass spectrometry (HS-SPME-GC-MS) to establish a relationship between wine, leaf composition, and varied aspects of leaf damage (temperature, aging, freeze drying) to study the phenomenon. Leaf composition analysis revealed that two previously identified chemical markers, 6-methyl-5-hepten-2-ol and *p*-menth-en-9-al, described as coriander and herbal aromas respectively, varied significantly based on frost damage (naturally frozen > freeze dried > control (not frost damaged). Volatile analysis of Cabernet Sauvignon wines made with naturally frozen, freeze-dried, and no leaves (8.0 g/kg) using untargeted HS-SPME-GC-MS found 26 compounds, primarily terpenoids and norisoprenoids, differed statistically between treatments, including 6-methyl-5-hepten-2-ol and *p*-menth-en-9-al. The results establish a chemical relationship between leaf and wine composition; however, we have not yet established a sensory relationship. Our results also expose the limits of using freeze-dried leaves in lieu of naturally frozen leaves to study the "frost" taint wine phenomenon.

Funding Support: Washington Wine Grape Funds Washington Wine Commission

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Investigation of Grape Skin Thickness and Grape Skin Lipid Content for Differences in Smoke Taint Composition

Chanda Miller and Elizabeth Tomasino*
*Oregon State University, 100 Weigand Hall, Corvallis, OR, 97331, elizabeth.(tomasino@oreognstate.edu)

A plant's cuticle layer is an external waxy barrier to the lipid membrane and the plant's first line of defense. The cuticle and membrane layers' morphology and composition change in response to the fruit's developmental stage and physiology. It is important to understand how developmental changes of these barriers affect fruit defense to environmental exposures. This work investigates the formation of smoke-related compounds and their relationship with the cuticle and lipid membrane layers of grape skins. In particular, it is of interest to determine if these two factors play a role in the different levels of smoke taint that arise within different varietals during the same smoke event. Twelve *Vitis vinifera* winegrape varietals (Cabernet Sauvignon, Cabernet franc, Merlot, Petite Verdot, Pinot noir, Syrah, Malbec, Tempranillo, Chardonnay, Viognier, Pinot gris, and Sauvignon blanc) were investigated. Grapes were harvested at two time points and smoked out in custom smoking chambers, as no natural event occurred that year. Skin thickness was measured using scanning electron microscopy and compared with smoked volatile polyphenol and smoked thiol concentrations to determine if there is a varietal difference in smoke taint. Skin lipid extraction was measured to determine if the lipid composition of the skin affects smoke taint formation.

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*indicates corresponding author

Enology and Viticulture Research Report Posters—CONTINUED

Innovative and Sustainable Wine Fining: The Science Behind Plant Proteins

Lorenza Allen*
*Enartis USA, 7795 Bell Road, Windsor, CA, 95492, (lorenza.allen@enartis.com)

The use of plant proteins in enology is gaining interest as a means to enhance winemaking performance while meeting market demands for sustainability and allergen-free alternatives. Traditionally, animal-derived proteins such as casein and egg albumin have been used for wine fining, but increasing concerns over allergies and sustainability have driven research toward plant-based solutions. Pea (*Pisum sativum*) and potato (*Solanum tuberosum*) proteins present promising alternatives, aligning with consumer preferences and industry trends. This study examines the chemical and physical characteristics of pea and potato proteins and their effectiveness as fining agents. Key factors in their production, including temperature and pH management, play a crucial role in optimizing their enological performance. Controlled hydrolysis was employed to enhance their reactivity, ensuring optimal results in wine clarification and stabilization. The findings indicate that plant proteins demonstrate strong fining capacity, reducing astringency and improving colloidal stability. Pea proteins effectively mitigate oxidation, while potato proteins interact more efficiently with astringent tannins. When subjected to appropriate hydrolysis, these proteins also show significant metal-chelating properties, particularly with iron, further reducing oxidative risk. Proper dosage is essential to achieve optimal performance while preserving the wine's sensory balance. As sustainable and effective alternatives to traditional fining agents, plant proteins offer a viable solution to improve wine quality while addressing food safety concerns. This study provides a scientific foundation for their adoption, reinforcing the role of innovative, plant-based technologies in advancing the enological sector.

Funding Support: Enartis USA

Evaluating the Impact of Cool and Warm Climate on Grenache blanc and Viognier Wine Quality in California's Central Coast

Coleman Imrisek, Mercy Torres, Ozan Gencer, Sean Kuster, Federico Casassa and Miguel Pedroza*
*California Polytechnic State University, San Luis Obispo, 1 Grand Ave, San Luis Obispo, CA, 93407, (miguelp@calpoly.edu)

Mediterranean grape varietals such as Viognier and Grenache blanc are known for adapting to diverse climatic conditions with a vocation to be sustainably dry-farmed. These grapes are increasingly considered viable alternatives to commercially dominant cultivars in California's Central Coast, and the cool and warm climates in the region can be used as a model for assessing future climate change impacts, underscoring the need for comprehensive characterization of grape and wine quality. This work aims to provide a detailed chemical characterization of Viognier and Grenache blanc grapes and wines produced from cool (Santa Maria) and warm (Paso Robles) climate vineyards. We followed a 2 x 2 factorial design with vineyard climate (warm, cool) and varietal (Viognier, Grenache blanc) to compare the differences in grape composition, fermentation kinetics, and wine chemistry, including color, phenolic, and volatile composition, during the 2024 harvest. The wines were produced in triplicate using a standardized method across all treatments. Viognier wine made from cool-climate grapes was characterized by higher alcohol content and higher volatile terpene composition (linalool, geraniol, nerol, citronellol) compared to warm-climate wine. In contrast, Grenache blanc wine produced from

cold climates was characterized by a higher concentration of volatile esters, lower total phenolic compounds, and lower alcohol and volatile acidity. Together, these results could be used by winegrowers to align climatic conditions with stylistic goals, such as producing varietal aroma-driven wines or increasing texture attributes and body in white wines.

Funding Support: Agricultural Research Institute

Evaluating the Impact of Cool and Warm Climate on Grenache and Syrah Wine Quality in California's Central Coast

Coleman Imrisek, Dan Simon, Mercy Torres, Sean Kuster, Federico Casassa and Miguel Pedroza*
*California Polytechnic State University, San Luis Obispo, 1 Grand Avenue, San Luis Obispo, CA, 93407, (miguelp@calpoly.edu)

Grenache and Syrah are grape varietals known for adapting to diverse climatic conditions and producing distinctive wine styles ranging from medium to full body and varied levels of aroma, acidity, and alcohol. The California Central Coast offers an opportunity to characterize these varietals within a single region, but produced in cool and warm climates, which may be used by growers in different viticultural areas as a model to evaluate future climatic variability. This work aims to provide a detailed chemical characterization of Grenache and Syrah grapes and wines produced from cool and warm climate vineyards in Santa Maria and Paso Robles. We followed a 2 x 2 factorial design with vineyard climate (warm, cool) and varietal (Syrah, Grenache) and compared the differences in grape composition, fermentation kinetics, and wine chemistry including color, phenolic, and volatile composition during the 2024 harvest. The wines were produced in triplicate using a standardized method across all treatments. Results at the end of fermentation showed that Grenache wine from the warm climate had a lower content of anthocyanins (-45%), and a higher content of tannin (+95%) and total phenolics (+59%) with respect to the cold climate wine. On the other hand, Syrah from the cold climate had higher alcohol (+0.7%), titratable acidity (2.34 g/L), color intensity (293%), tannin (25%) and total polyphenols (98%) with respect to warm climate. The preliminary results of this work clearly indicate a significant interaction between climate and varietal that should be considered by grapegrowers for alignment with wine stylistic expectations. Ongoing analysis of volatile compounds is expected to broaden the scope of this interaction.

Funding Support: Agricultural Research Institute

Natural Biopolymer-Based Coatings to Improve Water-Use Efficiency and Heat Tolerance in Cabernet Sauvignon

Xavier Rideout, Guadalupe Partida, Vincenzo Cianciola, Alessandro De Rosa, Adan Solis, Marco Saldivar, William Whalen and Luca Brillante*
*Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740, (lucabrillante@csufresno.edu)

Climate change has intensified droughts in California, posing challenges to viticulture. Elevated temperatures can reduce photosynthetic efficiency by limiting CO_2 assimilation, increasing photorespiration, and inducing physiological stress. Heat can also accelerate total soluble solids (TSS) accumulation, decrease acidity, and compromise fruit quality. To mitigate these effects, natural biopolymer-based coatings have been explored for their potential to modify plant water use and physiological responses. This study evaluates the effects of three biopolymer-based

**indicates corresponding author*

treatments: di-1-*p*-menthene (a terpene-based polymer from pine resin), xanthan gum (a microbial polysaccharide), and starch (a plant-derived polysaccharide) on water stress, leaf gas exchange, and vine physiology in Cabernet Sauvignon grown in the Central Valley. Treatments were applied at pre-veraison and veraison, with physiological responses assessed through gas exchange and stomatal conductance (measured using a LICOR-6800) and stem water potential (measured via pressure chamber). Fruit composition, including TSS, pH, and titratable acidity, was analyzed using high-performance liquid chromatography. Results indicated that starch application improved net assimilation after the second application without significantly altering stomatal conductance or stem water potential, demonstrating an improvement in water-use efficiency. Di-1-*p*-menthene application delayed ripening, leading to lower TSS accumulation while maintaining acidity, while xanthan gum accelerated TSS accumulation and slightly reduced acidity. At harvest, no significant differences were observed in yield components across treatments. These findings suggest that natural biopolymer-based coatings can influence vine water relations and fruit ripening dynamics, offering potential tools for drought adaptation. Starch may enhance carbon assimilation efficiency, while di-1-*p*-menthene could be leveraged to modulate ripening and acidity retention in warm climates. Further research is needed to refine application strategies, providing grapegrowers with sustainable solutions to improve resilience against climate change.

Funding Support: Bronco Wine Company Chair in Viticulture

Environmental Drivers of White Winegrape Quality: A Survey of Chardonnay Ripening in Northern California

Kaitlin Libbey, James Campbell, Larry Lerno, Susan Ebeler and Elisabeth Forrestel*
*University of California, Davis, RMI Sensory, 392 Old Davis Rd, Davis, CA 95616, Davis, CA, 95616, (ejforrestel@ucdavis.edu)

Climate change is shifting the timing and conditions of winegrape berry ripening, affecting development and composition. Extreme heat during ripening can alter the nuanced balance of sugar accumulation, acid degradation, and aromatic potential in berries. These elements are particularly important for white wine grape cultivars, despite much less work focusing on climate impacts on white wine quality. To assess the relationship between climate and Chardonnay berry composition, we tracked the development of primary metabolites and aromatic precursors over the course of ripening in 22 different vineyards, spanning diverse microclimates in the North Coast wine regions. Rather than hydrolyzing bound compounds and using gas chromatography-mass spectrometry, we directly assessed the glycosidic aroma precursors using high-performance liquid chromatography-quadrupole time-of-flight mass spectrometry. On-site weather stations, within-canopy temperature sensors, and stable isotope analysis ($\delta^{13}C$) provided insights into ripening conditions and their influence on aromatic compound accumulation. Further, differences in accumulation were observed between skin and pulp. Future work will apply these findings to the modification of current suitability indices (i.e., Winkler index) using finer-scale microclimatic data and additional quality parameters to inform cultivar selection for future climate resilience.

Funding Support: Winiarski Foundation, UC Davis College of Environmental and Agricultural Science, UC Davis Department of Viticulture and Enology

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Enology and Viticulture Research Report Posters—CONTINUED

Phenotypic Characterization and Cold Hardiness Assessment in *Vitis riparia* and *Vitis amurensis* Mapping Populations

Hava Delavar and Harlene Hatterman-Valenti*
*North Dakota State University, 1360 Albrecht BLVD. Loftsgard Hall 470, Fargo, ND, 58102, (h.hatterman.valenti@ndsu.edu)

Freezing injuries cause an estimated 15% global grape production loss annually, presenting a significant challenge to sustainable viticulture. This study investigated phenotypic variations correlated with cold hardiness in two bi-parental mapping populations to explore potential markers for cold hardiness selection. Additionally, quantitative trait loci (QTL) mapping was conducted to identify QTLs that could accelerate cultivar development of environmentally resilient grape varieties. Two mapping families of 312 F1 hybrids from *Vitis riparia* x *Vitis vinifera* "Fresno Seedless" and 302 F1 hybrids from *Vitis amurensis* x *V. vinifera* "Valley Pearl" were examined. Differential thermal analysis was used to assess bud cold hardiness, complemented by comprehensive phenotypic trait measurements including bud water content, trunk and cane diameter, and postbudbreak phenology. Buds were analyzed after 7 and 28 days of cold storage at 4°C, examining low-temperature exotherms (LTE50). Significant variations were observed in cold hardiness and other phenotypic data. High-quality genetic linkage maps were successfully generated for both mapping populations, providing a crucial foundation for subsequent QTL analysis and marker identification. This research offers a potential sustainable strategy to develop cold-hardy grape cultivars that can maintain productivity under challenging environmental conditions and hasten the breeding processes in support of climate-adaptive viticulture.

Funding Support: Specialty Crop Research Initiative Competitive Grant, Award No. 2022-51181-38240, of the USDA National Institute of Food and Agriculture

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Soil Moisture and Soil Temperature Interact to Alter Grapevine Water Relations and Aquaporin Gene Expression

Geraldine Diverres, Seanna Hewitt, Amit Dhingra and Markus Keller*
*Washington state university, 24106 N Bunn Road, Viticulture and Enology, Prosser, WA, 99350, (mkeller@wsu.edu)

The combined effect of soil moisture and soil temperature on grapevine growth, yield, and fruit quality is gaining more attention in the context of global warming. However, their interaction and impact on grapevine physiology and water relations remain poorly understood. Grapevines can regulate water uptake in response to environmental changes by adjusting root aquaporin activity or gene expression. Published research shows that drought and cool rootzone temperatures limit plant water uptake and decrease root hydraulic conductance, possibly by reducing root aquaporin gene expression. Using custom-built pots in a climate-controlled growth chamber, we manipulated rootzone temperature independently of canopy temperature by recirculating chilled glycol or hot water to investigate the effect of soil moisture and temperature on gas exchange, leaf water potential (Ψ_{leaf}), and whole-plant hydraulic conductance (K_{plant}), using own-rooted Cabernet Sauvignon vines. Soil moisture was manipulated through irrigation management. After seven days, RNA was extracted from actively growing, unsuberized roots for RT-qPCR analysis. We focused on four *Vitis vinifera* plasma membrane aquaporins (*Vv*PIP1;1, *Vv*PIP2;2, *Vv*PIP2;2, and *Vv*PIP2;4N) for differential gene expression analysis. Our results show that the leaf-level responses were primarily influenced by soil moisture, while root aquaporin gene expression was more sensitive to soil temperature. Cooler

**indicates corresponding author*

root-zone temperatures reduced K_{plant}, stomatal conductance, and aquaporin gene expression. Soil moisture and soil temperature were correlated with Ψ_{leaf} and K_{plant}, supporting the hypothesis of an interaction between these factors. The experiment was repeated to test different rootzone temperatures in 2024 and data analysis is still ongoing. During the last repetition in 2024, we observed that a sustained rootzone temperature of ~33°C for three consecutive days resulted in vine decline and death.

