Technical Abstracts

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AMERICAN SOCIETY
FOR ENOLOGY AND
VITICULTURE

Technical Abstracts

Wednesday, June 28

Thursday, June 29

Wednesday, June 28 & Thursday, June 29

NOTE: Pages 1-42 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.

Alphabetical Listing of All Authors with Submitted Abstracts

Enology—Microbiology Session

Quantifying the Effect of Microbial Terroir on Wine

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Terroir is the relationship between the characteristics of a wine and its geographic origin. Early research into terroir focused on geographic differences in climate, soil, and human practices. A growing understanding of wine-associated microorganisms has led to more studies focused on the microbial contribution to terroir. Investigations into the role of microbial terroir have used modern sequencing technologies to determine that microbial populations from different geographic areas contain different microbes. While these studies consider microbial population variations as evidence for microbial terroir, the quantitative effects of these different microbial populations on wine chemistry, aroma, or flavor are typically not measured. The goal of this study was to quantitatively evaluate the role of microbial terroir in wine, including its effects on wine chemistry and sensory perception. Over two years, grapes were sampled immediately before harvest from 29 vineyards in six key wine regions across three states in the northeastern United States. To specifically evaluate the contribution of diverse microbial populations, microorganisms were collected from each grape juice sample, then inoculated into an identical, sterile grape juice. Samples were taken throughout fermentation to monitor fermentation kinetics and population dynamics using metagenomic sequencing, while chemical and sensory analysis was conducted on the finished wines. The quantitative effects of inoculation timing on the chemical and sensory properties of the resulting wines were also evaluated. These results will provide winemakers with applicable knowledge for making data-driven decisions during wine production, including risk mitigation.

Funding Support: E & J Gallo Winery. Startup funds provided by Cornell University

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Microbial Contributions to Regional Wine Typicity and Potential Consequences of Climate Change

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Microbial communities play a core role in the quality of agricultural products, with measurable effects on nutrient availability and plant disease resilience. The wine industry is particularly dependent on the role microbial communities play during fermentation, transforming grapes to wine, and how they contribute to the quality of wine produced. Previous research reports microbial community composition correlates with wine chemical properties. In combination with microbial community differentiation by geographic region, there is now compelling evidence of a microbial aspect to wine regional typicity, or terroir. However, climate change models predict temperature increases for all winegrowing regions in New Zealand. Temperature can alter microbial species interactions and community dynamics in model communities, but how this translates to microbial communities of significance for wine styles is unknown. We predict that increases in temperature will change the composition of microbial communities in New Zealand vineyards and are interested in their interaction with vine physiology and effects on wine characteristics, including regional wine typicity. Using a combination of field and laboratory-based experiments, we will evaluate aspects of microbial community ecology and population biology to understand how temperature shapes microbial communities associated with vines and winemaking, and how these differences might affect wine chemical composition. By understanding changes in microbial communities and plant phenotypes in response

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to climate change, the New Zealand Wine Industry will be better prepared to implement strategies to adapt to potential changes in regional wine styles with the aim of retaining their current reflection of regional wine typicity.

Funding Support: New Zealand Winegrowers Bragato Research Institute University of Auckland

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Effect of Sequential Inoculation with *Pichia kluyveri* on Fermentation Kinetics and Chemical Composition of Varietal Wine

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Non-Saccharomyces yeasts are increasingly being used to diversify wine flavor profiles by producing metabolites that modulate the aroma, taste, and mouthfeel of wines. Among the currently available non-Saccharomyces yeasts, Pichia kluyveri stands out for developing a film on the surface of wine during the first days of fermentation, producing fermentative metabolites such as esters, thiols, and glycerol, and reducing ethanol. These effects may be susceptible to the inherent juice quality of different grape varietals. The aim of this research is to assess the effects of sequential inoculation with P. kluyveri on the fermentation kinetics and chemical composition of red and white wines. The experimental design included four grape varietals (Chardonnay, Cabernet Sauvignon, Muscat, and Zinfandel) and two fermentation styles (sequential inoculation with P. kluyveri followed by *Saccharomyces cerevisiae* and traditional inoculation with only *S. cerevisiae*). All treatment conditions were done in triplicate. Fermentation curves showed that sequential inoculation wines could take one to three additional days to finish fermentation due to the extended lag phase induced by the development of P. kluyveri. The fermentation rates during the *S. cerevisiae* stage were not affected by the sequential inoculation treatment. The effect on pH, residual sugars, volatile acidity, ethanol, and glycerol was heterogenous within varietals. Ongoing sensory evaluation is expected to reveal key attributes and preferences between the fermentation styles using a consumer panel.

Funding Support: CSU Agricultural Research Institute Gusmer Enterprises

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Using Non-*Saccharomyces* Yeast for pH Reduction during Wine Fermentations of Chambourcin Grapes from a Warm Growing Region

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Like many cultivars in the United States, Chambourcin (*Vitis* hybrid) grapes from warmer growing regions can have high pH at harvest, thus affecting wine quality. Acid additions or malolactic fermentation (MLF) can modify wine pH; however, non-*Saccharomyces* yeast, such as *Lachancea thermotolerans*, can modify pH, acidity, and other attributes during wine production. In 2021, 168 kg of Chambourcin grapes grown commercially in Arkansas were harvested and transported to the University of Arkansas System Food Science Department for wine production. The grapes were randomized into batches, crushed, and destemmed. Four inoculation treatments in duplicate were conducted using *Saccharomyces cerevisiae* (SC) with and without malolactic cofermentation (SC-MLF) and *L. thermotolerans* in a sequential inoculation with *S. cerevisiae* (LT-SC) with and without malolactic cofermentation (LT-SC-MLF). Basic composition, sugars, and organic acids were evaluated daily during

fermentation for 14 days at 21°C, with all inoculation treatments completing fermentation in six days (total sugars <0.3%). Prior to inoculation, soluble solids, pH, and titratable acidity (TA) were 18.78%, 3.51, and 0.73%, respectively, with the main acids as tartaric (0.31%) and malic (0.44%). Regardless of MLF, by fermentation day six, TA, lactic acid, and total organic acids were higher in LT-SC wines than in SC wines, while the pH of LT-SC wines was lower than SC wines. From fermentation day 0 to bottling, use of *L. thermotolerans* in Chambourcin wine production resulted in changes in acidity attributes, with reduced pH (~4%) and malic acid (~10%) but increased TA (~55%), lactic acid (64%), and total organic acids (~58%), regardless of MLF. Mixed fermentations with *L. thermotolerans* and *Saccharomyces* yeasts produced wines with lower pH and higher acidity, contributing to microbial and color stability while providing winemakers with options for producing more complex wines.

Funding Support: Lallemand, Inc

Timing of Nitrogen Addition on Chardonnay Fermentation with Sequential Inoculation of *M. pulcherrima* and *S. cerevisiae*

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Metschnikowia pulcherrima and *Saccharomyces cerevisiae* can be used in either sequential or co-inoculation to produce wines containing lower amounts of ethanol. Like *S. cerevisiae*, *M. pulcherrima* requires a range of nutrients such as amino acids and ammonia (collectively referred to as yeast assimilable nitrogen, or YAN). Due to limiting YAN concentrations present in grape musts, there is competition between these yeasts for nutrients. In this work, *M. pulcherrima* P01A016 was inoculated sequentially with a commercial strain of *S. cerevisiae* (Lalvin NBCTM) to determine the effects of the timing of nitrogen addition on fermentation. Using a commercially prepared Chardonnay must, a completely random experimental design was applied, with N addition time as a variable (day 1, 3, or 5 after *M. pulcherrima* inoculation). All Chardonnay wines reached dryness by day 31, exception those without N addition. The addition of N prior to *S. cerevisiae* inoculation (day 1 or 3) resulted in increased biomass production over treatments with N added on day 5 or without N addition. Overall, *M. pulcherrima* greatly depleted the Chardonnay must of YAN prior to inoculation of *S. cerevisiae* in all treatments, even when N was added on day 1 or 3. This result indicated that *M. pulcherrima* has a high N requirement and care must be exerted when using this yeast with *S. cerevisiae*, especially in grape musts containing low amounts of N.

Funding Support: Washington State Grape and Wine Research Program, the Northwest Center for Small Fruits Research, and the Ph.D. scholarship of Turkish Higher Education Council (YOK 100/2000).

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Viticulture—Irrigation Management

Measured and Modeled Vineyard Canopy Development and Water Use

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Two publicly available applications relevant to vineyard irrigation management are described. OpenET is a satellite-based system that applies an ensemble of remote sensing methods to enable wide-area monitoring of evapotranspiration (ET) and related measures such as vegetation canopy development (via the NDVI spectral index). Data are freely available at one-quarter acre spatial resolution and may be automatically aggregated to the individual block level. The satellite-based daily ET data were compared with in-situ eddy covariance measurements collected by micro-meteorological instrumentation in a Central Coast vineyard over a three-year period (2020 to 2022). Estimate uncertainties were reasonably consistent with prior reports for GRAPEX sites in the Central Valley and North Coast. The CropManage (CM) web application is a free software tool developed and operated by UC Cooperative Extension for ET-based irrigation scheduling of major specialty crops. CM provides specific guidance for irrigation events as irrigation system runtime. Applied water recommendations are based largely on estimated ET, derived from assumed canopy cover and associated crop coefficients, since the last irrigation or rainfall event. The application was recently adapted to vineyards by accounting for the presence of a winter/spring cover crop, and for vine water stress imposed by regulated deficit irrigation. A 2022 field campaign involved 12 Central Coast and San Joaquin Valley commercial vineyards, and OpenET data were used to help evaluate CM output. Maximum percent vine cover was compared to estimates derived from average July satellite NDVI. The difference for 10 sites lacking midseason groundcover ranged from 0 to 7% between data sets, with average agreement near 4%. Cumulative ET estimates agreed with OpenET to within 12% at most sites, while larger discrepancies at the remaining sites may require additional data collection and analysis during the 2023 season. Satellite-based systems such as OpenET have the potential to help parameterize CropManage and similar agricultural decision support systems.

Funding Support: CA Dept. Food & Agriculture

Viticulture—Irrigation Management—CONTINUED

UAV-based NIR/SWIR Hyperspectral Imaging to Assess Grapevine Water Status in a Variably Irrigated Vineyard

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Remote sensing is a developing component of sustainable water management, particularly by identifying spectral and spatial information. In 2022, we began a study on Cabernet Sauvignon located in the San Joaquin Valley. We installed an automated irrigation system to execute variable irrigation across 48 watering zones, encompassing 12 irrigation regimes with four randomized replicates each. Irrigation schedules were a fraction of the grower control, which corresponded to the maximum water allocation received in the area. We collected spectral information across all zones throughout the growing season using an unmanned aircraft vehicle (UAV)-based hyperspectral imaging in the near infrared (NIR) – short-wave infrared (SWIR) from 900 to 1700 nm. Within this range of wavelengths are high-water absorption bands that were used in machine-learning regression models to predict plant water status. Plant water status measurements (stem water potential and leaf gas exchange) were taken as contemporarily as possible to the UAV flights every two weeks from June to harvest (five flights and ~1000 individual readings) to ground-truth spectral information. The collected measurements were averaged by experimental zone. Data analysis consisted of extraction of the pure canopy signal from the images using segmentation methods (accuracy >99%) and then averaging each experimental zone. This information was then used to train and predict water status measurement values using a random forest modeling approach. Recursive feature elimination was performed to reduce the number of predictors by 65%, to a total of 80 wavelengths. We obtained a 0.53 R^2 and root means square error (RMSE) of 0.12 MPa in a 10-fold cross-validation routine. This project is a step toward developing new methods to precisely monitor and manage irrigation in vineyards.

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

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Delaying Irrigation Initiation Reduces Vine Yield More Compared to Relative Increase in Fruit Quality

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Initiating irrigation is a critical annual management decision that has cascading effects on grapevine productivity and wine quality in the current and subsequent growing seasons. A multi-site trial was begun in 2021 to optimize irrigation initiation timing using midday stem water potential (Ψ_{stem}) thresholds characterized as departures from non-stressed baseline ψ_{stem} values ($\Delta\psi_{stem}$). Plant material, vine and row spacing, and trellising systems were concomitant among sites, while vine age, soil type, and pruning systems varied. Five target $\Delta\psi_{stem}$ thresholds were arranged in an RCBD and replicated eight times at each site: 0.2, 0.4, 0.6, 0.8, and 1.0 MPa (T1, T2, T3, T4, and T5, respectively). When thresholds were reached, plots were irrigated weekly at 70% ET_c. Yield components and berry composition were quantified at harvest. Across sites and years, consistent linear trends were found for several key production and fruit composition variables. Compared to T1, vine yields decreased by 7, 15, 22, and 30% for T2, T3, T4, and T5, respectively, when averaged across years and sites. These reductions were driven by reductions in berry weight,

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but in the second year of the study, cluster numbers per vine were also reduced. Comparatively, basic berry chemistry varied little among treatments. Juice total soluble solids consistently decreased from T1 to T5 across sites and years, but the trend was mild and not significant, and there were no consistent responses of juice pH and titratable acidity. Fruit anthocyanins increased linearly from T1 to T5, but the rate of increase (1% per 0.1 MPa of delay) did not match rate of yield loss (-4% per 0.1 MPa of delay). Because producers are paid by the ton and contracts stipulate a target maturity level, results after two years suggest that there may not be an economic incentive to delay irrigation initiation, regardless of vineyard site.

Funding Support: Oregon Wine Board Oregon Department of Agriculture Northwest Center for Small Fruits Research

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Canopy Growth and Extractable Soil Water as Tools to Irrigate Different Winegrape Varieties

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The main approach to vineyard irrigation management in Washington is a regulated deficit irrigation program customized to fit either red or white varieties. However, growers report that many varieties show distinctive behaviors, making irrigation management ambiguous and sometimes resulting in over- or underirrigation of some varieties. This study explored some simple tools that can help growers irrigate different winegrape varieties. A field trial was conducted in 2021 and 2022 in a drip-irrigated research vineyard at WSU Prosser to evaluate the responses of 30 winegrape varieties to soil water deficit. Varieties were fully irrigated through bloom, then the soil was subjected to two drydown cycles to create gradual moisture stress. The first cycle began at fruit set and the second at veraison, following irrigation to replenish soil moisture to near field capacity. Findings showed approximately two-fold differences in canopy size among the 30 varieties, and the soil dried down faster under varieties with bigger canopies. Unexpectedly, all varieties were isohydric as the soil dried down, but became anisohydric once soil moisture declined below a relative extractable soil water (ESW) threshold of ~0.35. However, varieties responded differently, considering the ESW that remained at a midday Ψ_{leaf} of -1 MPa, indicating a transition from mild to moderate water stress. There were those with higher (0.15 to 0.2), medium (0.1 to 0.15), and low (<0.1) ESW thresholds. These findings suggest the following: (1) Canopy-based measurements (e.g., via remote sensing or pruning weight) can be used in irrigation scheduling for different winegrape varieties. Vigorous varieties may need more frequent irrigation once control of shoot growth has been achieved and during heatwaves; and (2) Growers can establish an ESW-based tool to similarly irrigate winegrape varieties with the same soil moisture threshold at which plant water status transitions from mild to moderate stress.