Funding Support: Washington State Grape and Wine Research Program; Chateau Ste. Michelle Distinguished Professorship in Viticulture

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How Grow-Tube Type Influences the Vine Microclimate in Winter

Madison Shaw, Devin Rippner, Jake Schrader and Michelle Moyer*
*Washington State University, 24106 North Bunn Rd, Prosser, WA, 99350, (michelle.moyer@wsu.edu)

Cold injury is an issue for grapegrowers in regions with low winter temperatures. This injury often occurs when air temperatures drop faster than the vines can acclimate. There are viticultural practices that may exacerbate this risk of damage, including the use of grow tubes overwinter. We addressed this concern through a series of experiments that observed air temperature immediately surrounding Vitis vinifera Chardonnay vines when grown in paper, plastic, or no grow tubes during the 2024 to 2025 winter in eastern Washington State. The experiment used a randomized block design, with four replicates per treatment. Internal-tube temperate (or immediately surrounding temperature in the case of no tubes) was recorded every 15 min using HOBO data loggers; solar radiation was recorded at the nearby AgWeatherNet 'Prosser' weather station. Overnight, all treatments achieved the same air temperature immediately surrounding the vine. During the day, the range in temperature difference between paper tubes and no tubes was 3°C. This temperature difference range exceeded 14°C comparing plastic tubes to no tubes, with the air temperature inside plastic grow tubes being warmer than ambient air. The largest differences between ambient and plastic grow tube temperatures were generally associated with sunny days. Daily accumulated solar radiation was a positive predictor for increased daytime air temperature inside plastic grow tubes (R^2 = 0.58) over ambient air temperatures, but had no influence on the daytime air temperature inside paper grow tubes (R^2 = 0.007). We are also investigating the effect these daytime temperature swings have on bud cold hardiness. While preliminary, this study highlights the role grow tube material choice may have on vine winter temperature response. Results could be used to enhance cold-hardiness models for young vines, accounting for grow tube material choice and forecast weather conditions.

Funding Support: Washington State University, USDA National Institute of Food and Agriculture, Hatch project 7005262, and USDA-ARS project #2072-30500-001-000-D.

Enology and Viticulture Research Report Posters—CONTINUED

Assessing Carbon Saturation Potential of Regeneratively Managed Vineyard Soils

Gwendolyn Richards,* Cristina Lazcano, Charlotte Decock and Stewart Wilson
*Cal Poly San Luis Obispo, 1 Grand Ave, San Luis Obispo, CA 93407, (gwendolynarichards@gmail.com)

Soil carbon (C) storage is widely recognized as essential to both reducing atmospheric CO_2 levels and improving soil health. Interest is rising among viticulturalists in California in adopting regenerative practices that store C. To optimize soil C storage, it is important to understand both its potential and limitations. It is well known that soil mineralogy constrains the potential of a soil for longer-term C storage. By assessing C saturation points of different soils, a vineyard's soil C deficit can be determined and management can be catered accordingly. This study draws on soil samples from 87 vineyard soils with a long history of regenerative management to quantify the C saturation potential in California vineyards. The data set represents a wide range of soil mineralogical properties. Management practices include cover cropping, compost application, no-till, and grazing, with some practices adopted for up to 25 years. Soil organic C content across the data set ranges between 0.28 and 5.67%. To evaluate C storage potential, we plan to isolate two pools of C: particulate organic matter (POM) with a relatively fast turnover rate and mineral-associated organic matter (MAOM) associated with longer-term storage. In addition, all soil samples were analyzed for soil texture and oxalate extractable iron and aluminum. We aim to evaluate whether vineyards with a long history of regenerative management are reaching their C storage potential, and to determine the C storage deficit for participating vineyard blocks. Our findings will support new recommendations for promoting C storage in regenerative vineyards, taking into account mineralogical constraints.

Funding Support: Foundation for Food and Agriculture Research

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Arbuscular Mycorrhizal Fungal Abundance and Diversity Across Vineyards in the Western United States

Amanda Rodriguez,* Joshua Garcia, Axel Herrera, Alicia Hans, Kerri Steenwerth, Kabir Peay, Elisabeth Forrestel and Cristina Lazcano
*University of California-Davis, 387 N Quad, Davis, CA, 95616, (anrodrig@ucdavis.edu)

Arbuscular mycorrhizal (AM) fungi are a well-known example of microbial symbiosis, playing a critical role in enhancing nutrient and water uptake, improving soil structure, and supporting ecosystem resilience. In winegrape production, where a balanced nutrient supply is vital to fruit quality, AM fungi facilitate soil exploration of essential nutrients and water, helping maintain optimal vine health and fruit development without promoting excessive vegetative growth. These benefits have spurred a global market for AM fungal inoculants, valued at $996 million, to enhance soil health and crop productivity. However, commercial inoculants face significant limitations, including high rates of nonviability and reliance on only a few fungal species. This contrasts with evidence suggesting that diverse native AM fungal communities often outperform commercial inoculants, underscoring the importance of understanding native AM fungal biodiversity and its interactions with grapevines under varying conditions. However, the extent to which AM fungi symbiosis is influenced by factors such as climate, soil properties, and plant genotype remains poorly understood. This study investigates AM fungal communities across 11 vineyards along an edaphoclimatic gradient from Oregon's Willamette

**indicates corresponding author*

Enology and Viticulture Research Report Posters—CONTINUED

Valley to California's Santa Maria Valley. AM fungal colonization was assessed through traditional microscopy and community diversity data was obtained from ITS2-targeted amplicon sequencing. These metrics of abundance and diversity were correlated with soil physical, chemical, and biological characteristics. Our study observed high colonization rates in all analyzed samples. Findings show regional soil and climatic differences shape AM fungal abundance and community composition. Our research aims to guide adaptive vineyard management strategies by providing crucial insights into the spatial dynamics of AM fungal interactions in vineyards.

Funding Support: Foundation for Food and Agriculture Research, California Department of Food and Agriculture

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Linking Soil Carbon Stability and Microbial Diversity at Different Soil Depths in Northern California Vineyards

Connie Wong,* Luisa Robles Zaragoza, Bruna Albuquerque Vaz, Ivan Martinez, Axel Herrera, Joshua Garcia, Kerri Steenwerth and Cristina Lazcano
*University of California, Davis, 1 Shields Ave, Plant and Environmental Sciences Building Rm 1110, Davis, CA, 95616, (ctfwong@ucdavis.edu)

Grapevine (*Vitis vinifera* L.) cultivation contributes to soil carbon (C) stabilization, the process by which organic C is retained in soil over time, reducing its decomposition and loss. Long-term stabilization depends on the balance between C inputs and microbial-driven losses. Soil depth influences stabilization mechanisms, including physical protection in aggregates, chemical interactions with minerals, and biochemical recalcitrance. Stable mineral-associated organic carbon (MAOC) forms when microbial by-products and organic compounds bind to mineral surfaces. In topsoil, microbial activity dominates due to greater organic matter availability, while physiochemical properties may play a greater role in subsoil stabilization. However, the role of microbial communities in subsoil C stabilization remains poorly understood. We examined the vertical distribution of C pools, including MAOC and other labile pools such as particulate organic C (POC), microbial biomass C (MBC), and dissolved organic C (DOC), in three Northern California vineyards with varying ages, grape varieties, and rootstocks, but similar management and soil textures. Furthermore, we evaluated the relationship between soil physicochemical properties (texture, pH, moisture), microbial activity, and diversity. We hypothesized that MAOC content increases with depth, while the labile C pools decrease. We also hypothesized that in topsoil, MAOC formation is primarily influenced by properties related to nutrient cycling and microbial activity. In contrast, at greater depths, factors such as pH and moisture content may be influential in maintaining MAOC stability. Results show that C pools generally declined with depth, with the youngest vineyard retaining the most subsoil C. Preliminary data suggest that the vineyard with the lowest soil C exhibited smaller microbial diversity changes with depth. Multiple regression analysis will assess the drivers of C stabilization at different depths. The results of this study will lay a foundation for evaluating the effects of soil management practices on C dynamics, microbial communities, and soil properties in California vineyards.

Funding Support: Foundation for Food & Agriculture Research; California Department of Food and Agriculture - Specialty Crop Block Grant

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Enology and Viticulture Research Report Posters—CONTINUED

Untargeted Metabolomic Analysis of Heat Stress Response in Cabernet Sauvignon Grapevines

Samarth Rao, Brayden Hoke, Esther Ko, Karen Browning, Diana Zamora-Olivares* and Eric Anslyn
*The University of Texas at Austin, 2515 Speedway, Austin, TX, 78712, (diana_z.o@utexas.edu)

Worldwide, the United States is the fourth-largest wine-producing country, with 87% of grapes harvested from *Vitis vinifera* used for wine production. In Texas, where grape cultivation has a rich heritage and faces ever-increasing environmental challenges, understanding the physiological and metabolic responses of grapevine leaves to sustained heat stress is crucial to maintain crop quality and resilience. In this study, we investigated the effects of sustained heat stress on the secondary metabolite profiles of Cabernet Sauvignon grapevine leaves in a greenhouse with controlled temperatures (27 to 35°C). Experimental groups were subjected to heat treatment for 1, 3, 6, 10, and 13 days. Each heat-exposed group was further divided based on the timing of light exposure (morning versus evening), allowing us to assess the interplay between heat stress and light conditions. Control samples, harvested at corresponding time points without heat exposure, provided a baseline for comparison. Metabolites were extracted from leaf tissues and analyzed using high-resolution liquid chromatography–mass spectrometry for untargeted metabolomic profiling. Preliminary results revealed significant alterations in key secondary metabolites, suggesting that prolonged heat exposure triggers distinct metabolic reprogramming in grapevine leaves. Multivariate statistical analyses, including principal component analysis and partial least squares discriminant analysis, were employed to delineate correlations and identify potential biomarkers associated with heat-induced stress responses. This research represents one of the first efforts to discern the effects of heat stress on the secondary metabolite profiles of Texas grapevines. The findings not only enhance our understanding of stress physiology in grapevines but also pave the way for developing targeted strategies to improve crop resilience in a warming climate.

Funding Support: UT Austin

Kaolin and Zeolite Reduce Drought Damage to Gewürztraminer and Influence Berry Composition, Must Quality, and Wine Aroma

Stefano Zanoni,* Alessandro Bignardi, Sara Ammanniti, Silvia Carlin, Tomas Roman, Massimo Bertamini and Michele Faralli
*University of Trento (C3A, Centro Agricoltura Alimenti Ambiente), Via Mach 1, San Michele allíAdige, 38098, Italy, (stefano.zanoni@unitn.it)

Climate change is affecting Mediterranean viticulture regions due to frequent abiotic stress conditions such as drought and heat stress, which threaten grape and wine quality. Rock powders (Kaolin, Zeolite) have been identified as a possible adaptation strategy for abiotic and biotic stresses in grapevine. They influence leaf physiology and modify berry quality, thus wine characteristics, mainly by increasing organ reflectivity. This project assessed these rock powders' influence on grapevine physiology (leaf gas-exchange, VPDleaf); berry sunburn incidence; and berry composition, must quality, and wine aroma. We investigated 3% kaolin and 3% zeolite in a 2-yr trial (2023 to 2024) on Gewürztraminer, an aromatic cultivar in northern Italy (Trentino Alto Adige), in an east-west oriented vineyard trained to a vertical shoot-positioned trellis system and Guyot pruned (two spurs, one fruiting cane, nine buds). Rock powders were applied to both canopy sides every 14 days

**indicates corresponding author*

and after rainfall in a randomized Latin-square design (252 vines, 3 rows, 12 plots each, n = 36), with bunch-zone leaf removal (No LR, LR BBCH75, LR BBCH81). Five and six applications were carried out in 2023 and 2024, respectively. Both kaolin and zeolite reduced leaf and berry temperature ($p < 0.001$, -6°C and -4°C, respectively), significantly limiting sunburn in berries ($p < 0.05$). Leaf physiology showed few differences between treatments, likely due to vintage-specific conditions, confirming that in rainy years, rock powders do not hinder ripening or physiological fitness, while preserving quality in hot/dry years. Some significant differences in aromatic compounds were found in musts and wine, however, wine tasting revealed no perceptible differences. Future studies will focus on the terpene biosynthesis pathway (MEP, MEV) under drought and heat stress to better clarify kaolin and zeolite effects on must and wine aroma.

Funding Support: University of Trento, Lithos Crop Protect GmbH

Evaluating Methods to Measure Free and Total Sulfur Dioxide in Wine

Amanda Fleming, Erika Gomez and **Renee Threlfall***
*University of Arkansas, 2650 N. Young Ave, Fayetteville, AR, 72704, (rthrelf@uark.edu)

Additions of sulfur dioxide (SO_2) during wine production are used to maintain microbial and color stability. The three chemical forms (molecular [SO_2], free bisulfite [HSO_3^-], and sulfite [SO_3^{2-}] vary depending on wine pH, but wine should have 0.5 to 0.8 mg/L molecular SO_2. Methods for SO_2 analysis typically measure/calculate free, bound, or total SO_2 (sum of bound and free) using a standard method, aeration/oxidation (A/O) or colorimetric analysis. The accuracy, cost, and time for the A/O method and two colorimetric kits, Megazyme (Neogen®) and BioSystems, to measure free and total SO_2 in standard solution and wine (*Vitis*) samples were evaluated. For the standard solution samples, free SO_2 (12.5, 25, 50, 75, and 100 mg/L) and total SO_2 (50, 100, 200, 300, and 400 mg/L) were evaluated. For the wine samples, five co-fermentation treatments of Merlot (*Vitis vinifera*) and Noble (*Vitis rotundifolia*) wine were bottled at three molecular SO_2 levels (0, 0.8, and 1.5 mg/L) and evaluated. The A/O method cost $2.44/sample with a 25-min run time, Megazyme kits cost $5.13/sample with a 15-min run time, and BioSystems kits cost $4.50/sample with a 10-min run time. The A/O method offered accurate, timely, and cost-effective analysis of standard and wine samples. For standard SO_2 solutions, the Megazyme kit and the A/O method had the most accurate free and total SO_2, while the Biosystems kit was accurate for total SO_2, but not free SO_2. As Noble increased in wine samples, the kits had results that struggled to have total SO_2 levels that aligned with expected values. While kits provide faster options for analysis of SO_2, the reliability of the analysis differed per kit and sample type.

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Enology and Viticulture Research Report Posters—CONTINUED

Detection and Identification of Glutathionyl-Flavan-3-ol Adducts in Red Wine

Apramita Devi, Danielle J Fox, James F Harbertson and **Andrew L Waterhouse***
*University of California, Davis, Department of Viticulture and Enology, Davis, CA, 95616, (alwaterhouse@ucdavis.edu)

Astringency, a key characteristic influencing the mouthfeel of red wine, is primarily attributed to the interaction between condensed tannins and salivary proteins. Tannins could undergo structural transformations by their ability to react with various nucleophiles, such as anthocyanins, bisulfite, and glutathione (GSH), over time as the wine ages, thus affecting the mouthfeel of the wine. In this study, we hypothesize that GSH in wine may interact with C4-carbocations during the acid-catalyzed depolymerization of tannins, resulting in the formation of glutathionyl-flavan-3-ol adducts. To investigate this, we employed targeted mass spectrometry (LC-QToF-MS) analysis to identify and quantify glutathionyl-flavan-3-ol adducts in a set of 24 red wines from Washington State, aged between 1 and 20 years. Our results revealed that these adducts were most abundant in the youngest wines (1-yr-old), with a notable decrease in peak intensity as the wines aged. The results indicate that the reaction is influenced by various factors, including GSH concentration, wine pH, and tannin content, all of which significantly affect the chemical structure of tannins and may play a crucial role in modulating astringency in wines. Future studies should focus on the long-term stability of glutathionyl-flavan-3-ol adducts and their sensory implications, particularly their effect on the perception of astringency and mouthfeel in aged red wines.

Funding Support: Washington State Wine Commission

Assessing the Economic Sustainability of Regenerative Viticulture in Sonoma County

Axel Herrera,* Ellen Bruno, Kerri Steenwerth, and Cristina Lazcano
*University of California, Davis, Department of Land, Air and Water Resources, Office 3310, Davis, CA, 95616, (axherrera@ucdavis.edu)

The transition to regenerative agriculture (RA) is gaining attention for its potential to enhance sustainability in viticulture, yet questions remain about its economic feasibility and environmental impacts. This study investigates the farm-level economic implications of transitioning to RA in the viticulture sector, with an application to California's Sonoma County. We analyze data from four vineyards and evaluate the financial outcomes of implementing RA practices—such as no-till, composting, and livestock integration—compared to conventional viticulture practices. Our findings reveal that conventional and RA practices result in similar profitability over a 30-yr horizon, with RA averaging 0.54% to 1.63% lower in net present value across vineyards under the assumption of maintained yields. While in-house RA practices involve higher initial costs, they provide long-term benefits, including lower operational expenses, improved soil health, and additional revenue from sheep grazing integration. The profitability of RA is influenced by site-specific factors such as grape variety, vineyard layout, vine age, and density, as well as the ability to maintain yields or obtain price premiums that compensate for potential yield reductions. Given the variability in yield impacts across different grape varieties and vineyard conditions, site-specific assessments are crucial to inform the transition to RA.

**indicates corresponding author*

Enology and Viticulture Research Report Posters—CONTINUED

Funding Support: California Department of Food and Agriculture (CDFA) and Foundation for Food and Agriculture Research (FFAR)

High-Resolution Approaches to Vineyard Nutrient Optimization

Nataliya Shcherbatyuk, Terry Bates, Manoj Karkee, Patricia Skinkis, Paul Schreiner and Markus Keller*
*WSU, 24106 N. Bunn Rd, Prosser, WA, 99350, (mkeller@wsu.edu)

Vineyard nutrient management is essential for maintaining vine health, productivity, and fruit quality targets. However, conventional vine tissue analysis methods are labor intensive, costly, and lack standardization and the ability to describe nutrient status spatially across vineyards. Our interdisciplinary team is refining tissue sampling techniques and creating decision-support remote sensing tools for real-time assessment of vineyard nutrient status. The project has four objectives: to 1) develop non-destructive tools to measure grapevine nutrient status; 2) determine the efficiency and suitability of precision vineyard nutrient management; 3) define grapevine nutrient thresholds based on the environment and production market; and 4) extend information and estimate the economic impact of nutrient management decisions. Nutrient prediction maps based on aerial spectral imagery and tissue samples were created for California and New York, while a ground-based imaging platform was used in Washington and Oregon. Field trials with nitrogen, potassium, and magnesium additions were conducted in Washington, Oregon, and Virginia. Tissue samples were compared across different growth stages from dormancy to leaf fall. Local events by project members reached state industries and the project podcast and website had reach from the local to international scales, with the podcast having over 4600 downloads and views from more than 30 countries. Although vineyard nutrient management is challenging, this project aims to enhance monitoring across the industry by refining assessment methods, improving tissue testing, and providing new tools and insights for more effective nutrient management

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Exploring Challenges and Needs of the United States Grape and Wine Industry: A Western Region Focus

Aude Watrelot,* Cain Hickey and Patricia A. Skinkis
*Iowa State University, 536 Farm House Lane, Ames, IA, 50011, (watrelot@iastate.edu)

Emerging wine regions commonly lack necessary knowledge and skills in grapegrowing and winemaking. However, viticulture and enology expertise exists and can be coordinated and optimized to improve the resiliency of these regions and the overall United States grape and wine industry. A transdisciplinary team of researchers and extension specialists with experience in a broad range of disciplines identified the primary challenges faced by grapegrowers and winemakers in these regions, and focus was placed on understanding resource needs. An online survey was conducted using a questionnaire that gathered demographics and quantified challenges in viticulture, enology, and winery business and marketing. This survey was distributed to grape and wine industry members across the U.S. in the first quarter of 2024. Data

were analyzed and regional focus group meetings were conducted in four regions of the U.S., including West, Midwest, Northeast, and South, to discuss results and understand challenges further during spring 2024. Results of both the survey and focus group meetings were used to develop a national strategic plan for outreach/education and research. The survey and focus group results showed that while regions differ, they had common concerns. The main viticulture challenges were pest and disease management and the main enology challenges were acidity and microbial spoilage management. The evolving consumer preference was the main concern for wine marketing. More targeted research and extension programs are needed to manage those challenges in all U.S. regions. While variations existed across the states of the West region, the national challenges and needs remained consistent throughout. Findings of this project will be presented with a specific focus on the West region that includes data from OR, CA, WA, and CO.

Funding Support: U.S. Department of Agriculture, National Institute of Food and Agriculture, Specialty Crop Research Initiative Award number 2023-51181-41189

Effects of Varying Concentrations of Sulfur Dioxide at Bottling

Aude A. Watrelot*
*Iowa State University, 536 Farm House Lane, Ames, IA, 50011, (watrelot@iastate.edu)

Sulfur dioxide (SO_2) is widely used in the wine industry as a preservative due to its antimicrobial and antioxidant properties. However, growing health concerns have led to regulations that limit the total SO_2 concentration in bottled wines to a maximum of 350 mg/L. In response to consumer demand and the desire to reduce chemical inputs, winemakers often add varying levels of sulfites during bottling. Producing high-quality wine with reduced sulfite levels presents challenges, as it increases the risk of microbial spoilage and oxidation. This study investigates red wines made from cold-hardy grape varieties Petite Pearl and Marquette, produced using standard winemaking techniques and bottled with 30, 60, or 90 mg/L of free SO_2. The chemical parameters were analyzed both at bottling and after 4 mo of aging, including pH, titratable acidity, ethanol content, hue, color intensity, free and total SO_2, monomeric phenolics, tannins, and acetaldehyde contents. Results showed that higher concentrations of free SO_2 at bottling negatively affected color intensity in all wines. For Petite Pearl, wines with 90 mg/L of free SO_2 had lower acetaldehyde levels, while hue and the b* parameter increased. In contrast, no significant effects of free SO_2 concentration on hue or acetaldehyde levels were observed in Marquette wines. The study also included white wines made from La Crescent grapes and the findings will be presented. Overall, while a rational use of SO_2 can help maintain wine quality in cold-hardy red wines during aging, the effects may vary by grape variety, so further research is needed to assess the long-term effects of reduced sulfite levels on wine quality.

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*indicates corresponding author

Enology and Viticulture Research Report Posters—CONTINUED

Chemical and Sensory Effects of Turbidity, Hyperoxygenation, and Redox Potential on Grenache blanc Wines from California

Mia Pargellis, Federico Casassa, Biljana Petrova, James Nelson, Sean Kuster, Bob Coleman and Jesus Villalobos
*Wine and Viticulture Department - Cal Poly San Luis Obispo, 1 Grand Avenue, San Luis Obispo, CA, 93407, (lcasassa@calpoly.edu)

Grenache blanc wines were processed with hyperoxygenation (HO) and without, keeping it reductive using SO_2, inert gas, ascorbic acid and glutathione (RED) and adjusted to two contrasting NTU levels (low: 30 to 60; high: 280 to 320 NTU) prior to alcoholic fermentation (AF), affording four treatments: HO-lowNTU, HO-highNTU, RED-lowNTU, and RED-highNTU. After AF, average redox potentials (and total phenolics) were -90 mV (80 mg/L), -94 mV (77 mg/L), -155 mV (142 mg/L), and -170 mV (143 mg/L), for HO-lowNTU, HO-highNTU, RED-lowNTU, and RED-highNTU, respectively. The ratio between reduced (GSH) and oxidized glutathione (GSSG) peaked at 152 and 129 in RED-lowNTU and RED-highNTU, respectively, while contrastingly remained between 2 and 3 in HO treatments, highlighting the contrasting redox status of the ferments. HO resulted in decreased absorbances in the 250 to 350 nm range, but increased absorbances in the 400 to 600 nm range throughout winemaking. While most terpenes were not affected by the treatments postferment, total ester content increased by 47% and 30% in HO-lowNTU and HO-highNTU wines, respectively, in relation to their RED counterparts. The basic chemistry of the wines (alcohol, pH, volatile acidity) was not altered. Sensory results from Pivot profile indicated that RED treatments showed greater color saturation and golden hue, with matchstick aromas and bitterness. HO-lowNTU was defined by banana aroma and HO-highNTU by floral, apple, and peach aromas. Control of the redox potential affords contrastingly stylistic sensory profiles in Grenache blanc wines, with effects of much lesser magnitude observed for turbidity.

Funding Support: Couch Family Wines and J. Lohr winery

Assessing the Impact of Skin Contact, Redox Potential, and Hyperoxygenation in Albariño Wines from California

Mia Pargellis , Federico Casassa,* Biljana Petrova, Sean Kuster, James Nelson and Bob Coleman
*Wine and Viticulture Department - Cal Poly San Luis Obispo , 1 Grand Avenue , San Luis Obispo, CA, 93407, (lcasassa@calpoly.edu)

Albariño wines were produced using six fermentation treatments: pressed white control (WhiteCon; daily full-volume pumpovers starting 1/3 through fermentation); pressed white reductive (WhiteReduct); pressed white hyperoxygenated (WhiteHO; daily full-volume pumpovers); skin contact control (SkinCon; daily punch-downs starting 1/3 through fermentation); skin contact reductive (SkinReduct); and skin contact white hyperoxygenated (SkinHO; daily punch-downs). Redox potential (ORP) was monitored during hyperoxygenation (HO). HO was achieved by injecting air at a rate of 5 cubic sq ft/hr for 2 hr, as confirmed by ORP of up to 376 mV (versus <100 mV in Reduct treatments). All skin contact treatments showed levels of tannins and total phenolics ~50 times greater than White ferments, and tannins levels were generally higher than those registered in average Pinot noir wines. Postalcoholic fermentation, WhiteHO showed the lowest color. Skin contact increased terpenes and resulted in ~5-fold increases of ethyl-cinnamate (fruity, balsamic) and methyl-salicylate (minty), but decreased esters by 50, 38 and 54% in SkinCon, SkinReduct,

and SkinHO, respectively. Sensory results from Pivot profile indicated matchstick and curry aromas and the greatest overall aroma intensity in WhiteReduct wines. WhiteHO wines were defined by fruity notes (apple, lemon, melon, tropical). Skin contact increased astringency and bitterness, with enhanced minty notes in SkinReduct and coriander notes in SkinHO.

Funding Support: Couch Family Wines & J. Lohr wines

Effects of Microoxygenation and Redox Potential Control by Air Sparging During Alcoholic Fermentation of Syrah Wines

Jordan Wright, Sean Kuster, Biljana Petrova, James Nelson, Bob Coleman and Federico Casassa*
*Wine and Viticulture Department - Cal Poly San Luis Obispo, 1 Grand Avenue, San Luis Obispo, CA, 93407, (lcasassa@calpoly.edu)

Syrah wines were made with two punch-downs per day (PD), air sparging activated upon oxidation reduction potential (ORP) < -40mV (SIN), microoxygenation (MOX) at a standard rate (PAR), and double the recommended standard MOX rate (2PAR) applied during alcoholic fermentation (AF). The concentration of acetaldehyde was greater in 2PAR and PAR compared to PD and SIN. Average ORP values were -16 mV and -14 mV for PD and SIN, and -51 mV and -56 mV for PAR and 2PAR wines. No differences were found in anthocyanins between all treatments. However, wine color, tannins, and total phenolics were greater in PAR and 2PAR wines than in PD and SIN wines, suggesting losses in PD and SIN wines or enhanced preservation in PAR wines. Concurrently, levels of reduced glutathione (GSH) were more than two times greater in PAR and 2PAR wines relative to PD and SIN wines. Epicatechin was 221% greater in PD than PAR wines. Total esters were 66% greater and 55% greater in PAR and 2PAR wines relative to PD wines, but generally, there were more terpenes in PD and SIN wines. At pressing, pH, titratable acidity, and ethanol levels were not affected by any of the treatments. Volatile acidity was lower and acetaldehyde levels greater in PAR wines relative to PD and SIN wines. MOX during fermentation proved a valid tool to achieve proper phenolic extraction and preserve the ester pool of the resulting wines, likely by keeping comparatively lower ORP during alcoholic fermentation.