Funding Support: Washington State Department of Agriculture Specialty Crop Block Grant Program and Washington State Grape and Wine Research Program

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Viticulture—Irrigation Management—CONTINUED

Severe Water Deficit Affects Grape Composition Differently In Varieties with Contrasting Hydraulic Behavior

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Grapevine cultivars differ in their hydraulic behavior during droughts and are arranged on a continuum of isohydric/anisohydric responses due to varying stomatal regulation. It is unclear how the varying hydraulic responses between grapevine cultivars are reflected in changes to grape yield and composition. The aim of this research was to determine the effect of severe drought on the berry size and composition of two grapevine cultivars with contrasting hydraulic behaviors. Two-year old, own-rooted Semillon and Grenache vines were grown in 11.3-L pots in a greenhouse at the University of British Columbia. Vines were exposed to progressive drought by withholding irrigation at postveraison for approximately two weeks, while controls were irrigated daily to maintain the soil water content at 90% of total capacity. Predawn and midday water potentials were measured daily with a Scholander pressure chamber. Stomatal conductance was measured daily with a porometer. Berries were sampled at varying degrees of drought and subjected to HPLC-RID analyses to determine organic sugar and acid content. Semillon maintained a higher stomatal conductance and dropped predawn and midday water potentials more rapidly than Grenache during drought. This coincided with Semillon berries having smaller changes in volume and metabolite concentrations during drought. These results suggest that a more anisohydric behavior might mitigate drought effects on berry volume and sugars postveraison.

Funding Support: NSERC Discovery Program (AWD-000128 NSERC 2020); American Society for Enology and Viticulture (Traditional Scholarship); BC Hospitality Foundation (BC WISE Scholarship)

Enology—Tannin Management Session

Effect of Cap Management and Ethanol Levels on the Chemical and Sensory Profile of Cool-climate Syrah Wines

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Syrah wines were made into triplicate fermentations following a two-by-two factorial experimental design using the factors cap management technique (punch-downs and submerged cap) and ethanol level (control and chaptalized, 2% difference in alcohol). Additionally, half of the punch-down wines underwent a four-month extended maceration after alcoholic fermentation was complete. Submerged cap control wines had sign0ificantly higher pH and lower titratable acidity than the submerged cap chaptalized wines. Punch-down wines had 16% and 36% more anthocyanins and 54% and 42% more tannins than submerged cap and extended maceration wines, respectively. The mean degree of polymerization of tannins will be assessed in all wines at four months postpressing. According to volatile chemistry results, punch-down wines had the highest levels of esters (isoamyl acetate and ethyl octanoate) and phenylethyl alcohol than other cap management treatments, while control wines

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had higher isobutanol and ethyl lactate levels. Extended maceration wines had the lowest levels of total anthocyanins and tannins. Due to the low levels of phenolics seen in the extended maceration treatments, tanks underwent an additional heating protocol starting on the second month of extended maceration. There was a 23% increase in total tannins and a 3% increase in seed weight from heating. However, heat treatments on the extended maceration wines did not significantly affect the volatile chemistry profile according to solid phase microextraction results. Wines will undergo formal sensory evaluation using a modified Pivot Profile method with an expert panel of 15 winemakers. The relationship between sensory results and volatile chemistry will be assessed using partial least squares regression.

Funding Support: Funding Support: Cal Poly Baker-Koob Endowment (Cal Poly San Luis Obispo), Pacific Coast Farming (San Luis Obispo, CA)

Characterization of Enological Oak Tannin Extracts Using a Multi-analytical Methods Approach

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Oak tannin extracts are commonly used to improve wine properties. The main polyphenols found in oak wood extracts are ellagitannins that release ellagic acid upon hydrolysis and comprise numerous structures. Oak tannin extracts also contain other compounds, giving a complex mixture. Consequently, the official OIV method based on gravimetric analysis of the tannin fraction adsorbed onto polyvinylpolypyrrolidone is not sufficient to describe their composition and highlight their chemical diversity. Eight commercial oak tannins were characterized using a combination of analytical approaches. Polyphenols were analyzed using the OIV method, UV spectrophotometry, UPLC-UV-MS analysis before and after acidic methanolysis, and HPLC-SEC-UV. Neutral sugars and polyols were determined as alditol acetates by GC-FID analysis, before and after hydrolysis. Finally, samples were compared using a non-targeted metabolomic approach based on UHPLC-HRMS/MS. Gravimetric analysis, absorbance values at 280 nm, and the quantities of ellagic acid released by methanolysis revealed some differences among samples, indicating variations in tannin composition. This was confirmed by SEC analysis evidencing differences in tannin size distribution, particularly in larger polymer content. All samples contained significant quantities of sugars, particularly xylose, mostly found in the linked form, and quercitol, a polyol marker of oak origin. These compounds contributed up to 25% of the whole extract composition. The proportions of free and combined sugars and polyols also showed large variations among tannins. Non-targeted UPLC-HRMS analysis detected major ellagitannins such as vescalagin, castalagin, and roburins A through E, but also a large number of derivatives and other molecules such as lignans and quercotriterponosides, and highlighted large differences among samples.

This work demonstrates the variability in composition of commercial oak tannin extracts, likely to impact their properties, and emphasizes the need for detailed multi-method characterization, in the frame of quality control and selection of tannins for specific applications.

Funding Support: IOC

Enology—Tannin Management Session—CONTINUED

Impact of Grape Maturity, Alcohol, and Maceration Duration on the Sensory Profile of Cabernet Sauvignon Wines

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Cabernet Sauvignon grapes were harvested in 2019 from a Columbia Valley vineyard at three different maturities. At each harvest, musts were adjusted to three different alcohol concentrations (20, 24, 28 Brix). For each maturity-alcohol concentration combination, an eight-month maceration was carried out along with the respective controls (10 days). Descriptive analysis was carried out using 11 trained panelists. Sixteen aroma, three taste, and three mouthfeel attributes were evaluated. Significant differences were found for all taste and mouthfeel attributes (hotness, viscosity, astringency, sourness, bitterness, and sweetness). Seven aroma attributes were found to be significant (light fruit, dry fruit, vegetables, chemical, cheesy/yeast, alcohol aroma, and overall aroma). Analysis of variance (ANOVA) and principal component analysis (PCA) were performed on the data. PCA explained 69.51% of the variation on the first two components. Both the first component (47.66% of variation) and the ANOVAs showed that the lower alcohol concentration was related to higher sourness and light fruit aromas, while high alcohol content was related to higher viscosity, hotness, sweetness, chemical, alcohol, and overall aroma. The second component (21.85%) separated the samples according to maceration treatment and showed that extended maceration was related to increased astringency, bitterness, and dry fruit. Three-way ANOVA showed a significant interaction between the three variables for astringency and a significant alcohol-harvest interaction on bitterness, with higher alcohol content increasing the intensity of both descriptors, but the impact of harvest was inconsistent. Veggie aroma was significantly highest in the first harvest, low alcohol control wine than in all other treatments, which were not different from each other, suggesting that both chaptalization and long-term, extended maceration were effective at reducing vegetal aromas in wine. Overall, the results suggest that harvest time was less important than alcohol concentration and maceration on the sensory results.

Funding Support: Washington State University, Auction of Washington Wines and all Washington State winegrape growers and wineries through the Washington State Wine Commission.

Effects of Accentuated Cut Edges on Phenolic and Volatile Compounds in Pennsylvania Hybrid Cultivars

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Accentuated cut edges (ACE) is a relatively new method of fractioning the skins of grapes into smaller pieces to modify wine sensory characteristics. ACE increases the surface area of the skins touching the liquid, thus increasing the extraction of grape skin compounds. This method has been used to increase the polyphenol concentration in red wines. Work has primarily been done in red *Vitis vinifera* cultivars and little is known about its effects on the volatile composition of the final wine. Non-*V. vinifera* cultivars tend to have lower tannin concentrations, potentially allowing ACE to be an important tool in increasing this deficiency. Additionally, as skins are an important source of volatile compounds, there is potential to improve aromas in both red and white wines through this procedure. Two Pennsylvania

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hybrid red cultivars, Chambourcin and Noiret, were fermented in 20-L containers or microvinified depending on the vintage and five white cultivars were microvinified. Grapes were sampled over three vintages. Prior to fermentation, the grapes were either processed with ACE or not (control). Phenolic profiling of red wines was done using the Adams-Harbertson protein precipitation assay and all wine volatiles were profiled using gas chromatography-mass spectrometry solid phase microextraction (SPME). For the 2021 microinfarctions, both Chambourcin and Noiret had an increase in iron-reactive tannins from 2.27 to 6.93 and from 7.91 to 244.38 mg/L CE, respectively. For the same vintage, in the 20-L fermentations, ACE influenced the volatile composition. For example, the ethyl caprate concentration was affected due to ACE in both Chambourcin and Noiret, from 13.9 to 26.1 and 68.8 to 47.7 ng/mL, respectively. The mean concentration of β-damascenone across all white grape cultivars was found to be higher in ACE treatments. These results demonstrate that ACE can impact both phenolic and volatile compounds in these Pennsylvania hybrid cultivars.

Funding Support: Pennsylvania Wine Marketing and Research Board

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Modified Tannins: Chemistry and Their Identification in Wines

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Tannins are known to react with a number of substances, such as anthocyanins and sulfur dioxide, based on related chemical reactivity. These reactions lead to modifications in the tannins and affect their physical and chemical properties, potentially changing their sensory qualities. Anthocyanins have been shown to alter the sensation of astringency from tannins and reactions with sulfite eliminate tannin-protein binding. The present study examines tannin modification chemistry during winemaking and aging and their identification in aged wines. We prepared one modified tannin type, sulfonated tannins, from the reaction of commercial grape tannins in the presence of SO_2 at wine pH. The sulfonation reaction was studied at varied pH (2, 3, and 4) and temperature (23, 35, and 45°C). The products were identified using LC-Q-TOF MS. Epicatechin sulfonate is the major monomeric flavanol sulfonate produced, as epicatechin is the predominant extension unit in tannins. Sulfonation was favored by low pH and high temperature. Considering the wine pH and optimal storage temperature, we estimate that in red wine, ~2% of the tannin would react in a year. So, during normal aging of tannic red wine, the conversion of tannin via sulfonation may be significant and could contribute to the decline of astringency observed in aged red wines. In addition, a database of modified tannins reported in the literature was created, and aged wines were evaluated for the presence of these modified tannins using LC-Q-TOF MS.

Funding Support: Washington State Wine Commission

What Factors Impact Wine Tannin Retention?

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To overcome the challenge of low tannin concentration in red wines made from cold-hardy hybrid grapes (*Vitis* spp.), we previously applied both the accentuated cut edges (ACE) technique and maceration enzymes to Marquette grapes (*Vitis*

Enology—Tannin Management Session—CONTINUED

spp.) at crushing. A higher tannin concentration was found in treated wines and was associated with the degradation of cell wall polysaccharides. However, the concentration of tannin diminished up to 45% between the third day of alcoholic fermentation and after pressing, regardless of treatment. To improve tannin retention, a better understanding of adsorption and interaction mechanisms between tannin and grape macromolecules is necessary. We examined the impact of grape flesh on retention of tannins from Pinot noir and Marquette skins and seeds under a wine-like condition. After peeling, each grape tissue (skin with/without flesh; seed with/without flesh; and a combination of skin, seed, and flesh) was soaked in a wine-like solution for five days. After soaking, tannin and anthocyanin concentrations in supernatants were quantified by HPLC-DAD/FLD. The composition of tannin was analyzed by HPLC-DAD after acid catalysis in the presence of an excess of phloroglucinol. In both cultivars, flesh caused a large decrease of tannin concentration in the supernatant of seed condition, followed by skin condition, and led to a decrease of monomeric anthocyanin concentrations. A lower mean degree of polymerization of tannins in supernatants of the Pinot noir skin, seed, and flesh combination compared to skin only suggested that larger tannins bind to macromolecules from the flesh. These results indicated that degradation of flesh tissues (for example, combining protease and pectinase) might be a potential strategy to hinder adsorption of extracted tannin further and improve retention of tannins in the finished wine.

Funding Support: No funding source.

Viticulture—Pests and Diseases Session

What Defenses Do Grapevines Have Against Piercing and Sucking Insects?

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Anthropogenic climate change increases mean temperatures, leading to increased humidity and unusual weather patterns. Scale insects are piercing and sucking pests that occur on certain cultivars in high numbers in Australian vineyards. As these scale insects feed on grapevine leaves, they may be affecting vine growth and fruit production. Scale insects also produce honeydew as their excreta, which can initiate growth of sooty mold on both leaves and fruit, reducing photosynthesis and affecting grape value. Our work aimed to describe the natural defenses present in grapevines against piercing and sucking insects, which could reduce pesticide use in the future, when these insects may be present in greater densities. Rootlings of Cabernet Sauvignon (CS) and Sauvignon blanc (SB) (resistant to scale insects) and Shiraz (S) and Chardonnay (Char) (susceptible to scale insects) were grown in greenhouses to measure growth, fruiting, and volatile organic compound (VOC) production when these cultivars were exposed to scale insects. At harvest, the number of scales per five leaves were counted, the number of grape bunches and grape mass were measured, and dried root and shoot masses were recorded. We found an increase in growth of SB with high numbers of scale and a decrease in benzyl alcohol, but no effect in Char. Within the CS and S comparison, leaves imported anthocyanin from

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another location in the plant within four weeks of scale insect infection. The presence of anthocyanin corresponded to an increase in leaf abscission in CS plants. Dropped leaves had several scale insects present and on other still-attached leaves, many scales had died. Although S did not drop leaves as well as CS did, their leaves also appeared to import anthocyanin.

Funding Support: Research School of Biology, Australian National University

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The Vine Mealybug Olfactory System: A Target for Next-generation Pest Control Tools

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Insects rely on detection of volatile chemical cues present in the environment to find mates and the plants they feed on. As such, insects possess an extremely sensitive chemical processing system in their antennae comprised of several types of olfactory proteins. These proteins have evolved independently in insects and are not related to those used by all other animals. Moreover, insect olfactory proteins are highly divergent, even between closely related insects, with many being unique to a single species. These characteristics make them ideal targets in "next-generation" insecticide development programs and ideal components for species-specific biosensors. The vine mealybug, *Planococcus ficus*, is a significant vineyard pest due to its role in transmitting the viruses that cause grapevine leafroll disease. Using transcriptomic libraries prepared from male and female mealybugs and a draft genome, we identified and evaluated expression levels of members of the odorant receptor, odorant binding protein, and odorant degrading enzyme gene families. Interestingly, only a subset of the 52 odorant receptor genes encoded in the genome were found to be expressed in adult mealybugs, likely a result of the male's short life span and inability to feed and the female's inability to fly. Eight of these odorant receptors were expressed in HEK293 cell lines and tested for their ability to respond to biologically relevant odorant molecules. Of these, PficOR6 responded dose-dependently to the vine mealybug sex pheromone component, lavandulyl senecioate. The discovery of the receptor for this species-specific compound will now allow development of vine mealybug-detecting biosensors and insecticidal chemistries that will likely have much lower off-target effects than traditional compounds.

Funding Support: USDA - Agricultural Research Service

Mating Disruption for Grape Mealybug, *Pseudococcus maritimus* (Ehrhorn), in Washington State

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Grape mealybugs, *Pseudococcus maritimus*, are the primary vector of grapevine leafroll associated viruses (GLRaVs) in Washington State winegrape vineyards and can be a late-season direct pest of fruit clusters. We demonstrated that one infected grape mealybug crawler can transmit GVLRaV-3 between 10 to 20% even with toxic doses of systemic insecticides. For the past 20 years, growers have applied imidacloprid on vineyards as cheap insurance to control *Ps. maritimus.* Unfortunately, growers are now reporting resistance to, and field failures with, imidacloprid chemigated for grape mealybug control. As a result, growers need to incorporate

Viticulture—Pests and Diseases Session—CONTINUED

alternative IPM strategies to help hinder insecticide resistance development and slow the spread of GLRaVs. We conducted a two-year study on mating disruption for *Ps. maritimus* by deploying twist-tie and Cidetrak pheromone-imbibed dispensers on grapevines in an even spatial manner of 0, 10, 30, 60, and 100 emitters and 32 and 50 emitters per acre, respectively. We included sentinel traps baited with the sex pheromone of grape mealybug in two replicates (twist-tie) and three replicates (Cidetrak) of five-acre blocks per deployment rate in commercial grower vineyards in Washington from May to August of 2022. Dispensers deployed at 100 and 60 (twist-tie) and 50 (Cidetrak) emitters per acre nearly shut down the capture of male *Ps. maritimus* in sentinel traps. This research is heartening and demonstrates that mating disruption of grape mealybug may have potential applications in winegrape vineyards.