Funding Support: GALLO & Parsec

Chemical Effects of Oxidation Reduction Potential on Syrah, Grenache, and Mourvèdre Wines and Their Blends

Jordan Wright,* Biljana Petrova, Jesus Villalobos, James Nelson, Bob Coleman and Sean Kuster
*Wine and Viticulture Department - Cal Poly San Luis Obispo, 1 Grand Avenue, San Luis Obispo, CA, 93407, (wjwright@calpoly.edu)

Syrah (SY), Grenache (GRE), and Mourvèdre (MV) grapes were fermented in controlled (CON), reductive (RED), or oxidative (OX) fermentation (AF) environments. CON consisted of two pump-overs twice per day, RED consisted of 10-sec air sparges activated upon an oxidation reduction potential (ORP) < -80 mV, and OX consisted of 10-sec air sparges activated upon an ORP < 50 mV. ORP for CON SY ranged from -90 mV to -10 mV, CON GR from -70 mV to 120 mV, and MV from -120 mV to -40 mV. After AF, CON for each varietal were blended in equal parts (blCON) and replicated in RED (blRED) and OX (blOX) wines. There were no differences in anthocyanins, tannins, and total phenolics between CON, RED, and OX of both GRE

**indicates corresponding author*

and MV. However, there were significant differences in total phenolics (RED & CON > OX) and tannins (RED > OX) in SY. blRED and blCON had more phenolics and anthocyanins than blOX. Only blCON had higher concentrations of tannin than blOX. Differences were observed in catechin and epicatechin in MV (CON & RED > OX), while only CON > OX and RED > OX for catechin and epicatechin, respectively, in SY. CON GRE and CON MV were yellower in color than RED and OX at pressing. Overall, esters were much more abundant in RED treatments, except for ethyl isovalerate. For example, ethyl butyrate was 22% higher in GR RED than in OX. GR RED showed a 47% increase and MV RED showed a 20% increase in ethyl hexanoate compared to OX treatments. Hexyl acetate was 37% more abundant in GR RED and 58% more abundant in MV RED compared to GR and MV OX. Ethyl n-octanoate was 35% higher in MV RED than OX. Ethyl decanoate was 22% higher in GR RED and 37% higher in MV RED compared to OX treatments.

Funding Support: Couch Family Wines

Optimizing Strategies for Acid Management in Red Wines from the Central Coast of California

Charlotte Drop,* Sean Kuster, Jesus Villalobos, James Nelson and Bob Coleman
*Wine and Viticulture Department - Cal Poly San Luis Obispo, 1 Grand avenue , San Luis Obispo, CA, 93407, (cdrop@calpoly.edu)

Nebbiolo, Tannat, and Tempranillo wines from the Central Coast of California were produced using three acid management strategies with an untreated control wine. Treatments included blocking malolactic fermentation (MLFBlocked), fermentation with two strains of the lactic-acid producer *Lachancea thermotolerans* (Lach), and treatment with ion exchange (IE), followed by blending at a 30% proportion. Potassium levels in the Nebbiolo, Tannat, and Tempranillo fruit were 1400, 1650, and 2300 mg/L, while potassium levels in newly treated IE wines (before blending) were reduced to 137, 97, and 86 mg/L. Ca was also eliminated by IE. Across the three varieties, IE slightly increased titratable acidity (TA) by ~1 g/L and decreased pH by 0.30, 0.34 and 0.51 units in Nebbiolo, Tannat, and Tempranillo, respectively. MLFBlocked wines preserved their respective malic acid levels and showed on average ~1.1 g/L higher TA than control wines. MLFBlocked wines showed enhanced color, tannins, polymeric pigments, and total phenolics in Nebbiolo and Tannat wines, but not in Tempranillo wines. However, IE wines showed higher color and lower hue than control wines in all three varietals. Lach wines showed lactic acid levels ranging from 1.6 (Tannat) to 2.3 (Nebbiolo) (Laktia strain), to 5.8 g/L (Tempranillo) (Zymaflore Omega strain), and lower redox potentials than control wines (Nebbiolo: -60 and -74 mV; Tannat: -42 and -46 mV), except for Tempranillo (-78 and - 50 mV). Fermentation with Lach decreased esters by 60, 33, and 44% in Nebbiolo, Tannat, and Tempranillo, while MLFBlocked preserved or increased the ester content in the finished wines.

Funding Support: No funding

Wednesday & Thursday National Conference Poster Presentation Abstracts (Research Papers)

2025 NATIONAL CONFERENCE TECHNICAL ABSTRACTS

Enology and Viticulture Research Report Posters—CONTINUED

Haskap Variety and Winemaking Process Evaluations

Harlene Hatterman-Valenti, Aditya Anand and Brent Trela*
*NCI, 1844 10th street N, Fargo, ND, 58105, (trelab@hotmail.com)

Haskap (*Lonicera caerulea*) plants are cold-hardy, with relatively novel berries that are of increasing interest to North American fruit winemaking. Berries from 11 haskap varieties (cv. Aurora, Boreal Beauty, Boreal Blizzard, Honey Bee, Indigo Gem, Kaido, Kawai, Keiko, Solo, Taka, and Tana) were stored frozen, measured for winemaking chemical parameters (titratable acidity [TA], malic acid, pH, soluble solid content, yeast assimilable nitrogen, color, and total phenolics), and fermented into wine using different winemaking protocols: 200 g berry micro lots and 13 kg berry macro lot fermentations, comparing continuous submersion, punch-down, and accentuated cut edge (ACE) maceration regimes over 1, 2, and 5 days, with two different water amelioration levels (35% and 8 g/L TA) on the pressed juice must volumes. Total phenolic concentrations were measured and sensory analyses conducted to select and rank the intensity of attributes from sensorial differences in aroma, mouthfeel, and taste on the whole fruit, pressed berry solids marc, and the finished wines to determine phenolic extraction by maceration regime. The use of ACE and continuous cap submerged wines from frozen haskaps resulted in higher pH and more total phenolics, red color, tannin, bitterness, and astringency compared to other methods. These assessments will describe the selected commercially available haskap varieties and the effects of common winemaking process choices, characterizing their chemical and sensory impacts. They will also support approximating macro volume cellar technique results on laboratory microscale and stylistic winemaking decisions.

Funding Support: Northern Crop Institute

Ripening Kinetics and Grape Chemistry in Petit Manseng, a Non-Traditional Variety of *Vitis vinifera*

Joy Ting, Lauren Moccio, Ann Sandbrook, Beth Chang and Dennis Cladis*
*Virginia Polytechnic Institute and State University, Integrated Life Sciences Building, 1981 Kraft Drive, Blacksburg, VA, 24060, (dcladis@vt.edu)

Petit Manseng is a variety of *Vitis vinifera* valued in Virginia for its ability to consistently produce high quality grapes under variable, East Coast growing conditions. However, its high sugar and acid levels complicate dry wine production. This study characterized Petit Manseng ripening kinetics to inform harvest timing and winemaking decisions. Petit Manseng and Chardonnay were collected from veraison to harvest at six commercial sites over two years. Grape chemistry, including sugar and acid content, was analyzed for a total of 74 samples. The rate and timing of sugar accumulation and acid decline was described for both varieties, as well as the value at which physiological maturity was reached. Ripening kinetics were characterized using segmented regression analysis, principal component analysis (PCA), and linear discriminant analysis (LDA). The two grape varieties differed significantly in sugar accumulation and acid depletion throughout the harvest season. This was highlighted by the complete separation of Petit Manseng and Chardonnay grapes using PCA and the ability of LDA to correctly predict grape variety with 100% certainty using only titratable acidity and total soluble solids (TSS). However, when comparing malic acid and TSS, discrimination is lost, indicating that another acid (likely tartaric) is influencing this separation. As a result, vineyard practices to manage malic acid may not be effective in moderating acidity while cellar operations targeting tartaric acid (such as skin contact) may have more impact. Additionally, sugar accumulation in Petit Manseng results in

**indicates corresponding author*

a glucose:fructose ratio favoring fructose. Coupled with the high overall sugar concentration in Petit Manseng, a high proportion of fructose may lead to stuck fermentation and residual sugar. For winemakers seeking to produce dry style wine, use of fructophilic yeast coupled with diligent fermentation monitoring and prompt nutrient additions may be needed to successfully complete alcoholic fermentation.

Funding Support: The Virginia Wine Board

Proximal Multispectral Imaging and Artificial Neural Networks for Assessing Grape Ripeness and Quality in Vineyards

Carlos Perez Perez, Claudia Gonzalez Viejo, Sigfredo Fuentes and Juan Ignacio Valiente Banuet*
*Tec de Monterrey, Epigmenio Gonz·lez 500, Fracc, San Pablo, QuerÈtaro/76130, Mexico, (valiente@tec.mx)

The integration of multispectral proximal sensing and artificial intelligence provides a precise approach to monitor grape ripeness and quality in vineyards. Our study utilized a multispectral camera operating across six wavebands: blue (475 nm), green (560 nm), red (668 nm), red edge (717 nm), near-infrared (842 nm), and thermal (8 to 14 µm) to capture multispectral imagery that was correlated with critical grape-quality data from Cabernet, Merlot, and Parellada grape cultivars from the 2022 and 2023 vintages. The physiochemical parameters of total soluble solids (TSS), titratable acidity (TA), pH, soluble phenols, and monomeric anthocyanins were estimated using machine learning models based on artificial neural networks. Eleven models were developed, encompassing two general models for red cultivars and Parellada and nine specific models targeting individual chemometric traits. Individual models exhibited robust predictive performance, achieving correlation coefficient values above 0.80 in all models. TSS had the highest correlation coefficient of 0.96 on red cultivars, while TA had the best performance in Parellada models, with a correlation coefficient of 0.90. General models for red and white cultivars effectively predicted all parameters with correlation coefficient values of 0.91 for each one. The study confirmed the reliability of these models, demonstrating no signs of over- or underfitting. Our findings highlight the potential of artificial neural network-driven multispectral sensing to facilitate automated quality trait assessment via unmanned terrestrial vehicles, paving the way for enhanced precision viticulture practices and vineyard management.

Funding Support: Tec de Monterrey (Queretaro) Ph.D. Scholarship Secreteria de Ciencia, Humanidades, Tecnología e Inovacion (México)- Scholarship (1104865)

Profiling Texas-Grown and -Produced Wines Using Untargeted Liquid Chromatography-Mass Spectrometry-Based Metabolomics

Delaney Dyer, Samarth Rao, Nicholas Bastia, Chloe O'Patry, Diana Zamora-Olivares* and Eric Anslyn
*The University of Texas at Austin, 2515 Speedway, Austin, TX, 78712, (diana_z.o@utexas.edu)

Texas is the fifth top wine-producing state in the United States, housing eight American Viticultural Areas and contributing $20 billion annually to the Texas economy. The wines of Texas have rich chemical diversity that reflects years of cultivation by expert winemakers and viticulturists. Studying the secondary metabolites that constitute environmental stress response in grapevines and wines has revealed valuable information about the resulting sensory features in finished

wines. This information is becoming increasingly useful for winemakers to optimize wine quality and inform reproducibility across vintages. To our knowledge, no previous metabolomic studies on the biomarker profiles of Central Texas wines have been completed. The present study seeks to discover putative biomarkers in a selection of eight wines produced in Central Texas establishments using liquid chromatography-mass spectrometry (LC-MS)-based metabolomics and characterized their presence and significance in the metabolic profile of each varietal. Wine samples were collected from four vineyards in Central Texas and the metabolites were isolated via a liquid-liquid extraction. Following LC-MS submission, compound annotation in Compound Discoverer and principal component analysis and partial least squares discriminant analysis in MetaboAnalyst allowed for the identification of 537 putative biomarkers that significantly contributed to chemical differentiation in the wine samples. Resulting heatmaps and a standard data validation workflow revealed the relative concentrations and relevance of prominent biomarkers in each varietal sampled.

Funding Support: University of Texas at Austin

Deficit Irrigation Strategies for Sustainable Grapevine Production in the San Joaquin Valley: Three Years of Insights

Vincenzo Cianciola, Adan Solis, Marco Saldivar, Xavier Rideout, William Whalen, Eve Laroche-Pinel and **Luca Brillante***
*Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740, (lucabrillante@csufresno.edu)

As drought conditions intensify in the San Joaquin Valley, grapegrowers face increasing pressure to optimize water use while maintaining productivity. This study evaluates the physiological responses of grapevines to different deficit irrigation strategies over three years, providing practical guidance for sustainable vineyard management. Conducted in a commercial Cabernet Sauvignon x 1103 Paulsen vineyard, this research assessed the effects of sustained deficit irrigation (SDI) and regulated deficit irrigation (RDI) strategies during the 2022 to 2024 seasons. A semi-autonomous irrigation system monitored actual water applications using flow meters. SDI treatments supplied 40, 60, 80 or 100% of crop evapotranspiration (ET_c), while RDI treatments adjusted water availability pre- and postveraison (e.g., 100/40, 80/60, 60/100). Stem water potential and gas exchange were measured from June through harvest, with grape composition monitored from veraison onward. Yield components were evaluated at harvest. While vines receiving 40% ET_c under SDI showed significant reductions in performance compared to the 100% ET_c control, RDI strategies and SDI treatments with moderate reductions in ET_c achieved similar or improved outcomes while conserving water. This study provides critical insights into the effects of deficit irrigation on vine water status, gas exchange, berry composition, and yield. The findings offer practical recommendations for growers seeking to enhance water-use efficiency without compromising grape quality, supporting the long-term sustainability of viticulture in drought-prone regions.

Funding Support: American Vineyard Foundation; California State University - Agricultural Research Institute

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Enology and Viticulture Research Report Posters—CONTINUED

Using Proximal Sensing Technologies to Predict Grapevine Stem Water Potential in a Semiarid Viticultural Region

Runze Yu,* Jesse Anastacio, Sho Murakoshi, Seiya Nishimura, Gen Sakoda, Takashi Takinami and Hiroyuki Okita
*California State University, Fresno, 2360 E Barstow Ave, M/S VR89, Fresno, CA, 93740, (crzyu@csufresno.edu)

Water is a crucial natural resource for vineyard production due to its significance in grapevine physiology. However, increasingly frequent drought conditions have significantly hindered vineyard productivity and grape quality in California. Grapegrowers must improve water use efficiency to mitigate these effects. This study investigated the integration of both soil moisture sensing and weather station data to predict grapevine stem water potential and provide practical help for grapegrowers to schedule irrigation in a hot viticultural region in California. The experiment was conducted in a Barbera vineyard in Fresno, California during 2023 and 2024. Four irrigation treatments were applied, including 50, 75, and 100% crop evapotranspiration (ET_c) replacement, and an over-irrigated condition. Three spatial frequency domain transmissometry sensors and three time-domain reflectometry (TDR) sensors were installed at depths of 20, 37.5, and 75 cm, along with an additional TDR sensor installed at 150 cm in one experimental replicate of each treatment. Weather data was obtained from the California Irrigation Management Information System station #80 at Fresno State. Grapevine stem water potential was continuously measured on-site across both seasons to train predictive models. Permutation feature importance (PFI) analyses were performed using all collected explanatory variables. Soil moisture at 75 cm, air temperature, and relative humidity emerged as the most significant variables in the well-performing models. The partial least squares model exhibited the most consistent and robust R^2 values, achieving R^2 = 0.7084 with two variables (soil moisture at 75 cm and air temperature) and R^2 = 0.7150 with three variables (soil moisture at 75 cm, air temperature, and relative humidity) predicting grapevine stem water potential. Overall, this study can provide practical and applicable knowledge to grapegrowers in hot viticultural regions to predict grapevine stem water status for irrigation scheduling.

Funding Support: Sony Semiconductor Solutions Corporation

Improving Vineyard Resilience Against Climate Change by Trellis Selection and Applied Irrigation Amounts

Runze Yu,* Nazareth Torres, Sahap Kaan Kurtural and Justin D Tanner
*California State University, Fresno, 2360 E Barstow Ave, M/S VR89, Fresno, CA, 93740, (crzyu@csufresno.edu)

Trellis selection is crucial to establish grapevine canopy architecture in winegrape vineyards, while irrigation plays a vital role in California viticulture. However, vineyard productivity and grape/wine quality are increasingly threatened by rising temperatures and limited water availability in many viticultural regions. This study evaluated the efficacy of various trellis systems and irrigation regimes in addressing these challenges in Oakville, CA during the 2020 and 2021 growing seasons. Six trellis systems were tested: traditional vertical shoot-positioned (VSP), two relaxed VSP systems (VSP 60 and VSP 80), a cane-pruned VSP (Guyot; GY), a single high wire (SH) and a high quadrilateral (HQ). Three irrigation treatments were applied: 25% crop evapotranspiration replacement (ET_c), 50% ET_c, and 100% ET_c. The SH and HQ trellis systems required more time to establish, but once mature, achieved higher yield and fruit maturity within the same growing season. Additionally, SH and

HQ provided better canopy microclimates, reducing heat damage and preserving flavonol and anthocyanin concentrations. In contrast, VSP-based systems exhibited a greater risk of cluster overexposure to solar radiation and high air temperature. Lower water applications (25% ET_c) reduced yield but enhanced berry flavonoid concentration, suggesting a potential quality trade-off. Overall, this study highlights the need to transition from traditional VSP systems to more efficient and protective trellis systems and to adopt adaptive irrigation strategies to mitigate climate change effects and maintain grape and wine quality in warm-to-hot viticultural regions.

Funding Support: UC Davis Fellowships

Calibrating a New Short-Wave Near-Infrared Spectroscopy Sensor for Measuring Table Grape Maturity

Joy Hollingsworth* and Tian Tian
*UCCE Tulare, 4437 S Laspina St, Suite B, Tulare, CA, 93274, (joyhollingsworth@ucanr.edu)

Felix Instruments has created a handheld sensor that uses short-wave near-infrared spectroscopy and a chemometric predictive model to determine a variety of fruit composition metrics, including total soluble solids (TSS), hue, and titratable acidity (TA), non-destructively and in real time. To improve the model, a large and diverse data set was needed. Beginning in summer 2022 and continuing for the next two years, our team collected data from 16 table grape varieties in the southern San Joaquin Valley. The varieties were chosen based on their production in California, and because they represented a wide range of colors (green, black, and red) and harvest maturities (early, mid, and late season). We used the sensor to scan berries from 10 to 20 bunches from each variety, one to three times per season. We then used standard laboratory instruments (refractometer, colorimeter, and autotitrator) to measure the TSS, hue, and TA from the same grapes and submitted the data to the company. Felix Instruments then incorporated the data into their new model using a combination of independent and hold-validations. Each year saw improvements in the accuracy of the model predictions. After the data from 2024 season was incorporated, the company realized the benefit of creating three models for table grapes, one each for green, black, and red varieties. The accuracy for TSS measurements was shown to be +/- 0.69, 0.64, and 0.85 Brix for the green, black, and red varieties, respectively. For TA, it was +/- 0.12, 0.10, and 0.14 g/100 mL. For hue, it was +/- 1.98, 83.87, and 27.41°. The F-751 Table Grape Quality Meter is expected to be launched in early 2025.

Funding Support: California Table Grape Commission

Advancing Tannin Quantification in Wines: A Rapid, Reliable Approach with Machine Learning and a BioSystems SPICA Analyzer

Marilyn García Tenesaca,* Jose Morales Ariza and Andreu Tobeña Montanuy
*BioSystems, Carrer Costa Brava, 30, Barcelona/08030, Spain, (mgarcia@biosystems.es)

Wine phenolic compounds are important secondary metabolites in enology due to their nutraceutical properties, their role in development of color and flavor, and the protection they offer from oxidation and spoilage. Tannins are particularly valuable for their contribution to mouthfeel and overall wine quality. However, the quantification of tannins remains challenging due to labor-intensive and complex methods. This study proposes a new automated method to quantify precipitable tannins during winemaking that is comparable to the widely used methylcellulose

**indicates corresponding author*

precipitation manual assay (MCP). Several physicochemical analyses—including anthocyanins, total polyphenols, color indices, catechins, and absorbance at 280 nm—were performed using the automated BioSystems SPICA analyzer, alongside ethanol content and pH. These analyses were part of a collaborative effort involving multiple laboratories, including BioSystems, several wineries, and university research groups. Different grape varieties (Cabernet, Chardonnay, Syrah, Tempranillo, and others) were analyzed, sourced from diverse regions (mainly in Spain, Chile, the United States, and France) and representing different winemaking processes, encompassing both must and finished wines. This variability in data sources significantly enhanced the robustness and reliability of the study. The reference value for precipitable tannins was determined using the MCP method. Machine learning tools such as multiple linear regression with regularization methods (i.e., ELASTIC NET, RIDGE) were applied to identify and describe the relationship between variables and the MCP method. The final predictive model achieved an R^2 of 0.72 on the test set, demonstrating strong alignment with the reference method despite inherent inter-laboratory variability. The proposed statistical modeling provides a reliable, fast, automated, accessible, and cost-effective solution for tannin quantification. Its robustness under real-world analytical conditions ensures broad applicability across various laboratory settings, wine types, and vinification processes, making it a valuable tool to optimize wine quality.

Funding Support: BioSystems

A New Method for Tannin Fingerprinting and Quantification via LC-MS/MS-Electrospray Ionization In-Source Fragmentation

Yanxin Lin, Robert (Sui) Qiang, Misha Kwasniewski* and Bruce Pan
*Food Science Department, Penn State University, Penn State University, Rodney A. Erickson Food Science Building, State College, PA, 16803, (mtk5407@psu.edu)

Tannins are a critical element of red wine quality, influencing mouthfeel, astringency, and aging potential. Wine tannins are categorized into condensed tannins (CTs), derived from grape skins and seeds, and hydrolysable tannins, including ellagitannins and gallotannins, introduced through oak aging and tannin additives. However, current analytical methods lack specificity, sensitivity, or require extensive sample preparation due to their structural complexity and polymerization variability. We present the development and validation of tannin fragmentation fingerprinting (TFF), a rapid LC-MS/MS method utilizing electrospray ionization in-source fragmentation for comprehensive characterization of both CTs and hydrolysable tannins. CT fingerprints are created by applying three cone voltages (30, 110, and 140 V) in the ion source to depolymerize the CT and generate in-source ions. The depolymerized spectra that contribute most to CT differentiation are further fragmented in the collision cell, using multiple reaction monitoring (MRM). MRM transitions from analytical CT standards are correlated to target samples via multidimensional linear regression, enabling comprehensive fingerprinting while retaining chromatographic information related to compound polarity. The method accurately predicted mean degree of polymerization (mDP) across 19 mixtures of five B-type CTs (DPs 1 to 5), demonstrating high accuracy and precision. Additionally, TFF has been adapted for high-throughput quantification of hydrolysable tannins, allowing precise differentiation of ellagitannins and gallotannins. Validation across 30 white wines and

33 red wines showed a strong correlation (r^2 = 0.98) with the acid hydrolysis method, which requires over four hours of sample preparation. The TFF method has been able to differentiate wines with subtle variations in tannin composition that other established methods would miss. It also has been optimized into a high-throughput approach for routine quantification that will significantly increase the information available in studies related to wine tannins.

Funding Support: None

Enhancing Precipitable Tannin Quantification: A Validated, Ready-to-Use Alternative to Traditional Methods

Jose Morales Ariza,* Marilyn García Tenesaca and Andreu Tobeña Montanuy
*BioSystems, Carrer Costa Brava, 30, Barcelona/08030, Spain, (jmorales@biosystems.es)

Tannins are essential phenolic compounds that influence wine color, taste, and protection against oxidation and spoilage. Precipitable tannins, typically larger and more structurally complex, are closely linked to sensory attributes like astringency. Quantifying these tannins provides insights into product quality, concentration, and their impact on flavor and texture. However, tannin determination is challenging, often relying on labor-intensive, time-consuming methods or complex techniques. The BioSystems tannins (precipitable) method, based on methylcellulose (MCP) capability to bind and precipitate tannins, is a semiautomated method to quantify condensed and hydrolyzable tannins in musts and finished red wines. Validation followed OIV guidelines using the BioSystems SPICA analyzer and wines from diverse origins and grape varieties. Key parameters such as linearity, bias, recovery, precision, limit of quantification, selectivity, interferences, stability, and robustness were evaluated. Recovery tests spiked samples with commercial tannins from grape skins, wood additives, and chemical additives. A comparative study with the MCP method, as defined by the Australian Wine Research Institute, was conducted on samples with tannin concentrations from 500 to 3500 mg/L. The method demonstrated its capability to measure condensed and hydrolyzable tannins from various sources and winemaking stages with enhanced precision, thanks to automation of 280 nm readings. Equivalent tannin concentration results were obtained using the MCP method and the BioSystems kit, which also showed satisfactory recovery rates and no interference with phenolic compounds. Reagent stability was significantly improved, confirmed by stress tests at 45°C, resulting in a kit with a shelf life of at least 18 mo compared to the reference method's 7 days. The BioSystems tannins (precipitable) method provides ready-to-use, stable reagents and incorporates automation to streamline tannin analysis. By simplifying and improving tannin measurement compared to existing methods, it offers a reliable and efficient solution for monitoring tannin content in musts and red wines.

Funding Support: BioSystems

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*indicates corresponding author

Enology and Viticulture Research Report Posters—CONTINUED

Characterizing Oregon Vineyard and Winery *Brettanomyces* Strains for Spoilage Potential

C. Michael Sonza, Emily Kaneshiro, Tess Snyder, Bjarne Bartlett, James Osborne and Christopher Curtin*
*Oregon State University, 232B Wiegand Hall, 3051 SW Campus Way, Corvallis, OR, 97331, (christopher.curtin@oregonstate.edu)

Brettanomyces bruxellensis is a well-known spoilage yeast that can cause economic losses due to blending or disposal of affected batches of wine. Although producers use mitigation strategies to prevent *B. bruxellensis* spoilage, variable efficacy in prevention of spoilage still occurs. Previous research linked this to differences in sulfite-tolerance between wine strains of *B. bruxellensis*, while mostly anecdotal evidence points toward certain vineyards carrying greater risk of spoilage occurrence. The extent to which sulfite-tolerant *B. bruxellensis* strains occur in Oregon wineries is unknown and few studies have evaluated the presence of *B. bruxellensis* in vineyards around the world. This study seeks to provide insight into these knowledge gaps by evaluating spoilage potential of *B. bruxellensis* stains isolated from Oregon wineries and vineyards. Building upon previous work, we successfully isolated 46 *B. bruxellensis* from winery samples representing 13 cellars in Oregon. Additionally, while we isolated 12 *B. bruxellensis* from vineyard samples previously, an additional 288 Pinot noir cluster samples are in the process of enrichment culturing to expand our collection. These samples are from 12 Oregon vineyards spanning the 2022 through 2024 harvests. Both wine cellar and vineyard isolates will be whole-genome sequenced, and the Oregon strains will be genetically compared against reference strains from other winemaking regions of the world, with a particular focus on identification of potentially sulfite-tolerant strains. The outcomes of this study will provide wine producers with an improved understanding of the spoilage potential of *B. bruxellensis* in Oregon, which will guide informed decisions to mitigate the risk of spoilage occurrence.

Funding Support: Oregon Wine Board and Oregon Wine Research Institute

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Biofilm of *Oenococcus oeni* on Yeast Derivatives: Trigger Malolactic Fermentation, Modulate the Characteristics of Wine

Anne Flesch,* Evelyne Fonchy-Penot, Stéphanie Desroche-Weidmann and Arnaud Delaherche
*Fermentis, 7475 W Main St, Lesaffre Yeast Corporation, Milwaukee WI 53214, US, WI, 53214, (a.flesch@fermentis.lesaffre.com)

Malolactic fermentation (MLF) can occur naturally or be induced by inoculation of selected bacterial strains, most commonly *Oenococcus oeni*. Due to climate change, practices are evolving to adapt to more challenging conditions, especially increased alcohol content in wine, which is particularly harmful to the bacteria. Winemakers are deploying various strategies, including the use of newly-selected resistant lactic acid bacteria or the addition of yeast-derived nutrients to promote MLF. More recently, the use of bacterial biofilms has been described and investigated. A biofilm is a living community of one or more microbial species adhering to a surface and embedded in a self-produced polymeric matrix. However, the use of starters in biofilm form represents a major challenge, particularly because biofilms require abiotic supports (polystyrene, stainless steel, or wood) that may not be authorized additives. We have developed innovative biofilms of *O. oeni* on two different yeast-derived biotic supports: inactivated yeast and yeast hulls. The yeast derivatives have two initial objectives: immobilizing the bacteria to increase their fermentative ability and

promoting fermentation. We will present the use of these biofilms in microvinification of Syrah and in comparison with the planktonic bacteria form, with or without the use of derived products (inactivated yeast and yeast hulls) as malolactic nutrients/activators. For each of the 6 modalities we will present the growth of the bacterial cultures, the performance of the MLF, and the modulation of both the metabolome and volatilome of the resulting wines. Finally, we will discuss the potential interest of this new innovation to trigger the MLF and modulate the characteristics of the wines.