Funding Support: Washington State Wine Commission

Grapevine Virus Detection Using In-field Hyperspectral Images and Machine Learning Models

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Grapevine viruses are impacting vineyards, affecting fruit ripening, decreasing grape quality, and reducing yield. Identifying infected vines is crucial to limit virus spread. Remote sensing can measure the biophysical and biological properties of vegetation that are affected by viruses. We evaluated the potential of hyperspectral VIS/NIR imagery to detect red blotch-infected vines. We tagged and geolocated hundreds of vines in a vineyard in Napa, California. For each vine, we sampled leaves in 2020 and 2021 to identify infection using PCR analysis. At the same time, for the same vines, we took pictures of the canopy sides with a VIS/NIR hyperspectral camera (from 500 to 900 nm) mounted on a tripod (n ~ 700) and above the canopy with a drone. To classify infection in vine images, we tested different machine-learning algorithms, partial least square discriminant analysis (PLS-DA), random forest (RF), support vector machine (SVM), and their ensembles, obtained by simple averaging of predictions and stacks using PLS-DA as the input model. For images taken with the tripod, the best accuracies are reached using the PLS-SVM ensemble. For the entire data set, the accuracy reaches 69.5%, with 80% accuracy for the non-infected class. For the late season, the accuracy reaches 74.5%, with an accuracy of 83% for the non-infected class. Feature importance computation shows that the bands located in the red, green, and infrared domains are most informative for the model. The findings of this project are encouraging, as they have the potential to introduce a new method for inspecting vineyards, allowing detection of virus transmission and identification of suspect vines (predicted to be infected). Where a more cautious approach is necessary before removal, PCR analysis can be conducted on the targeted vines.

Funding Support: CDFA SCBGP; California State University - Agricultural Research Institute

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Young Vine Decline Fungi, From Nursery to Vineyard

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Young vine decline (YVD) fungi colonize the xylem of grapevines, resulting in their decline and eventual death within few years after planting. Ready-to-plant nursery material has been reported to be a source of infection; however, material sold in Canada has not yet been evaluated. Four nurseries selling grapevines in Canada were selected for identification and quantification of the most prevalent YVD fungi, including *Botryosphaeriaceae* spp., *Cadophora luteo-olivacea*, *Dactylonectria macrodidyma*, *Dactylonectria torrensensis*, *Phaeoacremonium minimum*, and *Phaeomoniella chlamydospora*, using droplet digital PCR. Results revealed 99% of plants were infected with at least one YVD fungus, with a mean infection of three fungi per plant. Fungal abundance of all YVD fungi varied significantly among sections of plants, individual plants, cultivars, and nurseries. This research indicates plants are likely to already be infected when planting; however, most grapevines are not symptomatic in young vineyards. Some YVD fungi may be latent pathogens, transitioning from an endophytic to pathogenic lifestyle under plant stress. Two greenhouse experiments were conducted to determine the effect of drought stress and infestation by the ring nematode, *Mesocriconema xenoplax*, on *P. chlamydospora* fungal abundance. *P. chlamydospora* spores were vacuum-inoculated into the base of dormant Merlot canes at a high (25,000 spores), medium (5000 spores), and low (1000 spores) inoculum to evaluate whether initial fungal abundance would impact disease development. Phenotypic measurements were conducted throughout the experiment to monitor the effect of drought stress and nematodes on plant health. Drought stress had a negative phenotypic impact on plants, but nematode infestation did not. Fungal abundance was higher in drought-stressed plants after two years, but was not in ring nematode-infested plants. Field trials are currently underway to evaluate the effect of plant stress on disease development under natural conditions.

Funding Support: Agriculture and Agri-Food Canada, Canadian Grapevine Certification Network, British Columbia Wine and Grape Council

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Impact of Grapevine Red Blotch Virus Infection on Phenolic Extractability during Winemaking over Two Growing Seasons

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Grapevine red blotch virus (GRBV), part of the *Geminiviridae* family, causes negative impacts on grapes, including a decrease in sugar accumulation, phenolic content, and extractability during winemaking. The impact of GRBV was studied across virus-infected GRBV(+) and non-infected GRBV(-), vines from a commercial vineyard in Paso Robles, CA across two growing seasons: 2021 and 2022. Sixteen GRBV(-) asymptomatic and 20 GRBV(+) symptomatic data vines were confirmed by qPCR test. Exhaustive extractions were conducted in four biological replications of five GRBV(+) and four GRBV(-) data vines, respectively, to characterize grape phenolic composition by high-performance liquid chromatography (HPLC). To evaluate the impact of GRBV on phenolic extractability, grapes were harvested when GRBV(-) reached 27 Brix. Fermentations were conducted in triplicate and the phenolic content

Viticulture—Pests and Diseases Session—CONTINUED

of the final wines analyzed by HPLC. Phenolic extractability was calculated as the ratio of wine to grape phenolic content. The 2022 growing season had more growing degree days, days above 35°C, and lower average precipitation than 2021. In 2021, GRBV(-) grapes had similar phenolic content to GRBV(+), while in 2022, GRBV(-) had lower anthocyanin content than GRBV(+), potentially due to degradation as a result of high temperatures. In this study, seasonal impact on grape phenolic content had a greater impact than GRBV. Despite the similarity in phenolic content, the final GRBV(+) wines showed decreases of 3% (v/v) alcohol and lower pH than GRBV(-) wines, suggesting delayed ripening due to GRBV infection. Phenolic extractability was greater in GRBV(-) than GRBV(+) grapes. This is in accordance with previously published studies, which relate greater phenolic extraction with ripening status and lack of GRBV infection. In the next step, cell wall composition of GRBV(-) and GRBV(+) grapes will be characterized to determine if compositional differences are related to phenolic extractability differences.

Funding Support: PD/GWSS Board-CDFA, UC Davis Horticulture and Agronomy Graduate Group, Jastro-Shields Research Award

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Enology—Method Development Session

A Machine Learning Application to Differentiate White Wine, Blanc de noir, and Rosé Wine Based on CIEL*a*b*

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Wine color plays a major role for wine quality and consumer acceptance. CIEL*a*b* data is used in wine research for descriptive purposes. A new method is proposed here on how to extract more information from CIEL*a*b* data. Recent development and accessibility of multivariable statistics and machine learning (ML) led to the exploitation of these methods in various disciplines. ML in wine research is mostly used to predict intangible parameters such as wine quality or price based on complex, time-consuming chemical analysis. In this study, wine color measurement, which can be obtained quickly and easily, is used as an example on how to make ML applicable for winemakers. Blanc de noir wines are white wines from red grapes and are produced worldwide. The light color of Blanc de noir wines is very important for consumer acceptance. In this study, CIEL*a*b* coordinates from over 150 Blanc de noir, white, and Rosé wines were calculated from the recorded spectrometric data. A support-vector-machine (SVM) was trained and used to classify the wines. The SVM was trained with 70% of the data; the model was validated against 30% of the data. An algorithm optimization was performed by full factorial grid search. The algorithm predicted whether a given wine was a Blanc de noir wine or a white wine with up to 96% accuracy in the cross-validated training data set. Validation of the optimized model resulted in a classification accuracy of 95%. A method to differentiate Blanc de noir from Rosé was developed, defining the lower color boundary of Blanc de noir wines. The validated model was exploited in a user-friendly dashboard, making this approach applicable to winemakers.

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Measuring the Aging Capacity of Wine - A Comparison of Different Methods

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Aging capacity is an essential factor in wine quality. The aging capacity of white Burgundy dropped between the vintages of 1995 to 2000, which impacted the reputation of Burgundy wine. An accurate and rapid aging capacity test is needed to better predict shelf life. We compared four proposed methods: the FRAP assay, a modified DPPH assay, the iron species ratio, and the sulfur dioxide addition method. These methods are designed to assess "antioxidant" capacity or quantity, not the speed of reactivity. The FRAP assay reflects the capacity of the wine to reduce Fe (â...¢) to Fe (â...i). The DPPH method (EC20) measured the volume of samples needed to reduce 20% of DPPH free radicals in 10 min. The FRAP and DPPH assays approximately reflected the concentrations of ascorbic acid, sulfur dioxide, and phenols. The iron species ratio was measured before and after an air saturation for one day to test for resistance to Fe (â...i) oxidation by air. Prior to air exposure, Fe (â...i) was the primary iron species (>92%) and the decrease varied widely after a one-day air saturation. The sulfur addition method determines weakly bound SO_2,

Enology—Method Development Session—CONTINUED

which is part of bound sulfur, but this form will release free SO_2 during oxidation. The FRAP assay, DPPH assay, and weakly bound SO_2 correlated strongly, while the iron species ratio method had low correlation with other methods. An accelerated oxidation procedure will be compared using these tests.

Funding Support: University of California, Davis

Arabinogalactan-Proteins Compete with Tannins for Saliva Proteins, Reducing Astringency in Cabernet Sauvignon Wines

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Wine polysaccharides produced with and without pectolytic enzymes were evaluated for astringency and in competition assays. Methods included gel assays, Nuclear magnetic resonance spectroscopy, size chromatography, comprehensive microarray polymer profiling immunochemistry with plant cell wall probes, and sensory assays. Polysaccharide addition reduced tannin levels in tannin-saliva-protein-polysaccharide complexes. The competing polysaccharides were analyzed using cell wall probes and shown to be primarily composed of arabinogalactan-protein-pectin-xyloglucan co-polymers derived from grape cell wall degradation. Polysaccharides from non-enzyme-treated wines were most effective in disrupting aggregates and releasing tannins. Enzyme-treated wines were therefore more astringent than non-enzyme-treated Cabernet Sauvignon wines.

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Viticulture—Climate Change Session

Comparison of Imputation Methods for Long and Varied Grapevine Phenology Data Sets

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Tracking changes in phenological data through time is a vital part of understanding the development of grapevines and plant response to various climate factors. Handling missing data values remains an ongoing challenge in the field of data science, which motivates this project to evaluate several methods of imputation on incomplete phenological time series data. Imputation is a favorable alternative to removing missing values, as the resulting data set is more substantial and retains the dimensions of the original data set. Furthermore, time-series analysis methods often demand complete series. The data set considered here originated from Conegliano, Italy, and contains phenological data for over 400 grape varieties collected at budbreak, flowering, veraison, and ripening since 1964. Depending upon the year and phenological stage, missing data values may make up anywhere between 10% and 70% of the measurements for a given year. This work used three leading imputation methods: K-nearest neighbor (KNN), multivariate imputation by chained equations (MICE), and missForest. Roughly 15% of each data set was held out as a test set, where original data values are replaced with artificial missing values. After the application of imputation methods, imputed values were compared for data points in the test set to assess the accuracy of each method. The imputed data sets with the lowest test root mean squared error for all phenological stages were produced using missForest and had average errors of three days for budbreak, four days for flowering, seven days for veraison, and 10 days for ripening on the test set. This work paves the way for future analysis with the imputed Conegliano phenological time series data set.

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Climate Change Impacts on Grapevine Phenology for Willamette Valley Pinot noir Using Temperature-Based Models

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Climate change is a growing concern for winegrape production worldwide. One of the unknowns associated with climate change is the impact of increasing temperatures on grapevine physiology. Increased temperatures may affect the timing of key phenological stages during the growing season, thereby impacting final crop quantity and quality. The relationships between grapevine physiology and growing degree day accumulation have been studied using temperature-based phenological models. However, these models perform inconsistently among regions, especially when models that were calibrated in one pedo-climatic context are applied to other regions, where factors that limit grapevine growth differ. We used the Smoothed-Utah and Wang-Engel phenological models and the Grapevine Sugar Ripeness model, each of which was applied to observed phenological dates from 2012 to 2021 for 18 vineyards across the Willamette Valley. Model performance was assessed using Root Mean Squared Error (RMSE), model efficiency, and adjusted R-squared. The RMSE values ranged from 5.5 to 8.5 days and R-squared values from 0.35 to 0.56 for each phenology stage modeled. Calibrated models were then used to project phenological dates from 2020 to 2100 under four climate change scenarios as

defined by the Intergovernmental Panel on Climate Change's Shared Socioeconomic Pathways. High-emissions scenarios indicate that bloom, veraison, and harvest will occur anywhere from three to five weeks earlier in the growing season. Additionally, as veraison and harvest shift earlier, they will occur at warmer stages of the growing season. However, budbreak dates are less affected by increased temperatures under high-emissions scenarios. The lowest-emissions scenarios project all phenology dates will shift roughly one week earlier. These results represent a resource for Willamette Valley grapegrowers as they anticipate future challenges and make informed decisions to address them.

Funding Support: Northwest Center for Small Fruits Research, Oregon Wine Research Institute, Oregon State University Viticulture Extension

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Comparative Life Cycle Assessment of Integrated and Organic Viticulture Based on a Long-term Field Trial in Germany

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Viticulture is one of the most environmentally impacted steps in the wine life cycle. Organic farming practices are considered a promising solution for reducing environmental burdens related to intensive agricultural management practices. However, organic agriculture is often associated with significantly lower yields. Therefore, the aim of the study was to compare the environmental impact of integrated and organic viticulture practices based on data from a long-term experimental vineyard in Germany (*Vitis vinifera* L. cv. Riesling) by means of Life Cycle Assessment (LCA). LCA in viticulture can provide valuable information for vineyard management to identify which inputs and processes are the most significant contributors to its environmental impact and to improve the environmental performance of viticulture. By direct comparison of the management systems within an otherwise harmonized system, sources of variation caused by the environment are excluded. The system boundary of the study is Cradle-to-Farm-Gate. The functional units of the LCA (the reference basis for calculations) are "area" (1 ha vineyard) and "mass" (1 kg grapes) to account for management-related changes in yield. This study provides a detailed description of hot spots within the different impact categories for every management system and identifies potential areas for improvement of environmental sustainability. The LCA is conducted in alignment with the ISO standards 14040 and 14044 and applying the indicators and methods defined in the Product Environmental Footprint Standard of the European Union using the software openLCA. The impact assessment revealed that the functional unit "mass" favored integrated and the functional unit "area" favored organic management practices, because of changes in yield. Environmental hotspots did not differ between the cultivation systems, except for metal resource use, because copper fungicides are used in organic farming. It was found that vineyard establishment, especially trellis construction, was the most impactful step of grape production.