Funding Support: Funding: Author contributions: CRediT : SW, AD, EFP, YG

Enhancing Wine Acidity Through Lactic and Succinic Acid-Producing Yeast Strains

Mirjam Fischer, Annegret Cantu, Sydney Rogers, Larry Lerno, Hildegarde Heymann and Ben Montpetit*
*University of California Davis, 595 Hilgard Ln, Davis, CA, 95616, (benmontpetit@ucdavis.edu)

Climate change presents a major challenge for the wine industry because of anticipated changes in grape composition at harvest, which include higher sugar levels (i.e., increased alcohol in wine) and decreased acidity. However, many consumers continue to prefer fresh and vibrant white wine styles, which can be achieved by using novel yeasts that offer a biological solution. For example, *Lachancea thermotolerans* metabolism produces lactic acid with an associated reduction in alcohol levels. Select *Saccharomyces* strains also have metabolic outputs that include increased amounts of succinic acid. In this study, a Riesling must (pH 3.5, 22.3 Brix, titratable acidity 4.69 g/L) was fermented using strains of *L. thermotolerans* and *Saccharomyces cerevisiae* that were selected for their ability to produce lactic acid or succinic acid. A commercial *Saccharomyces* yeast (DV10) served as the control. Results demonstrate increased total acidity, ranging from 1.4 to 5.5 g/L, and reduced pH from 0.04 to 0.3 units in *L. thermotolera*ns strains and *Saccharomyces* strains compared to the control. Furthermore, a decrease in alcohol content was observed, with reductions ranging from 0.13% to 0.67% by volume. Analyses are ongoing, gas chromatography-mass spectrometry for aroma compounds and high-performance liquid chromatography for fermentation by-products (e.g., acid levels), and a descriptive analysis will be conducted with a trained panel to describe the sensory profile of the wines. The results of this bioacidification study will offer insight into using this strategy in place of chemical acidification. Wines with increased acidity levels also serve as blending partners, or as base wines for sparkling wine when higher acidity is needed. It is expected that this approach can help mitigate the effects of climate change, with further research identifying conditions, methods, and new yeasts to expand the application of bioacidification.

Funding Support: Richard M. Kunde Endowed Chair, Flossfeder Scholarship, Horace O. Lanza Scholarship, J. Lohr Fund

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**indicates corresponding author*

Identification of Novel Californian *Saccharomyces cerevisiae* Strains with Enological Potential

Sydney Rogers, Mirjam Fischer, Jackson Moore, Annegret Cantu, Larry Lerno, Hildegarde Heymann, Vivien Measday and Ben Montpetit*
*University of California, Davis, 595 Hilgard Ln, Davis, CA, 95616, (benmontpetit@ucdavis.edu)

California's wine industry faces challenges due to both climate change and evolving consumer preferences. Rising temperatures, water scarcity, and unpredictable weather affect grape composition, fermentation outcomes, and overall wine quality. Historically, California winemakers have relied on commercial *Saccharomyces cerevisiae* strains of European origin, limiting region-specific fermentation strategies. However, increasing consumer demand for sustainability and regional authenticity presents an opportunity to explore local yeast populations adapted to California's climatic conditions. This study examined 24 *S. cerevisiae* strains isolated from spontaneous Pinot noir fermentations across four AVAs (Anderson Valley, Russian River Valley, Santa Lucia Highlands, and Santa Maria Valley). These strains, classified in either the Wine/European or the novel Pacific West Coast Wine (PWCW) clade, were assessed for commercial winemaking potential through benchtop microfermentations evaluating fermentation kinetics, wine chemistry, and volatile aroma production. Three yeasts, chosen to represent the diversity of these clades, were further tested in production-scale fermentations using Russian River Valley Pinot noir grapes. The resulting wines were analyzed using descriptive analysis, gas chromatography-mass spectrometry with solid-phase microextraction for volatile aromas, high-performance liquid chromatography for organic acids, and a full postfermentation chemistry panel. Results indicate that the three chosen yeasts exhibit distinct volatile aroma profiles, with desirable fermentation kinetics and wine chemistries (ABV, pH, titratable acidity) comparable to commercial strains. Moreover, genomic sequencing data showed that the PWCW yeast clade is defined by a significant mixing of genetic material from California Oak strains and European Wine strains. The exchange of genomic information between these two yeast populations indicates that these yeasts may have been selected to carry traits better suited to California's climate. Overall, it is expected that these *S. cerevisiae* strains unique to California could serve as a valuable addition to currently-used European yeasts, supporting wine quality while enhancing sustainability and regional identity.

Funding Support: Richard M. Kunde Endowed Chair, Wine Spectator, American Wine Society Educational Foundation (AWSEF)

Enology and Viticulture Research Report Posters—CONTINUED

Strain Selection and Fermentation Timing: Shaping the Chemistry of Pinot noir Wines

Nicholas Mannino, Elizabeth Tomasino, Cole Cerrato and James Osborne*
*Oregon State University, 100 Wiegand Hall, RM 108, Corvallis, OR, 97331, (james.osborne@oregonstate.edu)

Malolactic fermentation (MLF) is a crucial step in red and some white wine production and is traditionally performed sequentially after alcoholic fermentation (AF). However, concurrent MLF, where *Oenococcus oeni* or *Lactobacillus plantarum* is inoculated early in AF, offers potential benefits such as reduced production time. While previous research showed MLF timing can influence Pinot noir aroma and mouthfeel, its impact on chemical properties remains unclear. This study examined the effects of MLF timing (concurrent versus sequential) and ML strain selection on Pinot noir composition. Concurrent MLF did not prolong AF, and it was completed faster than sequential MLF. Among ML strains, *O. oeni* Berry completed concurrent MLF the fastest, while *L. plantarum* Prime was the slowest. Acetic acid levels varied, with concurrent MLF by *O. oeni* Berry producing the highest concentration and *L. plantarum* Prime the lowest. Post-MLF analysis of color, polymeric pigment, and total polyphenolics showed minimal color differences among *O. oeni*-fermented wines, regardless of timing. However, sequential MLF with *L. plantarum* Prime resulted in higher color intensity. Polymeric pigment content was higher in sequential MLF wines, irrespective of ML strain. Additional analysis will be conducted after nine months of aging, including volatile aroma and phenolic profiling. These findings provide insights into the influence of MLF timing and strain selection on Pinot noir chemistry. Understanding these effects can help winemakers optimize MLF management to achieve desired wine styles.

Funding Support: Oregon Wine Research Institute

Influence of Packaging Material on the Properties of Carbonated Blueberry Wine Under Accelerated Storage Conditions

Nick Wendrick, Andrew MacIntosh and Katherine Thompson-Witrick*
*University of Florida, 520 Newell Dr., Gainesville, FL, 32611, (kthompsonwitrick@ufl.edu)

Wine is a complex beverage containing an array of flavor compounds generally derived from volatile organic compounds (VOCs) and basic tastes attributed to sugars (sweetness), organic acid (sourness), and polyphenols (bitterness/astringency). These components may interact with the packaging material, significantly affecting the consumer experience. Alternative packaging has been gaining popularity with consumers due to portability, convenience, and recyclability. This project investigated the chemical changes in carbonated blueberry wine packaged in aluminum cans, polyethylene terephthalate (PET), and glass bottles at accelerated temperatures (35°C) for 60 days to parse the capacities of alternative packaging. Blueberry wine was packaged in cans and bottles, and the pH, titratable acidity (TA), free and total sulfites, sugar, alcohol, color, and flavor compounds were assessed. Several analyses showed no significant difference ($p < 0.05$), including TA, pH, sugar, and alcohol. The primary VOC classes identified included alcohols, acids, aldehydes, esters, and terpenes, with a starting concentration of 64.5 mg/L. The VOC analysis showed cans (70.8 mg/L) outperforming PET (44.4 mg/L) and glass bottles (58.9 mg/L), demonstrating suboptimal flavor stability. Moreover, there was a significant difference in spectrophotometric color intensity over 60 days, with a starting value of 1.78 AU

**indicates corresponding author*

for all packages; the means of the aluminum cans, PET bottles, and glass bottles were 1.67, 2.09, and 1.84 AU, respectively. The color hue was significantly lower for cans than for both bottle types, indicating better color retention. Additionally, free (starting 46.9 mg/L) and total (starting 140 mg/L) sulfites significantly differed after 60 days, as cans outperformed glass and PET bottles in both analyses. These research findings suggest that PET and glass bottles are not the ideal packaging types for carbonated blueberry wine. However, cans exhibit minimal chemical changes over time, supporting cans as a viable alternative package.

Funding Support: Florida Department of Agriculture and Consumer Services

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Inhibition of Pellicle Formation by a Solvent-Extracted Fraction from Non-Pellicle Wine

Fumie Watanabe-Saito,* Rina Goto, Shunya Muramatsu, Youji Nakagawa, Munekazu Kishimoto, Masashi Hisamoto and Tohru Okuda
*The Institute of Enology and Viticulture, Graduate Faculty of Interdisciplinary Research, University of Yamanashi, 13-1, Kitashin-1-Chome, Kofu, Yamanashi 400-0005, Japan, (fumies@yamanashi.ac.jp)

Pellicle-forming yeasts (hereinafter, pellicle yeasts) can develop a pellicle during winemaking, leading to unpleasant odors and wine quality deterioration. In this study, we inoculated and cultivated pellicle yeasts (*Saccharomyces cerevisiae* strain YFY-1) in various commercial wines. Some wines developed a pellicle (pellicle wine), whereas others did not (non-pellicle wine). A solvent-extracted fraction from non-pellicle wine exhibited pellicle inhibitory activity. To elucidate the underlying mechanism, we analyzed the behavior of pellicle yeasts in media with and without the inhibitory fraction. In media without the inhibitory fraction, the yeast population segregated into settled and floating cells. The total number of settled cells remained stable for 7 days, while their viable cell count declined from 69% (day 1) to 27% (day 7). The total number of floating cells increased until day 5 and then plateaued, with their viable cell count rising from 24% (day 1) to 72% (day 3). In contrast, in media containing the inhibitory fraction, the total number of floating cells remained largely unchanged over 7 days. The viable cell count in floating cells decreased from 37% (3 hr postinoculation) to 15% (day 2) and remained at 15% thereafter. These results suggest that pellicle yeasts can float and persist at the air-liquid interface in non-pellicle wine while the inhibitory fraction suppresses their activity, preventing pellicle formation. This finding offers new insights into strategies for mitigating pellicle contamination in winemaking.

Funding Support: JSPS KAKENHI Grant Number 22K05539

Enology and Viticulture Research Report Posters—CONTINUED

Conversion of Diglucoside Anthocyanins to Polymeric Pigments and Their Influence on Wine

Masashi Hisamoto,* Yumeko Ota, Fumie Watanabe-Saito and Tohru Okuda
*The Institute of Enology and Viticulture, University of Yamanashi, 1-13-1 Kitashin, Kofu, Yamanashi 400-0005, Japan, (hisamoto@yamanashi.ac.jp)

The instability of anthocyanins in wines is well known. During aging, anthocyanins react with acetaldehyde and flavan-3-ols, forming highly stable macromolecular pigments. *Vitis vinifera*, primarily cultivated for wine production, contains monoglucoside anthocyanins, while non-*V. vinifera* species contain diglucoside anthocyanins. *Vitis coignetiae* and its interspecific hybrids are known for having high diglucoside anthocyanin content. However, empirical evidence suggests they are not prone to color changes in wine. Using malvidin 3-*O*-glucoside (Mv3G), malvidin 3,5-*O*-diglucoside (Mv3,5DG), and malvidin 3-(6-*O*-*p*-coumaroylglucoside)-5-glucoside (Mv3,5DG-*p*CoA), we investigated the characteristics of anthocyanin hydration, reactivity with sulfites, and polymerization to understand their influence on wine. Mv3,5DG-*p*CoA exhibited exceptional stability under model wine conditions, suggesting its potential contribution to the black-purple coloration in wine. Through forced polymerization, we found that adding acetaldehyde promoted consumption of only Mv3G and not the ethyl cross-linking polymerization of diglucoside anthocyanins. Furthermore, adding catechin resulted in the formation of an ethyl bridge between each anthocyanin and catechin. The polymerization rate constants indicated that Mv3G had the highest reaction rate and Mv3,5DG-*p*CoA polymerization proceeded more rapidly than Mv3,5DG. We also assessed the contribution of anthocyanins to wine color by measuring high molecular weight pigments in commercial wines made from wild grapes and *V. vinifera*. Our analysis revealed that *V. coignetiae* and its hybrids had minimal levels of large polymeric pigments. In contrast, the levels of small polymeric pigments were comparable to those observed in Merlot.

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A New Method to Detect Fungicide Resistance in Grape Downy Mildew Using Aseptically Cultured Plants

Takuro IWAYA, Kanako YANAGISAWA and **Kanako SASAKI***
*Institute for Future Beverages, Kirin Holdings Company, Limited , 26-1-12-12, Muraoka-Higashi 2-chome, Fujisawa, Kanagawa 251-8555, Japan, (Kanako_Sasaki@kirin.co.jp)

Grape downy mildew caused by *Plasmopara viticola* is one of the most common and significant diseases affecting grapevines worldwide. Various fungicides are commonly used to control this pathogen in the vineyard. However, resistance to many of the most effective fungicides has emerged and spread within pathogen populations, compromising disease control. Therefore, identifying resistance and its prevalence is necessary to determine strategies for resistance management. Several methods exist to detect resistance to certain fungicides, such as the leaf-disc bioassay, PCR-restriction fragment length polymorphism (RFLP), and in vitro mycelium growth test on fungicide-amended media. However, these methods have disadvantages. For instance, maintaining plants in a disease-free condition for the leaf-disc bioassay is quite challenging, the mutation implicated in fungicide resistance must be identified for PCR-RFLP, and obligate biotrophs, including *P. viticola*, cannot be evaluated using fungicide-amended artificial media. To address

**indicates corresponding author*

these disadvantages, we developed a new method to detect resistance to certain fungicides through a two-step approach. First, we developed a method to cultivate *P. viticola* using aseptically-cultured grapevines. This method allows stable maintenance of *P. viticola* and provides a continuous supply for various assays. Second, we developed a way to detect resistance of *P. viticola* to quinone outside inhibiting fungicides using aseptically-cultured plants. This method can also be applied to other fungicides. Expanding the range of diseases and fungicides covered by this method is expected to further optimize disease management.

Funding Support: Kirin Holdings Company, Limited

Screening for Fungicide Resistance in *Botrytis cinerea* from California Central Coast Vineyards

Abraham Ahumada,* Dr. Shunping Ding and Skye Reading
*CalPoly San Luis Obispo, 8125 Amapoa Ave, Unit F, Atascadero, CA, 93422, (abahumada@yahoo.com)

Botrytis cinerea is a necrotrophic fungal pathogen that causes grey mold on a large spectrum of fruit. It is responsible for bunch rot in grapes and is managed by multiple fungicide applications throughout the growing season. Repetitive fungicide applications lead to accumulation of fungicide resistance in pathogen populations. Resistance monitoring is important to preserve fungicide efficacy. In this study, an assessment of resistance levels in *B. cinerea* isolates was conducted. Isolates were collected from four vineyards on the central coast of California (Paso Robles, Arroyo Grande, San Luis Obispo, and Greenfield). Each of the 36 isolates collected was exposed to two concentrations of an active fungicide ingredient (a high and a low concentration), as well as a control treatment (no fungicide). Screening for resistance has been completed for fungicide active ingredients fenhexamid (FRAC 17) and cyprodinil (FRAC 9), with additional fungicide classes to follow. Resistance was assessed by the level of inhibition of mycelial growth. For fenhexamid, 28% of isolates were moderately sensitive, while 72% were highly sensitive. In cyprodinil, 3% of isolates were highly sensitive, 61% were moderately sensitive, 33% were moderately resistant, and 3% were highly resistant. The findings from this study will contribute to ongoing resistance monitoring efforts and provide information on fungicide management strategies to optimize the control of Botrytis bunch rot in California vineyards.

Funding Support: Cal Poly San Luis Obispo

Impact of Grapevine Red Blotch Virus Infection on Grape Cell Wall Ripening Enzymes Over Two Growing Seasons

Arpa Boghozian,* Reddy Kishorekumar, Mysore Sudarshana, Ben Montpetit and Anita Oberholster
*University of California, Davis, 595 Hilgard Lane, Davis, CA, 95616, (amboghozian@ucdavis.edu)

Grapevine red blotch virus (GRBV), a member of the *Geminiviridae* family vectored by the three-corned alfalfa treehopper, *Spissistilus festinus*, causes delayed grape ripening. Fruit softening results from cell wall enzymatic hydrolysis and pectic polysaccharide changes including transglycosylation, solubilization, and depolymerization regulated by pectin methylesterase (PME), polygalacturonase (PG), pectate lyase (PL), and ß-galactosidase. These enzymes are responsible for pectin depolymerization and solubilization, initiating the fruit ripening process. In our recent studies, it was observed

that there is an increase in the pectin fraction in fruit from GRBV-infected grapevines during ripening. In this study, we investigated GRBV's effect on enzymes related to pectic depolymerization and solubilization using fruit from virus-infected (GRBV(+)) and non-infected (GRBV(-)) vines from a commercial vineyard in Paso Robles, CA in the 2021 and 2022 growing seasons. Grapes were harvested at four time points: preveraison, veraison, postveraison, and harvest. Biochemical analyses involved measuring ß-galactosidase activity in relation to total protein content. A Student t-test compared GRBV(+) to GRBV(-) at each ripening time point within each year. In the 2021 season at veraison, GRBV(+) and GRBV(-) grapes were significantly different in ß-galactosidase activity. In the 2022 season at preveraison and postveraison, GRBV(+) and GRBV(-) grapes were also significantly different. These data indicate that there are differences in ß-galactosidase activity between GRBV(+) and GRBV(-) grapes. The differences in activity between the 2021 and 2022 seasons could be attributed to the environmental impacts on enzymatic regulation. Further investigation into these differences, and other enzyme activities such as PME, PG, and PL, are needed to understand how GRBV infection affects enzymes related to pectic depolymerization and solubilization across the growing season. It is expected that understanding the viral impact on grape enzyme activity and its correlation with berry softening will help determine mitigation strategies for the winemaking industry.

Funding Support: CDFA-PD/GWSS Board, American Society of Enology and Viticulture Traditional Scholarship, UC Davis Department of Viticulture and Enology Scholarship, NIFA Specialty Crops Research Initiative

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Enhancing Grapevine Red Blotch Virus Detection: Multi-Vineyard Model Improvement and Deep Learning Integration

Eve Laroche-Pinel, Vincenzo Cianciola, Alessandro De Rosa, Adan Solis, Marco Saldivar, Marc Fuchs and Luca Brillante*
*Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740, (lucabrillante@csufresno.edu)

Grapevine red blotch virus (GRBV) is a significant viral disease affecting vineyards, reducing fruit quality by altering sugar accumulation and phenolic composition. Accurate and timely identification is crucial for disease management and vineyard sustainability. To improve the accuracy and reliability of our previous GRBV prediction model, we expanded our data set in 2024 by incorporating data from three additional vineyards alongside our primary site. Approximately 30 vines per vineyard were tested using PCR, while drone-based VIS/NIR imaging was conducted in late September. The updated data set, consisting of 669 vines with a 60.1% infection rate, was used to retrain the model. Following recalibration, the improved model achieved a test accuracy of 78.1%, with 75% accuracy in identifying non-infected vines and 81% accuracy in detecting GRBV-infected vines. Prediction maps were generated for each vineyard and presented to growers at the end of 2024. Comparisons between model predictions, PCR results, and growers' field observations validated the maps. One grower, actively mapping GRBV in his vineyard, found strong agreement between his independent screening and our prediction map, reinforcing the model's effectiveness. New efforts also focused on improving prediction accuracy through deep learning, particularly convolutional neural networks (CNNs), which have demonstrated strong performance in vineyard disease detection. By leveraging CNNs' ability to analyze complex spectral patterns, we aim to refine disease classification and enhance spectral indicators of GRBV. These advancements will contribute to practical, data-driven solutions for early disease detection and improved vineyard management strategies.

**indicates corresponding author*

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Role of the Stomatogastric Nervous System in Controlling Feeding in Hemipteran Pests of Grapevines

Paul Cooper*
*Research School of Biology, Australian National University, EE, Bld 46, Research School of Biology, The Australian National University, Canberra/A.C.T./2601, Australia, (paul.cooper@anu.edu.au)

Several insects feed on grapevines, leading to plant damage, decreased yield, and potential disease spread. Scale insects, mealy bugs, and leafhoppers are all members of the Hemiptera, a taxon that feeds by inserting their stylet (modified mouthparts) into the leaves and feeding on various parts of the plant. The control of feeding is regulated by the stomatogastric nervous system controlling the muscles of the head. Our work examined the muscle structure using traditional histological techniques combined with modern three-dimensional examination using microcomputer tomography. By including immunohistochemistry to trace the nerves that innervate muscles within the head and around the foregut (precibarium and cibarium) along with the 3D computer tomography, the control of the muscles that generate the pressures necessary to extract the plant nutrients may show how these insects feed at the cellular level. It is hoped that this work will indicate novel ways that lead to limiting insect damage using novel methods. As our previous work has shown how some grape cultivars are resistant to scale insect outbreaks, it is hoped that we can understand how the chemicals that are involved with this resistance may lead to a reduction of feeding as a result of interfering with the muscular movements necessary for feeding.

Funding Support: Research School of Biology, Australian National University

Integrating UV-C and Canopy Management for Grape Powdery Mildew Control

Jesse Stevens, Michelle Moyer* and Maria Mireles
*Washington State University, 24106 North Bunn Road, Prosser, WA, 99350, (michelle.moyer@wsu.edu)

The germicidal effects of UV-C light (254 nm) have been used as a method of grape powdery mildew (*Erysiphe necator*) suppression in multiple crops, including grapevines (*Vitis vinifera*). The use of UV-C light in Washington vineyards may help mitigate fungicide resistance by introducing new methods to expand IPM strategies for grape diseases. However, since the application of UV-C cannot be adjusted like traditional sprays (i.e., changes in water or air volume), information is needed on how grapevine canopy management influences the effectiveness of UV-C light applications. In 2023 and 2024, we conducted a study on the effectiveness of hybrid fungicide/ UV-C regimes and canopy management techniques on powdery mildew management. The study included integrated once and twice a week UV-C applications (200 J/m^2) during the powdery mildew "critical window" (start of bloom to 4 wk post full-bloom), an unsprayed control, and a sprayed grower control. Within each of these management regimes, we also nested and compared disease control between canopy management strategies, including shoot thinning, shoot thinning + early fruit zone leaf removal, and a no canopy management control. In both years,

canopy management did not help nor hinder disease severity in an already effective mildew management strategy, including both UV-C regimes and the grower control (p = 0.75). Canopy management did, however, have a significant effect in reducing mildew severity in the high-disease pressure unsprayed controls (p < 0.0001). Yield and fruit quality differences were primarily due to differences in fungicide treatments, not canopy management. This information re-verifies the usefulness of UV-C light as a method of grape powdery mildew control and highlights the effectiveness of canopy management in high-disease pressure situations.

Funding Support: Washington State Grape and Wine Research Program, Washington State University Auction of Washington Wines, Washington State wine grape growers and winery through the Washington State wine commission, Northwest Center for Small Fruits Research

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Effects of Air and Nitrogen Gas Mixing During Alcoholic Fermentation on the Oxidation-Reduction Potential and Chemical Outcomes of Syrah Wines

Dallas Parnigoni, Federico Casassa,* Sean Kuster, Bob Coleman and James Nelson
*Wine and Viticulture Department- Cal Poly San Luis Obispo, 1 Grand Avenue, San Luis Obispo, CA, 93407, (lcasassa@calpoly.edu)

Syrah wines were produced using three cap management protocols consisting of gas mixing with nitrogen (N_2) gas and air, with contrasting bubble sizes during alcoholic fermentation. These were: air injections through 2 µm pore size sinter elements (AirMixSinter, two 1 hr additions/day), air injections through 3 mm tubing (AirMixTubing, two 1 hr additions/day), and simultaneous air injections through a sinter element and N_2 gas injections through 3 mm tubing (MixGas, two 1 hr additions/day). Oxidation-reduction potential (ORP) was monitored in all treatments throughout alcoholic fermentation. AirMixSinter wines exhibited the highest mean ORP (105 mV), followed by MixGas (62 mV) and AirMixTubing (28 mV). At day 6 postcrushing, reductions in anthocyanins of 20% (AirMixSinter) and 16% (MixGas), reductions in tannins of 17% (AirMixSinter, MixGas), and reductions in total phenolics of 14% (AirMixSinter) and 12% (MixGas), compared to AirMixTubing wines were observed, which were maintained up to pressing. At pressing, AirMixSinter wines showed 22% reductions in flavonols, but insignificant reductions in flavan-3-ols when compared to AirMixTubing wines, suggesting preferential oxidation pathways. There were no differences between MixGas and AirMixSinter wines in flavonols or flavan-3-ols at pressing. While AirMixSinter and AirMixTubing wines showed no significant difference in total volatiles, MixGas wines showed the fewest concentrations of volatiles at pressing, with 18% and 20% reductions when compared to AirMixSinter and AirMixTubing wines, respectively, suggesting greater volatile purging with simultaneous N_2 gas injections in MixGas wines, which effectively had double the volume of gas injected compared to the other treatments. Varying air bubble size had marked effects on ORP response and phenolic losses, despite equal volumes and flow rates, while supplementary N_2 mixing had negligible effects on phenolic extraction under the given size and temperature conditions.

Funding Support: Couch Family Wines

**indicates corresponding author*

Hyperspectral Phenolics: Exploring the Covariation between Leaf and Berry Reflectance and Berry Chemistry

Alexandra Basquette,* Chris Wong, Jessie Lyons, James Campbell, Elisabeth Forrestel, Troy Magney and Fallon Ely
*University of California Davis, 392 Old Davis Rd, Davis, CA, 95616, (azbasquette@ucdavis.edu)

To track grape chemistry development across the growing season and ultimately determine harvest timelines, berries must be sampled regularly and analyzed across broad spatial and temporal scales. To reduce reliance on this time-consuming method, proximal sensing techniques have been employed to determine potential covariation between plant reflectance signatures and chemical indicators of berry ripeness and phenolics. This study relates both foliar and berry reflectance data to primary (titratable acidity [TA], total soluble solids [TSS], pH) and secondary (anthocyanin, flavonols, tannins) berry chemistry metrics. Developing reliable means to predict grape phenolics benefits the industry, as current methods require much time, cost, and expertise to measure accurately. Over the 2023 to 2024 growing seasons at the Robert Mondavi Institute Vineyards at UC Davis, six sampling time points were selected between version and harvest for the collection of berry samples and spectral reflectance data on 17 red grape varieties across 42 vines. One hundred forty berries were sampled per vine, with 60 being processed immediately for primary chemistry metrics (TA, pH, and TSS) and the remainder being frozen for later phenolic analysis. A Spectra Vista Corporation (SVC) spectroradiometer with a range of 400 to 2500 nm was used to take three foliar scans and three scans of collected berry samples for all study vines on the same date of berry sampling. Phenolic data was processed using high-performance liquid chromatography after undergoing acetone extraction. These data will be analyzed via a partial least squares regression model to identify the spectral bands or regions that best predict berry chemistry. Preliminary results indicate success in predicting tartaric acid data across the growing season (Wong et al. 2025). This study builds on previous work by including phenolic chemistry and berry spectra, as well as increasing postveraison measurements across multiple growing seasons.

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Enology and Viticulture Research Report Posters—CONTINUED

Wine Technical Tasting Reveals No Yield-Specific Sensory Relationship in Pinot noir Crop Load Trial

Patricia Skinkis,* **Ainsley McCollum**, Elizabeth Tomasino and James Osborne
*Oregon State University, 2750 SW Campus Way, 4017 Ag & Life Sci Bldg, Corvallis, OR, 97331, (patricia.skinkis@oregonstate.edu)

Low yields have been synonymous with quality in premium wine production, and this is often achieved through thinning clusters to reach target yields. Premium Oregon Pinot noir is known for quality and vineyards have been heavily cluster-thinned to achieve low target yields for decades. However, producers began to question the validity of this practice for fruit and wine quality, especially with raising production costs. To address this, a 10-yr project was conducted in more than 20 Pinot noir vineyards in Oregon's Willamette Valley from 2012 to 2021. Wines produced from replicated vineyard trials at collaborator vineyards were evaluated in a double-blind technical tasting in 2019. This tasting event included winemakers, enologists, and other vineyard and winery staff in horizontal and vertical tastings of 63 wines from 2014 to 2017. A total of 58 participants were involved in the vertical tasting (three vintages by one producer). Participants were then split into three groups for horizontal tastings of multiple producers by vintage, focusing on 2014, 2015 and 2016. Quantitative and qualitative results by individual and group discussion were analyzed from all tastings. Results show that there was no clear preference based on crop yield and the most-preferred wines were not always the lowest yield. There was no clear trend of lower yield resulting in distinctly better color, aroma, taste, or mouthfeel. However, mouthfeel was the most common reason for wine preference. This work shows that yield management for quality is not straightforward, as seasonal weather conditions, vineyard characteristics, and winemaking team have the greatest impacts on wine sensory results.