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Enology—General Enology Session

Role of Mg and Ca Ions on Maillard Reaction Product Formation during Accelerated Aging of a Modified Sparkling Base Wine

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The Maillard reaction (MR) is a non-enzymatic reaction between sugars and amino acids that occurs gradually during production and aging of traditional method sparkling wines. The reaction generates a cascade of volatile compounds and several Maillard reaction-associated products (MRPs), including furans, thiazoles, and other heterocycles that exhibit caramel, roasted, and toasted aromas. Metal ions have previously been shown to accelerate formation of MRPs in model systems, so a modified sparkling base wine was evaluated to determine if the addition of metal ions increased the concentrations of MRPs during aging. Chardonnay base wine was modified by adding a single amino acid (lysine, glycine, or cysteine; 0.01 M) and fructose (0.02 M), along with Ca or Mg at zero, low (10 mg/L), or high (50 mg/L) levels. All components were selected for their known involvement in the MR and their presence in sparkling wine. Due to the low pH and temperature conditions of sparkling wine during production and aging (pH ~3.2; 12 to 14°C), the MR occurs slowly (months to years). Thus, an accelerated aging regime, whereby samples were held at 50°C and sampled at intervals of 0, two, and four weeks, enabled rapid evaluation of the potential role of metal ions on MRP formation. MRPs were quantified by HS-SPME-GC-MS, sugar concentration was measured by enzymatic assay, and amino acids and free metal ions were evaluated by capillary electrophoresis. Preliminary analysis showed that mean fructose levels decreased between the two and four week intervals. Free metal levels did not vary systematically by treatment during aging. Analysis of amino acids and MRPs is currently underway. Understanding the effect of MR-precursors in the presence of Ca and Mg ions in modified base wine conditions is a key step toward characterizing the MR in sparkling wine.

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Effect of Harvest and Alcohol Concentration on Sauvignon blanc Wine Chemical and Sensory Attributes

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Sauvignon blanc grapes were harvested at three potential alcohols (11, 13, and 15% v/v, ABV) from a vineyard in Paterson, Washington, in 2018 and 2019. Alcohol was controlled for prefermentation by either adding water or sugar. Basic analysis of main wine components was performed. Wine samples were analyzed first using untargeted solid-phase microextraction-gas chromatography-mass spectrometry (SPME-GC-MS) to identify major aroma compounds present. Targeted analysis was performed on various classes of wine aromatics (alcohols, esters, aldehydes, and thiols) informed by the untargeted analysis. Descriptive analysis was performed on the 2019 wines by 12 panelists (five male, seven female). There were significantly more esters and isoamyl alcohol in the first harvest and 15% ABV treatments. Thiols and one of the corresponding esters and alcohols were found to depend significantly on harvest and alcohol, with 3-mercaptohexyl acetate, hexyl acetate, and cis-3-hexen-1-ol having the

highest concentration in the first harvest wine. 3-Mercaptohexanol was found to be significantly affected by alcohol and was highest in the last harvest, 15% ABV wine. There was significantly less methionol in the last harvest wine. A two-way analysis of variance of the sensory attributes found that tropical, citrus, melon, sour candy, sweaty, and overall aromatic intensity were significantly greater in the first harvest wines. For the first harvest wines, sweet and hot taste attributes were significantly greater while sour was significantly less. Herbal/mint, briny, earthy, floral/grassy, and boxwood were significantly greater in the second harvest wines. Increased alcohol concentration significantly increased stone fruit, oxidized, alcohol, and overall aromatic intensity aroma attributes and hot, viscous, bitter, and sweet taste attributes. Both harvest and alcohol impacted the aroma and taste attributes of the wines. Notably, alcohol alone is effective at altering aromatic and taste attributes and wine volatile aromatic concentrations independent of harvest.

Funding Support: Washington State University, Auction of Washington Wines and all Washington State wine grape growers and wineries through the Washington State Wine Commission.

Sensory and Chemical Profiles of Cabernet Sauvignon Wines Exposed to Different Irrigation Regimes During Heatwaves

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Heatwaves, defined as three or more consecutive days above average historic maximum temperatures, significantly impact agricultural crop yields and quality, especially in arid or semiarid regions with reduced water availability during the growing season. In grapevine, excessive heat can lead to crop loss and reduce the quality of berries and the resulting wine. The primary means of mitigating damage from heatwaves is by applying excess irrigation water before and during the heatwave event, thus promoting evaporative cooling by the plant and reducing soil temperatures in the rooting zone and surface. California winegrowing regions, among others, face a future of decreased water availability combined with increased heatwave frequency and intensity. Thus, we require greater understanding of the effects of heatwaves and water use at different times during development on grapevine physiology and berry composition and wine chemistry and quality. In two consecutive years, we evaluated the impact of different pre-heat wave irrigation practices on vine physiology and berry composition across the 2019 and 2020 growing seasons in a commercial Cabernet Sauvignon vineyard in the Northern Central Valley of California (Lodi, CA). Differential irrigation treatments were applied only when a heat event took place and started one or two days before each heatwave and continued until the last day of the heat event. Three irrigation treatments were implemented:

- A control or baseline, which was exposed to deficit irrigation and held at 60% evapotranspiration (ET)
- A second treatment where the irrigation was double the baseline (2 baseline ET)
- A third treatment with triple the amount of water of the baseline (3 baseline ET)

Replicated wine lots were fermented from each treatment following a standard red wine fermentation protocol. Two trained sensory panels characterized the aroma

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Enology—General Enology Session—CONTINUED

and flavor profiles of the wines. Moreover, the wines' volatile and phenolic profiles were analyzed and compared to the sensory. Vines could recover from physiological stress caused by heat events, but berry biochemical traits were negatively impacted. Negative effects on berry chemistry resulted from over- and underwatering during heat waves. The sensory results showed how these differences translated to the wines' sensory properties and chemical characteristics.

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Viticulture—Vine Nutrition Session

Elucidating the Role of Soil Phosphorus on Nutrient Bioavailability and Vine Productivity in Winegrape Vineyards

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The critical phosphorus (P) level for winegrape whole leaves at veraison is thought to be 0.15% of dry weight for eastern Washington (WA) winegrape vineyards, but other research suggests that this may be too high. Therefore, more P is likely being applied to soil than is necessary, leading to excess P in soil and possible alteration of other nutrients in soil and in vine tissues. This study tested the impact and/or limitations of P application to a vineyard soil (via fertigation) on i) soil-P concentrations and bioavailability, ii) leaf-P concentrations, and iii) vine productivity and physiology. Approximately 20 acres of Cabernet Sauvignon grown near Paterson, WA was split into four replicates, where all replicates contained three treatments (four rows each). Three rates of P were evaluated: a 10 lb/ac application of P (as H_3PO_4), 20 lb/ac application of P, and a zero-P control. Soil, leaf, and root samples were collected at multiple stages over the annual growth cycle of the grapevine: initial treatment application, prebloom, bloom, fruit set, lag phase, veraison, harvest, and postharvest. Micro-x-ray adsorption near-edge spectroscopy (μ-XANES) was performed on select soil samples to assess changes in P-speciation and mineralization over a growing season and across treatments. Results were compared with soil and leaf nutrient analyses, such as total soil- and leaf-P, soil-P sequential extraction, colonization of roots by arbuscular mycorrhiza fungi, and vine productivity. Results will be used to provide better P management recommendations and assess current tissue-P standards for Cabernet Sauvignon vineyards in eastern Washington.

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Managing Nutrient Inputs and Arbuscular Mycorrhizal Fungi in Vineyards

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Grapevine roots are heavily colonized by symbiotic arbuscular mycorrhizal fungi (AMF) that enhance nutrient uptake, especially of phosphorus (P). However, their role in the uptake of other nutrients, including nitrogen (N) and potassium (K), is unclear. Further, knowing how fertilizers added to vineyards alter AMF and their

ability to supply nutrients is important to develop sustainable nutrient management practices. Data from numerous vineyard trials and controlled greenhouse studies are summarized here to provide a clearer picture of how best to manage AMF and vine nutrition. In vineyard trials, N additions to soil, but not to foliage, reduced AMF colonization in roots and, in some cases, this reduced vine P status. Foliar P additions in vineyards reduced AMF colonization, and foliar P additions in greenhouse trials rapidly reduced arbuscules in roots. However, adding P fertilizer to soil in a recent vineyard study had no negative impact on AMF in roots. A recent trial indicated that K fertilizer additions to soil had no impact on AMF in roots. These results contrast with findings under controlled conditions, where we have shown that AMF vastly improve vine P uptake, often improve K uptake, but do not improve N uptake by grapevines. AMF have also improved uptake of zinc and copper in controlled studies. Soil N inputs appear to have an outsized impact on AMF in grapevines compared to soil P or K, even though AMF do not appear to enhance vine N uptake. Therefore, soil N additions to vineyards should be managed carefully to maintain AMF and ensure that N use does not interfere with uptake of other nutrients. These findings will be discussed in light of sustainable nutrient management in vineyards and the regulation of AMF by grapevines.

Funding Support: USDA-ARS

Influence of Nitrogen, Potassium, and Magnesium Vineyard Application on Vine Nutrient Status and Productivity

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The supply of mineral nutrients is essential for optimal vine growth and fruit production. We studied the impact of nitrogen (N), potassium (K), and magnesium (Mg) fertilization on nutrient status, productivity, and fruit composition over two years in western Oregon vineyards. The N trial in Chardonnay used three rates of soil-applied N. The K trial, conducted in a K-deficient Pinot noir vineyard, had four treatments, three rates of soil-applied K and a single foliar treatment. A Mg trial in a Mg-deficient Pinot noir vineyard included three rates of foliar-applied Mg. Each treatment was replicated four times using a randomized block design at each vineyard. The Chardonnay trial showed that leaf blade and petiole N status at bloom and veraison were elevated to greater extent as the rate of N increased, although minor variations occurred among tissue and time. Yeast assimilable nitrogen in must increased with increasing rate of N in year 1, but was similar in year 2 at medium and high rates of N. Soil-applied K increased leaf blade and petiole K at bloom and veraison in Pinot noir in year 2, but foliar K applications did not. However, all three added K treatments increased K in woody canes at dormancy. In the Mg trial, both the low and high rates of Mg applied to the canopy elevated leaf blade Mg status by veraison and reduced the extent of Mg-deficient leaf symptoms developing in late summer, but petioles did not respond to Mg fertilization. In all three trials, neither vine size nor yield increased thus far by fertilizer additions. In addition, cluster size, berry size, and must maturity indices have yet to be altered by N, K, or Mg additions. It will be interesting to see if productivity, yield, or fruit composition will be altered in the future.

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Enology—Smoke Taint Session

Volatile and Glycosylated Markers of Smoke Impact: Levels and Patterns Observed in 2020 Wines from the United States West Coast

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Smoke impact in wines is caused by volatile phenols found in wildfire smoke. These compounds are absorbed into berries, where they may also become glycosylated. Both volatile and glycosylated forms eventually cause off-flavors in wines. In large wildfire events, economic losses for all wine industry actors can be devastating. To assess smoke impact, a selection of volatile and glycosylated phenols is proposed, mainly based on Australian research. It includes guaiacol, 4-methylguaiacol, cresols, phenol, syringol, and 4-methylsyringol, in addition to their glycosylated forms guaiacol rutinoside, 4-methylguaiacol rutinoside, cresol rutinoside, phenol rutinoside, syringol gentiobioside, and 4-methylsyringol gentiobioside. The accurate and reproducible measurement of these compounds is now possible, due to the commercial availability of standards and isotopic analogues. The 2020 vintage was particularly affected by wildfires all over the Western United States, giving us an opportunity to collect extensive data for this suite of markers in wines made from smoke-exposed grapes. In the large majority of cases, levels of both volatile and glycosylated markers in wines appeared closely related to the intensity of vineyard smoke exposure. This confirms the relevance of these markers in the Western United States. In some cases, however, volatile markers were relatively low, sometimes barely indicating any exposure to smoke, while glycosylated markers were high. This suggests very efficient glycosylation mechanisms in some grapes and vines exposed to smoke. We also observed the opposite pattern: high levels of volatile markers in combination with low levels of glycosylated markers. This may be the consequence of impaired glycosylation pathways in the plants, possibly related to a severe heat wave experienced in mid-August 2020. These observations confirm that measuring both volatile and glycosylated markers is advisable to identify wines from smoke-exposed grapes.

Funding Support: ETS Laboratories

Comparison of the Relative Efficacy of Applying Different Potential Barrier Sprays to Grapes in a Wildfire Scenario

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The increasing incidence of wildfires in grape-producing regions has highlighted the need to develop mitigation strategies to manage the impact of smoke and volatile phenol exposure on grapes and the resulting wines. Smoke taint can reduce product quality and cause financial losses for grapegrowers and wine producers. This experiment compared the effects of different materials applied to grape bunches in reducing absorption of smoke marker compounds in a simulated wildfire scenario. The experimental design involved applying 12 different treatments to individual grape bunches on four Cabernet Sauvignon vines close to harvest time. Three bunches from each vine were treated per treatment. Treated vines were exposed to intentional smoke using a smoke tent for two hours. Control samples were taken before smoking and from control vines on either side of the structure. Smoke-exposed control (no barrier applied) grapes were sampled at different time points after exposure. Air parameters were monitored using a Thingy sensor and

atmospheric samples were taken during smoke exposure. The free and acid-labile forms of volatile-phenols in grape were analyzed by GC-MS and the individual glycosylated forms by UHPLC-qTOF-MS. There was strong stratification in the distribution of volatile phenols within the structure. The heterogeneous distribution of smoke is reflected in the different levels of uptake of volatile phenols in the grapes. We observe that glycosylation begins to occur within a few hours, with significant increases in almost all glycosylated compounds within four hours of smoke exposure over the non-smoked controls. However, variation in smoke exposure could affect the glycosylation kinetics of volatile phenols. Some potential barrier sprays lowered the amount of volatile phenols in the grapes during smoke exposure under these conditions. However, some applied materials seemed to aggravate the absorption of smoke volatiles.

Funding Support: USDA-ARS

Amelioration of Smoke Effect in Wine Using Reverse Osmosis and Immobilized β-Glucosidase

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Instances of smoke-affected wines are becoming a frequent issue in wine-producing countries. Wine made from grapes that have been affected by smoke can have unpleasant burnt, dirty, leather, or smoky sensory attributes. Although the issue of smoke-affected wines has received significant research attention, there is as yet no effective means to mitigate affected wines. Reverse osmosis with solid phase adsorption reduces free smoke-related phenols, but not bound smoke-related phenols. This project evaluates the use of reverse osmosis combined with immobilized β-glucosidase and adsorptive activated charcoal as a potential technique to reduce both free and bound smoke-related phenols in wine. Smoke-affected wines were treated using commercial reverse osmosis. Before enzyme hydrolysis, β-glucosidase was immobilized in a chitosan-silica support, which had been crosslinked with glutaraldehyde. Untreated, permeate, and treated wines were then subjected to hydrolysis by immobilized β-glucosidase to break the bound phenol-glycosides. The concentration of smoke-related phenols decreased after the wine was treated with reverse osmosis. Yield of enzyme hydrolysis is dependent on the initial concentration of free smoke-related phenols, temperature, incubation time, and batch or continuous hydrolysis. Batch enzyme hydrolysis of phenol-glycosides had varying results, depending on temperature and incubation period. Temperatures of 25°C and 35°C led to hydrolysis of phenol-glycosides, while 45°C led to trans glycosylation. Continuous enzyme hydrolysis led to more trans glycosylation than hydrolysis. This study demonstrated that reverse osmosis in conjunction with enzyme hydrolysis and activated charcoal adsorption can be used as remedy for smoke-affected wines. However, conditions that favor hydrolysis over trans glycosylation still need to be determined.