Funding Support: Oregon Wine Board, OSU Viticulture Extension, and Erath Family Foundation Undergraduate Scholars Program

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Evaluating the Sensory Impacts of Fermentation Techniques on Tropical Fruit Aroma in Chardonnay Wines

Mara Anton, Camilla Sartori, Amanda Dupas De Matos and Elizabeth Tomasino*
*Oregon State University, 100 Wiegand Hall, Corvallis, OR, 97331, elizabeth.(tomasino@oregonstate.edu)

Tropical fruit aromas in white wine have been identified as positive sensory qualities by wine consumers. This research expands upon previous work by investigating how a fermentation temperature gradient and cold soak techniques affect aroma development in Chardonnay wine. This work continues on from the first year of techniques to determine if these treatments result in similar sensory qualities for an additional vintage. Chardonnay grapes from the 2024 vintage in the Willamette Valley, Oregon were used. Five treatments were used: (1) control (no skin contact) with fermentation at 13°C, (2) control with fermentation at 20°C, (3) 24 hr skin contact with fermentation at 20°C, (4) Control (no skin contact) with fermentation at 20°C for 5 days, then at 13°C thereafter, (5) 18 hr skin contact with fermentation at 20°C for 5 days, then at 13°C thereafter. Sensory evaluations were conducted using a consumer panel to include overall acceptance, emotional response, and a check-all-that-apply (CATA) characterization for aroma description that contained 19 aroma target words. Samples from each treatment were taken at the time of sensory evaluation to identify and quantify aroma compounds present that have previously been identified as contributors to the target aromas evaluated in the CATA

**indicates corresponding author*

characterization. These results will be compared to sensory evaluation measurements to provide both a chemical and sensory profile of the six treatments, and to similar results from a previous vintage.

Funding Support: Oregon Wine Research Institute and Erath Family Foundation Undergraduate Scholars Program

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Effect of Training System and Pruning Severity on Teroldego Grapevines in the San Joaquin Valley, California

Marnelle Salie,* Runze Cliff Yu, Qun Sun, Keith Striegler and Sonet Van Zyl
*GALLO, 600 Yosemite Blvd., Modesto, CA, 95354 & Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740, (marnelle.salie@ejgallo.com)

Proper training and pruning systems are crucial to winegrape production. These viticultural practices affect vine physiology, yield, fruit composition, and wine quality. However, for the *Vitis vinifera* variety Teroldego, studies have not been conducted on the appropriate training and pruning method for the San Joaquin Valley of California. Teroldego is primarily used for red blends due to its high anthocyanins and mild tannins. Traditionally, it is head-trained and cane-pruned, a very expensive way to farm winegrapes due to the rising cost of hand labor. In this trial, Teroldego was evaluated using two training/pruning systems: head-trained/cane-pruned and cordon-trained/spur-pruned from 2021 to 2023 on a quadrilateral trellis. Each training system treatment received three levels of pruning severity: five, 10, and 15 retained nodes per 0.45 kg of pruning weight to compare both methods equally through balanced pruning. Yield, vegetative growth, pruning components, fruit composition, wine quality, and economic performance were evaluated. Yield and yield component results showed significant vintage interactions, but pruning severity had the greatest influence on cluster number per vine, leading to greater yields in treatments with more retained nodes. Fruit composition differed among treatments due to crop load, but all treatments achieved target maturity and were within industry quality standards. Shoot density was greater with more retained nodes; however, no consequences were observed in the fruit or wine. For growers, switching from head-trained/cane-pruned to cordon-trained/spur-pruned systems allows more vineyard mechanization and ~76% savings on pruning costs. This trial shows an opportunity for Teroldego to be grown more economically in the San Joaquin Valley by lowering operational costs while maintaining viable yields and equivalent quality.

Funding Support: GALLO

Enology and Viticulture Research Report Posters—CONTINUED

Evaluation of Seven Rootstocks Under Drought and Saline Condition for Wine Varieties in the Southern San Joaquin Valley

Shijian Zhuang,* Karl Lund, Matthew Fidelibus and Philippe Rolshausen
*University of California Cooperative Extension at Fresno County, Suite 210-B, 550 E Shaw Ave, Fresno, CA, 93710, (gzhuang@ucanr.edu)

Soil salinity and saline groundwater are primary challenges for viticulture in the western San Joaquin Valley, which accounts for 60% of winegrape production in California. Great uncertainty regarding availability of surface water and continuing drought have jeopardized sustainable grape production in this region. Unpredictable winter precipitation and limited outsourced water for leaching have made the saline condition more severe. Boron is the main concern of toxicity for this region. A three-way (two varietals x two irrigation regimes x seven rootstocks) split-block field trial was established in 2020 at the UC Westside Research and Extension Center near Five Points. Two varietals (Barbera and Colombard) and seven rootstocks (1103P, 140 Ruggeri, Ramsey, GRN3, Freedom, RS3, and own root) were replicated four times with seven vines designated as an experimental unit. Two irrigation regimes were used: 40% ET_c and 80% ET_c from budbreak to harvest. Freedom had the most accumulated yield and the largest canopy size, measured by pruning weight, and less B in the plant tissues. Rootstocks mainly affected berry pH and titratable acidity, while berry total soluble solids were affected more by yield. Water deficit caused yield reduction by reducing berry weight, while also reducing pruning weight. No interaction of rootstock and irrigation regimes was found. The two-year results highlighted the challenges of growing grape in such saline conditions and the importance of selecting the optimum rootstock for better vine growth and crop production.

Funding Support: CA Grape Rootstock Commission

*indicates corresponding author

Enology and Viticulture Research Report Posters—CONTINUED

Understanding Spatial Variability of Vine Yield Components in Sonoma County Cabernet Sauvignon Vineyards

Riley Hibbard, Brent Sams,* Mahyar Aboutalebi, Luis Sanchez and Nick Dokoozlian
*GALLO, 1541 Cummins Dr, Modesto, CA, 95358, (brent.sams@ejgallo.com)

Vineyard yield has been shown to vary spatially by 10x in a single vineyard, but individual yield components (berry weight, clusters per vine, etc.) have not been widely studied spatially at the commercial scale. These yield components are extremely important as it is imperative to have accurate counts and weights for good estimates of final yield. In the highly manipulated vineyards of Sonoma County, California, clusters per vine may vary less than in mechanized vineyards of higher-production regions like the Central Valley, but differences in yield are still present. In 2024, yield components were collected from five Cabernet Sauvignon vineyards in northern Sonoma County at four phenological stages: bloom (cluster count only), fruit set, veraison, and commercial harvest. Plots were distributed according to a histogram analysis of a normalized difference vegetation index derived from a Sentinel 2 image from mid-June of the 2023 season to ensure data were captured across different canopy sizes (high, medium, low). Cluster counts were found to be relatively stable across vigor classes and time points, but berry weights, berry counts, and rachis weights varied by canopy size. Berry size increased as the season progressed in all vigor classes, but differed by canopy size, with the rate of increase slower in low vigor canopies. Further work will focus on identifying causes of different rates of berry growth by canopy vigor.

Funding Support: GALLO

Enology and Viticulture Research Report Posters—CONTINUED

Strategies to Mitigate Heat Stress and Delay Berry Ripening in Grape Production Amid Climate Change

Guadalupe Partida, Luca Pallotti, Vincenzo Cianciola, Alessandro De Rosa, Marco Saldivar, Xavier Rideout, William Whalen and Luca Brillante*
*Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740, (lucabrillante@csufresno.edu)

Global warming increasingly threatens grape production in regions like California's Central Valley. Late-season practices aimed at reducing photosynthetic efficiency may enhance vine resilience and delay ripening. Over three years, this study compared an untreated control (C) with applications of pinolene (P) and diatomaceous earth (D), as well as a novel shoot twisting (T) treatment designed to mimic the benefits of topping while preventing excessive cluster exposure. Measurements of leaf area, light interception, midday stem water potential, and gas exchange were collected throughout each growing season. Berry ripening progression and grape production at harvest were also assessed. Shoot twisting led to desiccation of the upper portion of the shoot, reducing leaf area while maintaining low irradiance in the fruiting zone. Stem water potential data indicated that D, and particularly T, alleviated stress conditions, while P negatively affected vine water status. D significantly influenced gas exchange, increasing transpiration and stomatal conductance, resulting in a trend toward improved water use efficiency. Additionally, D and T treatments promoted higher berry weights in the first half of the season, likely due to improved water status, while P had the opposite effect. All treatments altered berry ripening dynamics, leading to higher titratable acidity and lower must pH without reducing yield. These findings demonstrate that modifying traditional, easily mechanizable practices—such as topping—and incorporating new products like diatomaceous earth are effective strategies for mitigating summer heat stress and delaying ripening in hot, arid regions.

Funding Support: Bronco Wine Co. Chair in Viticulture

Physiological and Ripening Responses of Cabernet Sauvignon to Plant Growth Regulators Under Drought and Heat Stress

Adan Solis, Guadalupe Partida, Vincenzo Cianciola, Alessandro De Rosa, Marco Saldivar, Xavier Rideout, William Whalen and Luca Brillante*
*Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740, (lucabrillante@csufresno.edu)

High temperatures and water stress can significantly affect vine physiology and grape ripening, highlighting the need for effective strategies to optimize plant responses. Plant growth regulators (PGRs), including abscisic acid (ABA), ethylene, and salicylic acid, have been proposed to modulate stress responses and ripening processes in grapevines. However, their comparative effects in winegrapes remain underexplored. This study aimed to evaluate their influence on gas exchange, water stress tolerance, and grape composition in commercial settings. A field trial was conducted in a commercial Cabernet Sauvignon (*Vitis vinifera* L.) vineyard grafted onto 1103P rootstock in the Central Valley of California, a hot and arid climate, using a randomized complete block design with ABA, ethephon, and salicylic acid applied at veraison alongside an untreated control. Physiological responses were assessed throughout the ripening period, including leaf gas exchange, and midday stem water potential. At harvest, fruit composition—including total soluble solids (TSS), pH, and titratable acidity—was analyzed using high-performance liquid chromatography, while yield components were recorded. Salicylic acid-treated vines exhibited lower

**indicates corresponding author*

stress levels, indicated by fewer negative midday stem water potential values than the control. In contrast, ethephon-treated vines had more negative midday stem water potential values, suggesting increased water stress. In the early ripening phase, salicylic acid increased An and gs, but these parameters declined in the later stages. ABA-treated vines exhibited higher TSS at harvest, while no significant effects on yield were observed across treatments. These findings suggest that salicylic acid can enhance stress tolerance and early-season carbon assimilation, while ABA can accelerate sugar accumulation without affecting yield. The study provides insights into the potential role of PGRs in modulating vine stress responses and ripening dynamics under field conditions. Further research is needed to refine application strategies and assess their long-term effect on vineyard performance.

Funding Support: Bronco Wine Co. Chair in Viticulture

Effects of Calcium Carbonate and Diatomaceous Earth on Vine Physiology and Grape Composition in a Hot, Arid Climate

Marco Saldivar, Guadalupe Partida, Vincenzo Cianciola, Alessandro De Rosa, Adan Solis, Xavier Rideout, William Whalen and Luca Brillante*
*Department of Viticulture and Enology, California State University Fresno, 2360 E Barstow Ave, Fresno, CA, 93740,
(lucabrillante@csufresno.edu)

High temperatures and water stress can significantly affect vine physiology and grape quality, highlighting the need for effective mitigation strategies. Particle films such as calcium carbonate have been explored as potential tools to improve plant resilience under challenging environmental conditions. A field trial was conducted in a commercial Cabernet Sauvignon (*Vitis vinifera* L.) vineyard grafted onto 1103P rootstock in the Central Valley of California, a hot and arid climate, using a randomized complete block design with calcium carbonate and diatomaceous earth applied twice—at veraison and two weeks later—alongside an untreated control. Throughout the ripening period, physiological parameters such as net assimilation, stomatal conductance, and leaf temperature were monitored. The grape composition was measured routinely during ripening, including total soluble solids (TSS), pH, titratable acidity (TA), and anthocyanin profiles, while yield components were analyzed at harvest. Calcium carbonate slightly improved net assimilation in the second half of ripening, but had no effect on stomatal conductance. The control treatment exhibited slightly higher leaf temperatures during this period. Vines treated with diatomaceous earth exhibited consistently lower stem water potential throughout the experiment, beginning from an initially lower baseline, indicating a persistent trend rather than a treatment-induced response. Yield was not affected by either treatment. Regarding grape composition, calcium carbonate-treated vines produced fruit with higher pH and lower TA, which may be undesirable, while TSS remained similar in all treatments. These findings indicate that while calcium carbonate enhanced leaf carbon assimilation, it negatively affected berry acidity and pH balance. Diatomaceous earth-treated vines exhibited persistently lower stem water potential throughout the experiment, originating from an initially lower baseline, suggesting a consistent trend without clear physiological benefits. Further research is needed to determine whether these treatments could be optimized or if alternative approaches may be more effective in vineyard management under varying climatic conditions.

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Wednesday & Thursday National Conference Poster Presentation Abstracts (Research Papers)

Enology and Viticulture Research Report Posters—CONTINUED

Cold Damage May be a Game of Probability

Ben-Min Chang,* Brad Estergaard and Steve Marsh
*Agriculture & Agri-Food Canada - Summerland Research & Development Centre, 4200 Highway 97 S, Summerland, British Columbia, V0H 1Z0, Canada, (ben-min.chang@agr.gc.ca)

Weakened polar vortex was the cause of 2022 and 2024 cold snaps in North America. The bulk of the freezing air from the arctic area spilled into the midlatitude region and caused extreme low air temperature with prolonged exposure. For example, the duration of the 2022 event with air temperature lower than -18°C lasted 42 hr at Summerland Research & Development Centre in the Okanagan Valley, British Columbia, Canada. Conventionally, the lowest temperature during the event is used to estimate damage. However, cases with greater-than-expected damage were observed in the affected regions. Previously, we observed the time to kill 50% of sampled buds increased at higher exposure temperature. The results suggested exposure temperature might determine the probability of bud death. To quantify the probability, we treated Merlot buds with 12 sets of constant temperature exposure at 1°C increments from -22°C to -11°C for 24 hr. Samples were taken when LTE50 were between -22.3°C and -22.8°C. Bud damage could be observed in the treatment experiencing average temperature at -12.3°C. The survival rate plummeted at temperatures below -15°C. We did not observe surviving buds after 24-hr exposure at -21.4°C. The survival rate of primary and secondary buds against exposure temperature can be described using the Hill equation. We then simulated the conventional cold hardiness testing process with temperature ramping from -6°C to -25°C at a rate of -3°C/hr. The bud survival probability in every 15-min exposure step was calculated. The simulated LTE50 was at -22.8°C. With the probability approach, we may develop a bud damage estimation tool. However, long-exposure experiments on buds during acclimation or de-acclimation phases are required.

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*indicates corresponding author