Funding Support: USDA

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Enology—Smoke Taint Session—CONTINUED

Solving Smoke Taint: Strategies that Mitigate the Impact of Smoke Exposure on Grape and Wine Composition

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Grape and wine producers around the world are searching for strategies to mitigate the negative effects of vineyard exposure to wildfire smoke (unpalatable smoky and ashy characters, which can render wine unsaleable), and which in recent years has led to revenue losses estimated at hundreds of millions of dollars. In the vineyard, various preventative measures have been evaluated, from washing smoke-affected grapes to applying protective sprays or coverings to vines prior to smoke exposure. In the winery, remedial treatments have included postharvest ozonation, limiting skin contact during fermentation, spinning cone column distillation of juice or wine, and the addition of adsorbent materials such as activated carbon (either directly, or in combination with nanofiltration). The transformation of smoke-tainted wine into beverage spirit via distillation has also been evaluated. This presentation will provide an objective assessment of the efficacy of different vineyard- and winery-based mitigation strategies, by comparing the concentrations of volatile phenols (in free and glycosylated forms) as chemical markers of smoke taint, alongside descriptive analysis of wine sensory profiles. Limitations associated with promising mitigation strategies and the potential for strategies to be applied in tandem will also be discussed. The compositional data also demonstrates how the natural occurrence of volatile phenols in the fruit of some grape cultivars, and the susceptibility of different volatile phenol glycosides to hydrolysis, can complicate evaluation of smoke taint mitigation strategies.

Funding Support: Wine Australia, The Australian Research Council, he University of Adelaide, Peter Michael winery, Australian State and Federal Governments

Viticulture—Pierce's Disease and Glassy-Winged Sharpshooter Session

The Role of Climate on Pierce's Disease of Grapevines in California

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Pierce's disease (PD) of grapevines continues to be a serious disease in California and elsewhere. Temperature is known to impact PD prevalence and geographical distribution, notably at the northern edge of the PD distribution in California, where winter temperatures are considered too low for infections to survive. Infected vines are subject to winter curing if temperatures are low enough, a phenomenon that effectively clears plants from pathogen infections. However, recent research has demonstrated that winter curing is dependent on plant variety and pathogen strain, in addition to temperature alone. This work will be discussed in the context of climate change and the finding of new areas where PD was previously rare or not reported.

Funding Support: CDFA PD/GWSS Research Program

Advancing Biopesticides for the Management of Pierce's Disease

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Pierce's disease (PD) is a degenerative, deadly, and costly disease of grapevines caused by the Gram-negative bacterium *Xylella fastidiosa* subsp. *fastidiosa* (Xf). PD represents a major threat to the grape industry due to limited options for effective prevention and control in all grape regions of California. Biopesticides are an attractive solution for managing PD because they provide an alternative to strategies that use conventional agrochemicals for insect vector management and planting of PD-resistant grapevine. A field trial was performed in 2022 at UC Davis to test the effectiveness of different biopesticides for commercial application against PD. The trial included eight treatments plus two experimental controls. Treatments included XylPhi-PD, a commercially available bacteriophage-based biopesticide (A&P Inphatec) and OMRI-listed product that can directly target Xf, three beneficial biocontrols that showed promising results against PD under greenhouse conditions at UC Berkeley and UC Riverside, and different pairwise combinations of XylPhi-PD and each biocontrol agent. Each treatment was applied to ten 11-year-old Cabernet franc grapevines with four shoots per grapevine. All biopesticides were delivered to the vine using Xyleject. An 80 µL dose of each biopesticide was injected at the base of each shoot on both sides, following the XylPhi-PD label recommendation. Biopesticides were injected into grapevine one day pre-Xf inoculation and one-week post-Xf inoculation. Xf strain Stag's Leap (~1 107 CFU/mL) was used for disease positive, and non-inoculated plants were used for disease negative controls to compare the efficacy of the treatments. The vines were inoculated with Xf using a drop puncture method of two 10 µL doses between the second and third nodes of the shoot. Our preliminary results indicate that vines treated with XylPhi-PD showed 50% fewer foliar symptoms than plants treated with the Xf pathogen alone. Moreover, XylPhi-PD and other biocontrol agents performed better when combined than either treatment applied alone.

Funding Support: California Department of Food and Agriculture, Pierce's Disease and Glassy-Winged Sharpshooter Program, CDFA Agreement Number 22-0561-000-SA

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Viticulture—Pierce's Disease and Glassy-Winged Sharpshooter Session—CONTINUED

Gene-Editing of the Glassy-winged Sharpshooter, *Homalodisca vitripennis*, to Prevent Pierce's Disease

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Pierce's Disease (PD) is a serious disease of California grapevines caused by a pathogenic bacterium, *Xylella fastidiosa*, which is transmitted by the xylem-feeding insect, *Homalodisca vitripennis*, commonly known as the glassy-winged sharpshooter. We propose to eliminate PD by generating glassy-winged sharpshooter lines that are unable to transmit *X. fastidiosa* to grapevine though editing of the glassy-winged sharpshooter genome. Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)-based gene-editing technologies now make this possible provided that we can efficiently introduce the CRISPR macromolecules into chromosomes of glassy-winged sharpshooter to generate genetic lines. We developed a delivery system that achieves this goal. As proof of principle, we generated, at high frequencies, the first genetic mutants of glassy-winged sharpshooter using two eye pigmentation genes, white and cinnabar. These strains are robust, and we have maintained them in our laboratory for over 10 generations. We confirmed that these mutations were specific to the target sites, which is critical for genetic control strategies. We have also demonstrated that we can integrate DNA fragments into specific target sites in the white and cinnabar genes with high frequencies. We have used this technology to establish a platform for the rapid screening of gene regulatory sequences in glassy-winged sharpshooter. Our results show that we can perform gene-editing technology in this important pest insect, enabling us to inactivate specific gene targets and to introduce transmission-blocking genes into specific genetic sites in the glassy-winged sharpshooter genome. We have developed the foundational genetic tools required for the generation and testing of genetic strains of glassy-winged sharpshooter for the control of PD.

Funding Support: Pierce's Disease/GWSS Board, Californian Department of Agriculture and the Animal and Plant Health Inspection Service of the United States Department of Agriculture.

Enology—Fermentation Management Session

Impact of Cap Management and Fermentation/Aging Temperature on Phenolic, Chromatic, and Sensory Aspects of Grenache Wine

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Grenache wines were made in triplicate fermentations following a factorial combination of fermentation temperatures, ranging from Hot (spike of 34°C), to Cold (10 to 12°C throughout) and an alternation of them (Cold/Hot) with contrasting punch-down regimes (no punch-downs, NO PD; two punch-down/day 12 hrs apart, PD). Cold wines had higher pH and lower titratable acidity. Phenolic and chromatic parameters were largely unaffected by the punch-down regime, but did show differences as a function of fermentation temperature. At pressing, there were 58 and 52% more anthocyanins and 158 and 150% more tannins in Cold/Hot and Hot than in Cold wines, respectively. Small polymeric pigments increased significantly more in Cold/Hot and Hot wines after nine months bottle aging, resulting in higher wine color in these treatments. Additionally, an accelerated aging experiment (seven weeks incubation at 38°C) found these wines were equally impacted by aging: anthocyanins decreased by 90% and polymeric pigments increased almost two-fold (181%). Protein-precipitable tannins also increased during accelerated aging, which led to formation of large polymeric pigments (LPP). From a sensory perspective, fermentation temperature mostly impacted perceived color saturation and hue, while the absence of cap management led to wines with significantly greater reduction and mushroom-like aromas. Wines produced with the Hot fermentation regime had more alcohols such as isobutanol, hexanol, and phenyl-ethanol, while wines produced with the Cold fermentation regime had more ethyl-hexanoate and ethyl-octanoate.

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Effect of Fermentation Temperature Gradient and Skin Contact on Tropical Fruit Perception in Chardonnay Wine

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Wines with tropical fruit aromas are increasingly desirable to consumers. With so many wine styles available, it is important to understand the compounds that cause fruity aromas in wine. Previous work using microfermentations showed that fermentation temperature gradients and time on skins increased thiol and ester compounds postfermentation, and these compounds are known to cause tropical fruit aromas in wines. This work aimed to scale up these fermentations/operations to determine if the desired aromas could still be achieved and if there is a perceivable difference in tropical fruit aromas, liking, and emotional response in the wines by consumers. Four treatments were tested at varying fermentation temperature gradients and skin contact times: control (SC0FG0), skin contact (SC1FG0), no skin contact fermentation gradient (SC0FG1), and skin contact fermentation gradient (SC1FG1). Chemical analysis and descriptive sensory analysis were conducted to determine changes in the composition and aroma profiles of these wines. Check-all-that-apply (CATA) showed different prominent aromas for each wine treatment, with pome fruit, stone fruit, pineapple, honeysuckle, honey, and passionfruit being the most perceived aromas. Descriptive analysis (DA) showed that SC1FG0 was significantly different from both SC0FG1 and SC1FG1. SC1FG0 had the most tropical

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fruit aromas, SC1FG1 had more stone fruit, and SC0FG1 had more honey and lemon/lime. Consumer liking showed no significant difference, while emotional response showed a significant difference. SC0FG0 was described using emotions of satisfied, calm, and secure, while SC1FG0 was described using disgusted, agitated, and worried. Combining these descriptive and emotional sensory results can be used to help guide decisions of winemakers trying to achieve consistent tropical fruit aromas in Chardonnay wines.

Funding Support: AVF

Comparison of Pre- and Postfermentation Alcohol Adjustment on Chemical and Sensory Profiles of Sauvignon blanc Wines

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Sauvignon blanc grapes were harvested at three potential alcohols (11, 13, and 15% v/v, ABV) from a vineyard in Paterson, Washington, in 2018 and 2019. Alcohol was controlled for prefermentation by either adding water or sugar. For each harvest, the 13 and 15% ABV wines were dealcoholized to 11 and 13% ABV using a small-scale dealcoholization (DA) unit. The initial experimental alcohol was treated as the control, the dealcoholized wine as the treatment, and the wine sharing the same alcohol target and harvest date as the dealcoholized wine was designated as the negative control. Basic analysis of main wine components was performed and untargeted solid phase micro-extraction gas chromatography-mass spectrometry (SPME-GC-MS) was used to identify major aroma compounds. Targeted analysis was performed on various classes of wine aromatics (alcohols, esters, aldehydes, thiols) informed by the untargeted analysis. Descriptive analysis of the 2019 wines was performed by 12 panelists (five male, seven female). Harvest and pre- and postfermentation adjustments had the expected changes in alcohol concentration. Titratable acidity significantly increased by ~0.2 g/L tartaric acid equivalents as a result of DA in all cases. All aromatic classes measured were found to increase as a result of higher ethanol and decline as a result of DA, so as to match their negative controls. There were some exceptions, such as thiols, which were more strongly influenced by harvest than by either alcohol adjustment. A principal component analysis of the sensory data showed that DA altered aromatic descriptors significantly. For the first-harvest wines, the DA wines overlapped with their corresponding negative controls, shifting the aroma descriptors from melon and sour candy found in the control to sweaty. For the second- and third-harvest wines, similar trends were found, but they weren't always significant.

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Viticulture—Rootstock and Vine Physiology Session

Malolactic Starter Bacteria Lactiplantibacillus plantarum - A Solution for Challenging Wine Conditions

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Chardonnay is the white wine variety most likely to undergo malolactic fermentation (MLF); however, Chardonnay is also most likely to experience stuck MLF. It is important to understand the reasons behind stuck MLF on a molecular level. Understanding the reasons behind sluggish or stuck MLF (nutrient limitation or inhibitory compounds) addresses these issues through development of MLF nutrients, detoxicants, or selection of specifically adapted bacteria strains. Over the past three years, we have tested >150 Chardonnay wines from across the world for malolactic fermentability and categorized them using both targeted and untargeted metabolome analysis on LC/MS, GC-MS, and MS/MS to identify causes of sluggish/stuck MLF in Chardonnay wines. To eliminate the impact of vinification protocol, including the effect of yeast and yeast nutrition used for alcoholic fermentation (AF), must samples of some Chardonnay wines were collected. These underwent a controlled AF in the lab under a standardized protocol. MLF feasibility was determined by a quick test using a high inoculum of commercial *Oenococcus oeni* or *Lactiplantibacillus plantarum* strains, then assessing malic acid degradation over 72 hrs. The success rate for inducing MLF was significantly greater for *L. plantarum* than for *O. oeni*. This highly-concentrated *L. plantarum* culture also performed well in wines from other grape varieties that are prone to stuck MLF, even those with high SO2 levels. Targeted and untargeted analyses supported by multivariate statistical analyses allowed identification of potential molecular causes of stuck/sluggish fermentations by *O. oeni* outside of pH, lactic acid, K, and Mg, which enhance MLF, or SO2 and EtOH, which hinder MLF.

Funding Support: Lallemand INC

Screening Rootstocks Against the Northern Root-Knot Nematode (*Meloidogyne hapla*)

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The northern root-knot nematode (*Meloidogyne hapla*) is a prevalent plant-parasitic nematode in northern grapegrowing regions. This nematode induces small galls on roots that restrict water and nutrient uptake, resulting in poor vine establishment or exacerbated decline in stressed vines. Rootstocks can be a viable option for managing vine decline caused by *M. hapla* in commercial vineyards, but most screening efforts on grapevine rootstock tolerance to root-knot nematodes focus on *Meloidogyne incognita,* the southern root-knot nematode. This study reports the results of a greenhouse trial that screened nine *Vitis* spp. rootstocks (1616C, 99R, M4453, 140RU, Minotaur, SO4, SW, G3-5BB, and 1103P) and two *Vitis vinifera* controls (Chardonnay and Cabernet Sauvignon) against *M. hapla.* This experiment was conducted three times in two locations. Vines in 3.8-L pots were inoculated with 5000 *M. hapla* eggs, grown for three months, and then harvested destructively. *M. hapla* eggs were extracted from roots, counted, and the reproduction factor (R_f = final density/initial density) on each cultivar was calculated. An $R_f > 1$ indicates a susceptible host and an $R_f = 0$ indicates resistance (no reproduction). There was an

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impact of rootstock genotype on *M. hapla* R_f ($p < 0.0001$), driven by high R_f for *V. vinifera* Chardonnay (Rf = 56.5) and Cabernet Sauvignon (R_f = 30.9). *M. hapla* had lower R_f values on the non-*vinifera* rootstocks, although not all could be considered resistant. Rootstock M4453 is susceptible to *M. hapla* (R_f = 13.03), while S04 (R_f = 0.96), G3-5BB (R_f = 0.03), 140RU (R_f = 0.17), 1616C (R_f = 0.013), SW (R_f =0.0086), Minotaur (R_f = 0.005), and 99R (R_f = 0.027) are poor hosts for *M. hapla*. *M. hapla* did not reproduce on 1103P (R_f = 0). These results provide a baseline for rootstock selection for commercial grapegrowers managing for *M. hapla* in their vineyards.

Funding Support: Washington State Grape and Wine Research Program; USDA National Institute of Food and Agriculture, Hatch project 1016563.

Long-Term Influences of Rootstocks on Vine Performance and Fruit Quality in an 'Autumn King' Vineyard

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Although numerous trials have evaluated the influences of rootstocks on vine growth and berry composition in different production regions, rootstock effects on mature vines remain less known. GRN rootstocks are rarely compared with traditional rootstocks in mature vineyards. To understand the long-term effects of newer and traditional rootstocks on vine productivity and fruit quality, we obtained data in 2021 and 2022 from an older 'Autumn King' vineyard in Ducor, CA. The vineyard was planted in 2008 in loam soil. Own-rooted vines and vines on 12 rootstocks (Freedom, Harmony, Teleki 5C, Salt Creek, 1103 Paulsen, Crimson, 10-17A, RS-3, GRN-1, GRN-2, GRN-3, and GRN-4) were evaluated. Each rootstock was replicated five times with five vines each. Rootstocks had similar effects on vine productivity across two years. Vines on Salt Creek, GRN-2, GRN-3, Teleki 5C, and 1103 Paulsen performed well, showing higher yields and larger canopies than others. Vines on Freedom, RS-3, Harmony, and GRN-4 had intermediate yield and canopy growth. Vines on 10-17A had moderate yield, but a large canopy, suggesting vines on this stock may favor vegetative growth more than other stocks. Vines on GRN-1 performed poorly and had similar yield and growth as own-rooted vines. Because of limited canopy growth, the fruit of vines on GRN-1 and own-rooted vines was overly exposed, resulting in sunburn and fruit yellowing in both years. Vines on Crimson had intermediate yield and pruning mass in 2021, but their productivity declined in 2022. Rootstocks had minor influences on bud fruitfulness, vine water status, and berry composition (total soluble solids, pH, titratable acids, and berry firmness) at harvest. Overall, we found that GRN-2 and GRN-3 can be alternatives to popular traditional stocks, including Freedom, Salt Creek, and 1103 Paulsen, in areas with similar climate and soil conditions as the San Joaquin Valley of California.

Funding Support: American Vineyard Foundation and UC ANR

Viticulture—Rootstock and Vine Physiology Session—CONTINUED

Development and Deployment of an Auto-Machine Learning Prediction Model to Monitor Grapevine Freezing Tolerance in the Eastern United States

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Accurate, real-time monitoring of grape freezing tolerance is crucial for the sustainability of the grape industry in cool climate viticultural regions. However, on-site measurement is limited due to the complexity of measuring method. Current prediction models, generated by parameter-based modeling using local measurement data, underperform under other climate conditions, preventing large-scale deployment of these methods. Here, we combined grape freezing tolerance measurement data from multiple sites in North America and generated a prediction model based on newly developed hourly temperature-derived features and one-hot encoded cultivar features using AutoGluon, an automatic machine learning engine. The final model was tested and compared with previous biological models for performance under different climate conditions. Feature importance of the model was quantified by computing SHAP value. The final model (weighted ensemble model level 2) achieved an overall 1.31°C root-mean-square error during model testing. The model also out-performed the current standard models at all testing sites. Finally, the model was deployed in the major viticultural regions in the Northeastern and Midwestern United States, using daily-updated weather data in Applied Climate Information System (ACIS). A real-time freezing tolerance and freezing damage prediction system was developed and launched using R shiny.

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Evaluating the Hydraulic Behavior of Grapevine Cultivars Under Drought Using The Water Potential Curve

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Physiological stress thresholds such as stomatal closure and turgor loss can give insights into the performance of grapevine cultivars during drought. Recent studies have shown that predawn versus midday water potential curves accurately predict stomatal closure in a variety of species and predict turgor loss point in walnut. The water potential curve is a promising approach to classify the hydraulic behavior of grapevine (*Vitis vinifera* L.) cultivars under drought; however, it is unknown whether it accurately predicts turgor loss point in this species. The objective of this research was to determine the accuracy of water potential curves in predicting turgor loss points in different grapevine cultivars, and to confirm the accuracy of stomatal closure prediction. Two-year-old, own-rooted Grenache, Semillon, Cabernet franc, and Riesling vines were grown in 11.3-L pots in a greenhouse at the University of British Columbia. Vines were exposed to progressive drought by withholding irrigation for approximately two weeks, while well-irrigated vines were watered daily to maintain soil water content at 90% of capacity. Predawn and midday water potentials were measured daily with a Scholander pressure chamber. Stomatal conductance was measured daily using a porometer. Prior to withholding irrigation, pressure-volume curves were performed on hydrated leaves from each cultivar. Significant three-phase water potential curves were generated for each cultivar. These curves accurately predicted the turgor loss points determined via pressure-volume curves. Stomatal closure was not as accurately predicted, but differences in stomatal

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Viticulture—Rootstock and Vine Physiology Session—CONTINUED

regulation between varieties were reflected by water potential curves. These results highlight that the water potential curve is a promising approach to characterize the performance of different grapevine cultivars under drought.

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Enology and Viticulture Research Report Posters

Effect of *p*-Coumaric Acid on the Histamine and Tyramine Production of *Lacticaseibacillus paracasei* Isolated from Wine

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During the vinification process, the presence of undesirable lactic acid bacteria (LB) capable of decarboxylating free amino acids can cause formation of biogenic amines (BA). These compounds can affect consumer health and wine quality. Sulfur dioxide (SO_2) is used as an antibacterial agent in the wine industry, but this chemical can cause allergic reactions in sensitive people. For this reason, alternatives to replace the use of SO_2 are desirable. The effect on bacterial viability and production of histamine and tyramine in the presence of p-coumaric acid (P) of *Lacticaseibacillus paracasei* AT45, a BA producer isolated from Argentinean wine, was evaluated. The assays were carried out in wine obtained after controlled microvinification of Torrontes varietal grapes. The trials were supplemented with P at final concentrations of 200, 300, and 400 mg/L. Then, *L. paracasei* AT45 was inoculated at 10^3 or 10^7cfu/mL, then incubated 96 hrs at 23°C. Samples were taken at 0 and 96 hrs. The presence of histamine and tyramine was evaluated using a colorimetric method developed in our laboratory. In control wine, without P, the microorganisms maintained their viability until the end of the incubation time at both inoculum concentrations assayed. A maximum histamine and tyramine production of 15.03 and 7.87 mg/L, respectively, was observed at 10^7 cfu/mL. The greatest bacterial inhibition was evidenced in the presence of 400 mg/L P at the end of incubation. The production of both amines was dramatically reduced at all concentrations of P tested at undetectable level. Only a 62.81% decrease in tyramine production occurred in the presence of 200 mg/L P when the inoculum was 107 cfu/mL. The use of phenolic acids from wine could become a natural alternative to SO_2 for the control of spoilage wine LB during winemaking.

Funding Support: Consejo Nacional de Investigaciones Cientificas Y Tecnicas (CONICET)

Identification of Lactic Acid Bacteria Producers of Biogenic Amines in Tucuman Wines

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Different species of lactic acid bacteria (LAB) produce biogenic amines (BA) in wine, including histamine and tyramine. A selective isolation of LAB was carried out from four samples of Malbec and Cabernet Sauvignon wines at the end of vinification from two wineries located at the rural district of Colalao del Valle, Tucumán, Argentina. Thirty randomly selected isolates were first screened for histidine and tyrosine decarboxylase. Then, 16S rDNA gene sequencing and typing of the isolates by RAPD-PCR were performed. The detection of the *hdc* and *tdc* genes was carried out by PCR. Eleven isolates corresponded to *Lacticaseibacillus paracasei* species and through RAPD-PCR were grouped into four clusters. One representative strain was selected for the further assays: *L. paracasei* AT38 (group I), *L. paracasei* RA39 (group

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II), *L. paracasei* RA49 (group III), and *L. paracasei* AT45 (group IV). The evaluation of BA production was carried out in a laboratory wine inoculated with the selected strains of *L. paracasei* at a cell concentration of 10^6 cfu/mL for 96 hrs at 28°C. Quantification of amines was performed using colorimetric methods development in our laboratory. The presence of the *hdc* gene in two strains and the *tdc* gene in four strains was demonstrated. *L. paracasei* AT45 was the main producer strain of BA in wine. This study evidences, for the first time, histamine and tyramine-producing strains of *L. paracasei* isolated from Argentine wine.

Funding Support: Consejo Nacional de Investigaciones Científicas Y Técnicas (CONICET)

Phenolic Compound Modification by *Oenococcus oeni* Increases Antioxidant Activities in Apple Wine

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The antioxidant properties of apple wine (AW) can produce benefits to human health and are mainly attributed to phenolic compound (PC) content. The metabolism of *Oenococcus oeni* can modify the phenolic profile during malolactic fermentation (MLF) fermentation, and consequently, its antioxidant activity. Pasteurized apple juice was fermented with *Saccharomyces cerevisiae* EC1118 to obtain AW. Then, MLF was performed separately with two autochthonous RAM10 and RAM11 strains of *O. oeni* and a commercial VP41 strain. A control without MLF was carried out. The MLF was performed at 18°C for five days. High-performance liquid chromatography was used to monitor changes in concentration of 17 PCs during MLF, using a reversed-phase Kinetex C18 column coupled with a DAD-FLD detector. Antioxidant activity was determined using the FRAP method, and radical scavenging activities were determined by DDPH and ABTS. Caffeic acid was the major compound, representing more than 90% of the PCs analyzed, and its concentration increased after MLF. Myricetin, (-)-epicatechin, and phloretin were detected only after MLF and *p*-coumaric acid was only detected in the sample obtained from the RAM11 strain. DPPH radical scavenging activity remained unchanged, but increases in ABTS and FRAP activities were observed after MLF. The greatest antioxidant activity was obtained using the VP41 strain, which produced an increase of >60 and 15% in the ABTS and FRAP activities, respectively, over AW without bacterial inoculation. The RAM10 and RAM11 strains did not show significant differences in antioxidant activity after MLF. Controlled MLF with appropriate indigenous or commercial *O. oeni* strains increases antioxidant activities by PC modification.

Funding Support: Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)

Enology and Viticulture Research Report Posters—CONTINUED

Effect of Phenolic Fractions from Young and Aged Wine on the Viability of Enological Lactic Acid Bacteria

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During winemaking, the presence of lactic acid bacteria (LAB), principally *Lactobacillus* genera, can cause wine deterioration. This work examined the effect of wine low molecular weight (LMF) phenolic fraction on the viability of enological LABs. The LMF were extracted from a young (Y) and aged (A) Tannat wine varietal produced in the same wine cellar located at Tucumán, Argentina. LMF was obtained by successive extractions with ethyl acetate. The phenolic compound (PC) content of the LMF extract was characterized qualitatively and quantitatively by LC-DAD-FLD. Three strains of *L. hilgardii* (5w, 6F, and X1B) and two strains of *Oenococcus oeni* (m and VP41) were cultured in synthetic wine-like medium (SWM), pH 4.5, supplemented with LMF-Y and LMF-A at identical concentration as present in wine. In the LMFs, 20 PCs were identified and quantified. The total concentration of PCs was greater in LMF-Y (95.1 mg/L) than in LMF-A (61.4 mg/L). After 72 hrs incubation, all LAB studied increased the viable cell concentration in SWM (control), except for *O. oeni* m, which maintained its viability. In the presence of LMF-Y, *L. hilgardii* 5w and 6F stopped growing with respect to control medium, and *L. hilgardii* X1B, *O. oeni* m, and VP41 decreases their viability by 0.17, 0.34, and 0.12 log cfu/mL, respectively. The addition of LMF-A to SWM decreased microbial viability in all strains studied, but *O. oeni* VP41 was the most sensitive strain, with a strong decrease in cell concentration of 3.06 log cfu/mL. These results constitute an important contribution to elucidate, at least in part, the effects of wine aging on LMF composition and their influence on viability of enological LABs. In addition, a quali-quantitative characterization of PC composition was performed for the first time in Tucuman wines.

Funding Support: CONICET

Non-Destructive Spectrometric Assessment of Grape Cell Wall Composition and Phenolic Extractability

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Grape phenolics are compounds of primary interest for winemaking, as they are responsible for the main sensory characteristics and important physicochemical interactions with other molecules. These compounds are mainly extracted from the solid phase of the berry - skins and seeds - throughout alcoholic fermentation. The extent and rate of extraction depend strongly on temperature, alcohol concentration, and juice-mixing procedures. Cell wall (CW) composition of grape skin also been plays a key role in the net extraction of grape phenolic compounds. We proposed a mechanistic model for phenolic extraction that includes CW composition. This study aimed to use spectrometers to non-destructively measure CW composition and, integrating this technology into existing engineering models, predict grape phenolic extractability. Twenty-one grape samples were collected from eight different sites in Northern California. Studied varieties were Cabernet Sauvignon, Pinot noir, Petite Sirah, Zinfandel, and Barbera. Each grape set was microfermented in triplicate at 24°C. Commercial yeast strain EC1118 was inoculated. Sugar concentration was adjusted to 25 Brix, titratable acidity to 6 g/L tartaric acid, and yeast assimilable nitrogen to 250 mg/L. Grape and wine phenolic compositions were analyzed

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by reversed-phase high-performance liquid chromatography. CW material was isolated from berry skins and characterized: proteins, cellulose, and uronic acid were determined spectrophotometrically and lignin, gravimetrically. Intact berries were then scanned with Ocean Insight Flame and NirQuest+2.2 spectrometers (Ocean Insight, Orlando, FL), covering wavelengths from 350 to 2200 nm. Preliminary results show a correlation between CW composition and phenolic extractability and between variety and site-specific variability for extractability and CW composition. Recently, other groups have successfully detected CW components of fruits using spectrometry. We expect spectrometry data to show a correlation with CW composition and phenolic extractability of grapes.

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Prevalence of *Hanseniaspora* Species on Pinot noir Grapes in Two Willamette Valley sub-AVAs

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The apiculate yeast genus *Hanseniaspora* has been observed in association with grapes, grape must, and the early stages of wine fermentation for more than 100 years. Most enological research in that time has focused on the species *Hanseniaspora uvarum* due to its notable capacity to cause spoilage, especially in wines made using the cold-soak process, but detection of apiculate yeast does not always denote spoilage. In recent years, there has been research into the potential benefits of species such as *Hanseniaspora vineae* in producing more complex wines. Furthermore, large-scale DNA sequencing-based (metabarcoding) vineyard ecology studies have suggested there could be regionally variable populations of *Hanseniaspora* species. Does this mean that fruit from different vineyards could yield spoiled or complex wines depending on which *Hanseniaspora* species are present? As a first step toward addressing this question, in this study we are determining which of the 22 recognized *Hanseniaspora* species are present on Pinot noir grapes in the Willamette Valley AVA and which species persist during cold-soak and fermentation. In addition, our sampling design evaluates geographic differences in species make-up within vineyards, between vineyards, and between sub-AVAs. During the 2022 harvest, 108 commercially ripe multi-cluster samples were taken across 12 vineyards, six each in two geographically distinct sub-AVAs. Subsamples were taken at crush, after six days of cold-soak and after 10% completion of initial must sugar content (TT_10). Preliminary analysis shows the expected significant positive correlation between initial total soluble solids and TT_10 along with a significant negative correlation between must CFU and TT_10. Importantly, there was no significant difference between sub-AVAs for these parameters, suggesting our ability to detect geographic differences in yeast populations will not be skewed due to initial conditions. Currently we are evaluating the presence of *Hanseniaspora* species in each sample using metabarcoding analysis.

Funding Support: OWRI, OSU

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New Insights on Incorporating *Lachancea thermotolerans* into the Production of Assyrtiko Wines from the Volcanic Terroir of Santorini

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Assyrtiko is a rare ancient grape variety of Greece, known for production of Protected Designation of Origin Santorini white wines. Besides the famous character of the volcanic terroir, Assyrtiko of Santorini is also marked by low pH and sharp acidity. With climate change, this acid typicity tends to be under-expressed and ways to reinforce acidity in warmer vintages need to be sought. The aim of this study was to apply a new inoculation procedure that modulates the fermentation process by maintaining the unique sensory characteristics of Assyrtiko wines based on acidity. For this purpose, the *Lachancea thermotolerans* species, known for relatively extensive fermentation ability, low acetic acid production, and especially formation of lactic acid, was tested in sequential fermentation with three different *Saccharomyces cerevisiae* strains, isolated from the Greek terroir. At the end of fermentation, enological parameters were determined according to OIV protocols and the volatile compounds produced were measured by gas chromatography-mass spectrometry. Finally, all wines were evaluated using quantitative descriptive analysis by two groups of experts: a Greek team of enologists from Santorini Island, specialized in Assyrtiko wines, and a French team of enologists from Bordeaux. As expected, the inoculated strain dominated the fermentation process, but nine indigenous *S. cerevisiae* strains were also identified. *L. thermotolerans* produced 1 g/L lactic acid, while also modulating the volatile profile of the wines independently of the *S. cerevisiae* strain used. The origin of the panelists played an important role in bringing up sensory traits such as acidity and sweetness. Our results suggest a new and interesting application of *L. thermotolerans* for white wine production.

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Technology in Enology Education

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The advancement in semiconductors in the last century has changed the technology used in all steps of wine production. To prepare the next generation of winemakers, the curriculum of enology teaching programs should expose students to the latest technology available in both commercial and research settings. In the undergraduate wine production course at the UC Davis Viticulture and Enology Department, new technology elements were incorporated into the classroom. Fermentations at the 100 and 1500 L scale were monitored using a combination of commercially available and research sensors. The data was used with an existing wine fermentation model to provide fermentation diagnosis and prediction of future fermentation trajectory. The real-time data and fermentation modeling results were available to

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students through an online dashboard. The ability to have fermentations monitored automatically allows students to focus on aspects of winemaking beyond manual density measurements and enables opportunities for remote learning of production winemaking skills in the future.

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Extraction and Composition of Sugars from Oak Wood in Model Solution

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Sugars from oak barrels were quantified by extracting oak chips toasted under various conditions in model wine. When 6.0 g of untoasted chips were extracted in 1 L of model wine for 21 days, 73 mg/L of neutral sugars were quantified. Chips toasted at 180 °C to 240 °C for 10 min had similar or slightly higher levels of neutral sugars extracted than untoasted chips; the difference did not reach statistical significance. Toasting at 240 °C resulted in the maximum level of 74 mg/L. On the other hand, toasting at 260 °C and 280 °C for 10 min resulted in extremely low levels of neutral sugars extracted. Two acidic sugars and seven neutral sugars were detected by high-performance liquid chromatography after hydrolysis. Glucose, arabinose, and xylose were also detected, suggesting that sugars derived from wood polysaccharides such as cellulose and hemicellulose were likely to be extracted from oak chips. Furthermore, differences in toasting temperature affected the composition of the extracted sugars. Therefore, it is possible that different toasting temperatures may result in different extents of cellulose and hemicellulose pyrolysis inside the wood and significantly affect the amount and composition of sugars extracted. In addition, gel permeation chromatography was performed to estimate the molecular weight of the extracted sugars. The detected peaks corresponded to monosaccharides and oligosaccharides, and peaks that appeared to correspond to polysaccharides in some samples were also observed. These results indicated that different toasting temperatures of the barrel wood also affect the molecular weight of the extracted sugars.

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Impact of Malolactic Fermentation Timing and Use of *Torulaspora delbrueckii* on Pinot noir Wine Properties

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Malolactic fermentation (MLF) is an integral step in red wine production. Traditionally conducted after alcoholic fermentation, MLF can occur concurrently with alcoholic fermentation by inoculating with *Oenococcus oeni* soon after the initiation of alcoholic fermentation. Although a concurrent fermentation reduces the overall time required to ferment, there are concerns about excessive acetic acid production, color loss, and competition with *Saccharomyces cerevisiae*. If concurrent fermentations are to become more widely used, a better understanding of this winemaking technique is necessary. This study investigated the effect of MLF timing on Pinot noir wine

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properties, particularly color. The use of a non-*Saccharomyces* yeast during cold soaking was also studied due to potential interactions with *O. oeni* and production of acetaldehyde, a key compound involved in the formation of stable color. Six non-Saccharomyces yeast cultures were assessed for acetaldehyde production under cold-soak conditions in a model grape juice. *T. delbrueckii* Alpha produced the highest concentration of acetaldehyde (71.8 mg/L) and was selected for use in Pinot noir winemaking experiments. Pinot noir wines were produced with and without cold soaking, with and without *T. delbrueckii* Alpha, and with concurrent or sequential MLF. Only minor differences in the time to completion of alcoholic fermentation or MLF were observed between the treatments, suggesting that concurrent MLF did not impact the performance of the alcoholic fermentation. Acetaldehyde concentrations changed throughout wine production. At the end of cold soak, the treatments inoculated with *T. delbrueckii* Alpha contained significantly more acetaldehyde (21.5 mg/L) than their uninoculated counterparts (3.4 mg/L). Further, these treatments also had the highest acetaldehyde concentrations during alcoholic fermentation. Acetaldehyde rapidly decreased after *O. oeni* inoculation. The significance of these changes in acetaldehyde on color will be determined when wines are assessed for various color parameters, including anthocyanins and polymeric pigments.

Funding Support: Oregon Wine Board

Fermentation-Induced Changes to Grape Seed Morphology Influence Phenolic Release

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The extraction of phenols during red wine fermentation is a crucial step that determines the wine's final color and flavor. Release of anthocyanins and tannins from the grape is influenced by factors such as temperature, ethanol concentration, and fermentation conditions. It has been observed that the concentrations of skin tannin and anthocyanins decrease over time, following a first-order rate, but the release of seed tannin is at a zero-order rate, for still-unknown reasons. This research aims to understand the changes in seed morphology and internal pore structures during fermentation and how they affect extraction of phenols. The study uses x-ray microcomputed tomography to track the changes in seed morphology over time and determine their impact on phenolic extraction. A mechanistic model for diffusion of seed tannins based on internal porosity is also proposed.

Funding Support: USDA-ARS

Sensory Complexity in Hybrid Grape NY-81: A Commercial Yeast versus Native Yeast

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Native fermentation is a process that uses ambient, indigenous yeast from the vineyard as the inoculate for wine fermentation, as opposed to commercially produced dry cultures. In this experiment, these two methods of inoculation are compared. Microbial populations in each replicate were monitored by PCR analysis. Flavor was analyzed by monoterpene analysis and sensory difference testing by triangle test. It is hypothesized that these native yeast constituents will produce a wine with discernably different organoleptic complexity than commercially available

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yeasts. Native yeasts are found in different concentrations by grape variety, with uninoculated, native fermentations having the greatest diversity. Some rare species of yeast can be found on non-*vinifera* grape varieties. These microbial communities in each vineyard regulate grapevine health and the character of the resulting wine. A variety of native yeasts have been isolated that demonstrated fermentation abilities like glucose and ethanol tolerance equal to or greater than commercial control yeasts. Evidence was found that indigenous yeasts are more apt to create wines with preferred characteristics than their commercial counterparts. Further, the participation of indigenous microbes in fermentation may contribute to sensory complexity. This experiment illustrates the viability of native fermentation. Data collected shows differences in the speed of commercial and native ferments. PCR analysis demonstrated that while *Saccharomyces* does dominate native fermentation, certain microbes could be linked to elevated volatile acidity and malolactic fermentation. Analysis of finished wines demonstrated somewhat elevated sugar content in native replicates, variance in volatile acidity, and similarity in titratable acidity. Quantitative data from monoterpene analysis may provide further clarification upon receipt. These combined observations suggest that there may be a correlation between fermentation speed and yeast species, and between yeast species and flavor, and that extended research may be necessary.

Funding Support: FLCC, Cornell

Impact of Biofungicides on Fermentation and Aromatic Profile of Chardonnay Grapes from the Central Coast of California

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Chardonnay is the most widely planted variety in the Central Coast of California, but it is susceptible to many diseases, notably powdery mildew and botrytis bunch rot. Synthesized fungicides are commonly used in vineyards. However, these fungicides are costly and can harm the environment and human health. Moreover, frequent use of fungicides selects for pathogen resistance. The objective of this project was to investigate the impact of biofungicides on Chardonnay wine fermentation and wine aromatic profile. Eight experimental trials on Chardonnay winegrapes were conducted, including three combinations of biofungicides and synthetic fungicides, two with synthetic fungicide, two with biofungicides, and one untreated control. The grapes were crushed and pressed immediately after harvest in 2021. Both free-run and press fraction juice was racked into one gallon of glass carboys. The yeast EC-1118 was inoculated into the juice for alcoholic fermentation. During fermentation, the yeast population was enumerated every day, and Winescan was used to monitor fermentation status, including glucose, fructose, pH, TA, ethanol, and volatile acidity. Fermentation was considered complete when the residual sugar was <2 g/L. Upon completion of fermentation, potassium metabisulfite was added to maintain 40 mg/L free sulfur dioxide. The wines were stabilized at 2°C and screened for faults by an expert sensory panel prior to bottling. The finished wine was also measured for aroma compounds by headspace solid-phase microextraction gas chromatography-mass spectrometry (HS-SPME-GC-MS). Chardonnay berries sprayed with the biofungicide showed normal fermentation. All wines made from biofungicide-treated berries had a similar chemical composition profile to the control wine. The range in alcohol content was 12 to 13%. Residual sugar and volatile acidity were <2 g/L and

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0.5 g/L, respectively. The pH was maintained at 3.2 to 3.3, and titratable acidity at 7.6 to 8.2 g/L. There was no significant difference in aroma compounds such as linalool, beta-damascenone, 3-hexen-1-ol, isoamyl hexanoate, 1-octanol, 1-nonanol, or methyl salicylate among treatments. This study indicated that biofungicides may be used as an alternative to synthetic fungicides for Chardonnay wine.

Funding Support: Agricultural Research Institute

Practical Strategies for Early Tartaric Additions to High pH Cabernet franc and Petit Verdot in Virginia

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Cabernet franc and Petit Verdot are the two most-widely planted red grape varieties in Virginia. Despite characteristics that produce good quality fruit and distinctive wines, high fruit potassium (K) often leads to wines with high pH. A common winemaking approach to rectify high pH is through relatively large tartaric acid additions, but winemakers differ in when these additions are made. Prefermentation additions are often recommended; however, this approach lacks guidelines to determine how much acid to add to achieve a target pH without adverse sensory consequences. In 2020 and 2021, the Virginia Winemakers Research Exchange tested the chemical and sensory effects of adding relatively large amounts of tartaric acid at fruit processing compared to post-malolactic additions. Initially, additions were done based on prior experience, resulting at times in over-addition and wines with high sensory scores for acidity. In the second year, measurement of juice K prior to inoculation was used to estimate the final wine pH. Using published data from other regions and historic data sets from Virginia, ranges of K (low, medium, high, very high) were defined and tartaric additions were done according to where juice values fell within those ranges. As expected, juice K was a better predictor of wine pH than juice pH. Measuring juice K avoided over-acidulation in all trial wines. Wines with prefermentation acid additions had lower volatile acidity and were scored as more "fresh" than wines with postfermentation additions. Based on this approach, assessing juice K prior to inoculation may be a practical strategy to inform the magnitude of prefermentation acid additions and avoid the adverse sensory effects of over-addition.

Funding Support: Virginia Wine Board

Freeze Storage and Maceration Technique Effects on Microscale Winemaking of Cold Climate Frontenac and Honeyberry

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Chemical and sensory analyses were evaluated on wines made from fresh and frozen Frontenac grapes and frozen honeyberries (haskap) individually fermented at 300 g microscale using four different pomace maceration techniques: 1) continuously submerged cap; 2) emersion blended/accentuated cut edges (ACE); 3) twice-daily cap submersion/plunging; and 4) twice-daily inversion by container rotation. The musts were fermented with 0, 1, 2, and 5 days of skin contact after yeast inoculation. Sample collection occurred at crush, press, and first racking at 30 d for fermentation

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progress, basic chemistry, color attributes, and total phenolics. Wine sensory evaluation occurred 90 d after inoculation. ACE and continuous cap-submerged wines from frozen grapes were expected to have higher pH, total phenolics, red color, tannin, bitterness, and astringency than other methods. Fermentation and analyses are currently in progress. These results will reveal the differences among fresh and frozen fruit, maceration duration, and treatments to characterize their chemical and sensory impacts. The results will support rapidly approximating macro volume cellar technique results on a laboratory microscale and stylistic winemaking decisions.

Funding Support: Northern Crops Institute

Redox Control of Chardonnay Fermentation to Limit Conversion of Elemental Sulfur to Hydrogen Sulfide

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Elemental sulfur (So) is commonly used in vineyard management to control powdery mildew. However, the presence of So residues during fermentation can lead to unwanted reductive aromas, primarily through formation of hydrogen sulfide (H_2S). Oxidation reduction potential (ORP), or redox potential, is an effective tool to measure the chemical state of fermentations. When the redox potential of a wine drops below 100 mV (standard hydrogen electrode scale), the spontaneous chemical reduction of So to H2S can occur. The goal of this project was to determine if redox control during fermentation could prevent chemical reduction of So to H_2S.

Chardonnay juice with 25 mg/L So added was fermented in triplicate with and without redox control. The setpoint for redox control was 150 mV (standard hydrogen electrode scale) and was achieved through the addition of air. The redox potential was monitored continuously in all six fermentations and total soluble solids and H_2S were measured every 24 hrs. In each replicate, 9 L of juice was fermented in 5-gallon buckets using RC212 yeast, at an average fermentation temperature of 22°C. On average, redox-controlled replicates completed fermentation two days earlier than uncontrolled replicates. H_2S production peaked between days 2 and 3 of fermentation and reached 21 3 32 ppb in the redox-controlled fermentations and 222 3 19 ppb in uncontrolled fermentations. At the end of fermentation, H_2S levels were 2 3 2 ppb in the redox-controlled group and 99 3 73 ppb in the uncontrolled group. During fermentation, the redox-controlled group produced twice as much total free sulfhydryls (including glutathione) than the uncontrolled group. The results of this study demonstrate that the controlled use of air to control redox potential during wine fermentation can not only significantly reduce the formation of H_2S when So is present, but can also lead to shorter fermentation times.

Funding Support: Jackson Family Wines

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Baseline Levels of Smoke-Related Volatile Phenols in California Grapes: Impact of Variety, Region, and Harvest Year

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In recent years, the United States West Coast has witnessed increased wildfires that have impacted the grape and wine industry. Wildfires release large amounts of volatile phenols from burning woods that can absorb into nearby grapes, negatively impacting grape quality. Absorbed volatile phenols are glycosylated in grapes as part of the vine defense mechanism. These smoke-related volatile phenolic compounds also occur naturally in grapes and can confound quantification of actual smoke-tainted grapes during exposure to wildfire smoke. This work screened a wide range of non-smoke-exposed red and white grape varieties for free and glycosidically bound volatile phenols to create a database of typical baseline ranges for these compounds. Benchmarking baseline levels will help the industry make harvest and winemaking decisions during smoke events. We have measured free and total levels of guaiacol, 4-methylguaiacol (creosol), phenol, 4-ethylguiacol, *o*-, *m*-, *p*-cresol, 4-ethylphenol, 4-methylsyringol, syringol, and their glycosylated precursors in non-smoke exposed grapes from different regions of California over two harvest years, 2021 to 2022. Air quality measures (PM 2.5 and Air Quality Index) were consistent, with no major smoke events in the regions sampled, indicating that the samples provided a reasonable estimate of baseline levels. GC-MS/MS and LC-MS/MS were used to quantify the phenolic compounds. Results showed a wide variation in the distribution of volatile phenols, not only in the different compounds analyzed, but also across multiple sites. The data showed no correlation between free and total levels, meaning both measurements are essential for the baseline database. Interannual (2021 to 2022) comparison of volatile phenols in Cabernet Sauvignon and Chardonnay grapes indicated that the individual phenolic compound concentrations were highly variable. This study found a high degree of variability in levels and distributions of volatile phenol compounds across growing regions, varieties, and years, so robust baseline levels will require a large, multiyear database.

Funding Support: American Vineyard Foundation

Recognition Threshold Concentrations of Thiophenol:Phenol Mixtures for "Ashy" Off-flavor in Smoke-Affected Wine

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With the prevalence of wildfires in wine regions around the world, the flavor profile of wines has been negatively affected, causing an uncharacteristic "ashy" flavor. Smoke that reaches a vineyard transfers volatile compounds from the smoke into the grape. This then leads to wine with smokey, burnt, and dirty aromas, along with a unique ashy finish. All these descriptors are considered detrimental to quality. Although previously thought to be caused by volatile phenols found in wood fire smoke, recently a new class of compounds has been found to be a main causative agent. Thiophenols have been found in elevated levels in smoke-affected wines that, when in combination with the smoke phenols, lead to smokey and ashy flavors. There is no sensory threshold information currently available for thiophenols in wine. The goal of this work is to determine at what concentrations of thiophenols and phenols

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when present in Pinot noir, the wine is considered "ashy". Using an adaptive staircase procedure with a yes-no paradigm, the recognition threshold levels of thiophenols and phenols were determined. In addition to determining the threshold level of these compounds, this work investigated potential differences in individual recognition sensitivity to these compounds. Previous work reported that there is a section of the population that is unable to perceive smoke-related attributes in wine and that those who do perceive them, have varying sensitivities. To understand further these varying sensitivities to smoke-related flavors, additional demographic and food consumption information was collected to determine whether threshold clusters arise based on these factors. With wildfires becoming more frequent, this research can be used to determine economic thresholds for wine production and targets for risk decision making.

Funding Support: USDA-NIFA-SCRI, USDA-ARS

Treatment of Smoke-Impacted Wines Using a Molecularly Imprinted Polymer (MIP) Can Improve Sensory Outcomes

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Remediation of smoke-impacted wines presents a significant challenge to winemakers, as available treatments can strip many desirable attributes from a wine, including mouthfeel. Molecularly imprinted polymers (MIPs) present a unique treatment option, as they target compounds specifically by molecular structure, leading to more targeted compound removal. The goal of this study was to test the chemical and sensory outcomes of treating wines with a volatile phenol-removal MIP. Five 2020 smoke-impacted wines (three Napa County Cabernet Sauvignons and two Sonoma County Pinot noirs) were treated at both bench (0.5 to 2 L) and pilot (150 to 190 L) scales. At bench scale, the concentration of smoke marker compounds (guaiacol, 4-methylguaiacol, and *o*-, *p*-, and *m*-cresol) was reduced by up to 71 3 2% at the maximum treatment rate. Pilot-scale treatment of wines used lower treatment rates and removed 25 to 48% of smoke depending on the compound, wine, and treatment rate being evaluated. A sensory panel of 11 winemakers blindly evaluated the control and MIP-treated wines ~45 days after treatment. MIP treatment significantly improved sensory outcomes in three of the five wines. In those wines, MIP treatment significantly decreased the perception of smoke aroma. In one Pinot noir, MIP treatment also significantly reduced the plastic/chemical aroma and the smoke/ashy finish. Wine body, astringency, and bitterness were not impacted significantly by the treatment in any wine. Wines were analyzed again after one year and the concentration of smoke marker compounds had not significantly increased. Remediation of smoke-impacted wines with a MIP targeting volatile phenols represents a promising new tool for winemakers impacted by smoke exposure.

Funding Support: Jackson Family Wines, Amaea

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Using Instrument Measurements and Sensory Analysis to Assess the Impact of Smoke Exposure on Red Wines in California

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We investigated the impact of volatile phenols (VPs) released from burning wood (lignin thermal degradation) during wildfires on grape composition and that of the resulting wines. Wines made from these impacted grapes are characterized sensorially as smoky, burnt, ashy, barbeque, medicinal, and having a retro-nasal ashtray character. The study aimed to determine the baseline levels of VPs in grapes, to establish the sensory differences between smoke-impacted wines and non-smoke impacted wines, and to understand the drivers of smoke taint analytically. Descriptive analysis, multivariate statistics, and analytical measurements of the free and total VPs were used. The level of smoke impact depended on the concentration of free and total VPs present analytically. First, smoke-impacted, and non-smoke-impacted Cabernet Sauvignon wines from nine different sites across California were evaluated. Second, six other common California red wine varieties, Cabernet franc, Petite Verdot, Merlot, Syrah, Malbec, and Zinfandel, were studied. Analytical measurements gave varying concentrations of smoke marker indicator compounds present in the wine. The results show there are sensory differences between high-smoke impact wines and non-impacted wines. Wines which had low smoke impact, based on free and total VP concentrations, were not significantly different from the non-impacted wines when rated through descriptive analysis. Between the different varieties, some smoke-impacted varieties, such as Merlot, were similar in ratings to the non-smoke impacted varieties. Different wine matrices from the different locations and varietals play an important role in determining the level of smoke taint. The results of this study will contribute to our understanding of smoke taint and its wine quality impact by relating smoke marker indicator compounds to sensory attributes. It provides valuable insights for the wine industry and can inform future efforts to mitigate the effects of wildfire smoke on wine production.

Funding Support: Jackson Family Wines, USDA-ARS

Remediation of Smoke-Impacted Wine Using Molecularly Imprinted Polymers

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Smoke impact from wildfire events is a major problem in winegrowing regions around the world, and has been particularly damaging in recent years in premium winegrowing regions. Volatile phenols (VPs) released from burning wood have been associated with affecting the aroma and taste of wines, resulting in smoke and ashy characters. This study expands on prior research done in the Oberholster lab evaluating VP amelioration in wine. One of the more promising VP amelioration methods was molecularly imprinted polymers (MIP), which are synthetic polymers made with target molecules and used to pointedly remove compounds from affected wine. Adsorption tests are performed using MIPs, analyzing 11 VPs (guaiacol, creosol, *o*-cresol, phenol, 4-ethylguaiacol, *p*-cresol, *m*-cresol, 2,3-dimethoxyphenol, 4-ethylphenol, syringol, and 4-methylsyringol) at high concentration using gas chromatography-mass spectrometry to determine optimal contact time for its removal by MIP in a model wine solution. The study examines the efficacy of using MIP to remove VPs in both a batch and a continuous flow processing setting. In

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addition, the study evaluates how real smoke-impacted wines respond to treatment with MIP in comparison to the determined models. In previous tests, MIP removed up to 80% of free VP content in smoke-impacted wine in a model setting. The results of this study will offer new insights into an effective amelioration treatment for smoke-impacted wines, which could be a great advantage for the industry as wildfires and smoke impact become more common.

Funding Support: Constellation Brands, LLC and USDA-ARS

Rapid Smoke Impact Evaluation using Simultaneous UV-vis and Fluorescence Spectroscopy

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Winegrowing regions worldwide have seen more wildfires in recent years, costing the industry billions of dollars in lost revenue. During a wildfire event, significant quantities of volatile phenols are released into the air. These compounds are easily absorbed into grapes through the cuticle, where they become glycosylated into mono-, di-, and triglycosides. Wines produced from smoke-impacted grapes can have unfavorable sensory attributes described as smoky, medicinal, band-aid, ashtray, and burnt rubber. During the 2020 wildfires, analytical laboratories were inundated with an unprecedented volume of samples, creating delays of over a month. For this reason, a high-throughput method of analysis which can be easily adopted by commercial and winery laboratories is needed to assess smoke exposure risk. Reducing the number of samples to be analyzed using advanced analytical techniques will save time and money. Simultaneous UV-vis and fluorescence spectroscopy has shown that smoke-tainted wines can exhibit distinct absorbance and fluorescence spectral differences. Building upon this knowledge, a calibration curve will be developed using smoke-impacted wines and serial dilutions with non-smoked exposed control wines. Nine varietals were harvested from several Northern California vineyards in 2022 and used to produce 20 wines. Half of each grape varietal was intentionally smoked in a tent for five hour prior to fermentation in a controlled setting. Wines will be analyzed by both gas chromatography-mass spectrometry and fluorescence spectroscopy. Using multivariate statistical analyses, correlations between the two analysis methods will be developed. Future studies will incorporate sensory analysis to build a smoke taint index.

Funding Support: Specialty Crop Multi-State Program.

An Analysis of Activated Charcoal Protection from Smoke Taint on Grapes

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The wine industry around the world has seen an influx of smoke-related quality impact in wines due to smoke exposure. Wildfire risk has increased due to the increasing incidence of droughts and heat waves. During wildfires, high concentrations of volatile phenols (VPs) are released from wood; research has shown that these compounds can absorb into grape berries and reduce wine quality. There is currently no widely applied effective treatment in the vineyard to prevent absorption of VPs into grapes. Different carbon-infused materials can effectively

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protect the grapes from smoke in controlled smoke studies. However, placing black hoods over bunches could negatively impact grape ripening and phenolic evolution. This study investigated three different materials, loose- and tight-woven materials and a felt fabric, infused with activated carbon. These were placed as hoods over the bunches. In an additional treatment, the tight-woven fabric was strengthened with bird netting and placed on either side of the fruiting zone as a potentially less labor-intensive treatment. The treatments were applied after 100% veraison. Bunch samples were taken every week for seven weeks until harvest. HOBO temperature/humidity data loggers were placed inside each treatment to determine the impact of the fabric on bunch microclimate. Grapes are currently being analyzed to determine the phenolic profiles of the treated and untreated grapes by RP-HPLC, according to the method described in Panprivech et al. (2015). Although studies have shown that covering the grape bunches with activated carbon hoods is very effective in absorbing VPs in the atmosphere and protecting the grapes, this treatment is currently cost-prohibitive. Furthermore, if fabric protection comes at the cost of losing desired tannins, anthocyanins, or flavanols, it may not be a viable solution.

Funding Support: USDA-ARS

Absorption of Smoke Marker Compounds From Smoke-Impacted Wines Onto Wood

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In recent years, concerns have been raised regarding the reuse of barrels that contact smoke-tainted wines. Anecdotal reports from winemakers exist, stating that non-smoke impacted wines were negatively impacted by barrels that previously contained smoke-tainted wines. Thus, the current study was designed to evaluate the potential risk of reusing barrels that contained smoke-impacted wines. In a first step, the efficacy of standard barrel cleaning and sanitation procedures at removing volatile phenol smoke marker compounds from barrels that contained smoke-tainted wines was determined. Six American oak blocks were soaked in model wine, as a control, and 30 similar blocks were soaked in heavily smoke-tainted 2020 vintage Cabernet Sauvignon from Healdsburg, CA, for six weeks. After soaking, these blocks were removed, patted dry, and subjected to cleaning (hot water rinse) and various sanitation protocols such as steam and vacuum, ozone, and sulfur wick. Blocks were then shaved to depths of 0 to 4 mm, 4 to 8 mm, and 8 to 12 mm before each layer was dried, ground to powder, and extracted for chemical analysis. The extracts were analyzed by LC-MS/MS to determine the presence of volatile phenol glycosides. Free volatile phenols are naturally present in oak and would not be an indicator of smoke marker compound adsorption. Upon completion of the chemical analysis of each layer, the most effective cleaning protocol was used on a larger trial with three barrels each of non-smoke tainted wine, low-medium smoke-tainted wine, and medium smoke-tainted wine. Upon cleaning, these barrels underwent the same analysis as the oak blocks and their corresponding shavings. Analysis is ongoing and the presence of phenol-glycosides in different layers of oak staves will indicate concerns regarding barrel reuse after storing smoke-impacted wines and which cleaning method is most effective.

Funding Support: UC Davis Oberholster Lab

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Film Coatings as a Protective Layer in Reducing Grape Absorption of Smoke Phenols

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Winegrapes exposed to wildfire smoke can produce wines with burnt and ashy sensory characteristics, resulting in loss of product. Currently, there are no effective solutions in the market to prevent uptake of smoke compounds into grapes. In this study, innovative film coatings were developed to prevent smoke phenols from entering Pinot noir grapes. Four different film types were developed using cellulose nanofibers as the coat-forming matrix. The formulations were developed by incorporating different quantities of chitosan and/or β-cyclodextrin into the matrix. The coatings' effectiveness in reducing smoke phenols was investigated. Film coatings were applied at veraison in a vineyard in Southern Oregon, where two smoke events occurred during the 2022 vintage. At harvest, half of the grapes were washed to remove the films. This was to determine whether smoke phenols are blocked or bind to the film coatings. Further analysis of the interaction of smoke phenols with film coatings was done by observing any volatile phenol diffusion through the film using a custom-made polytetrafluoroethylene apparatus. Smoke phenols in grape juice were analyzed using gas chromatography-mass spectrometry and smoke glycosides using LCMS. Results show that some of the film coatings were effective at reducing the amount of smoke compounds that absorbed into the grapes.

Funding Support: USDA-SCRI, Oregon Department of Agriculture, USDA-ARS

Impact of Barrier Spray Application on Smoke Mitigation in Winegrapes

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The impact of wildfires on winegrape growing regions has increased. Wildfire smoke contains high concentrations of volatile phenols (VPs) that can absorb into grapes and negatively impact grape and wine quality. A few investigated barrier sprays have shown some efficacy in decreasing grape VP absorption from smoke. However, quantitative data regarding application methods is lacking. Two different industrial sprays (Kaolin and GM3-E) were selected for further study, as they showed promise in prior tests. The sprays were applied at two time points prior to intentional smoking, 10 and 21 days, to establish the most efficient application interval for regular protection. Each spray was applied using two different applications: only to the bunch zone, or to the bunch zone and the canopy, to determine the potential for VP translocation from leaves to grape bunches. Additional control samples (no smoked exposure) were taken before smoking. Intentional smoking was accomplished by constructing smoke tents, followed by overnight application of smoke with commercial smokers and hickory pellets. VP concentrations in the tents during smoking were monitored by TD-GC-MS. Samples were taken pre- and post-smoking from treated, untreated, and control (no smoke exposure) grape bunches. At maturity, the grapes were harvested and again split into two treatments: 50% of the grapes were washed with tap water and 50% were left unwashed. All grapes were then fermented in benchtop microferments. The wines from these ferments, berries from the smoked vines, and air samples taken from the smoking tents were

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analyzed using gas chromatography mass spectrometry (GC-MS) to quantify VP marker compounds in both the free and acid-labile forms. Analysis is ongoing and the results will indicate which treatment could be the most effective, as well as optimal application method and rate.

Funding Support: USDA NIFA SCRI grant

Activated Carbon Fabric: A Promising Strategy to Mitigate Smoke Taint in the Vineyard

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Activated carbon has proven to be a useful adsorbent for amelioration of smoke-tainted wine, enabling removal of smoke-derived volatile phenols (guaiacols, cresols, and syringols) thought to be responsible for objectionable smoky, medicinal, and ashy characters. Proof-of-concept studies recently demonstrated the potential of activated carbon fabric to mitigate smoke contamination of grapes in the vineyard. Postharvest smoke exposure of Mataro grapes resulted in wine with elevated volatile phenol concentrations (i.e., up to 21 µg/L). However, the composition of wine made from grapes that were enclosed in activated carbon fabric prior to smoke exposure was comparable to that of control wine; only 1 µg/L differences in guaiacol, *o*- and *m*-cresol, and/or syringol concentrations were observed. Furthermore, while wine made with smoke-exposed grapes exhibited diminished fruit intensity and pronounced smoke attributes, the sensory profiles of wines corresponding to activated carbon fabric treatments could not be differentiated from that of control wine. A small but significant loss of color was observed and attributed to adsorption of anthocyanins by activated carbon fibers that adhered to grape bunches and were therefore present during fermentation. The application of activated carbon fabric to individual bunches of grapes is clearly not feasible in commercial vineyards, therefore, field trials involving the application of activated carbon fabric to the fruit zone of grapevines were undertaken. The (black) activated carbon fabric caused premature senescence of covered leaves, but did not meaningfully affect berry ripening. Wine compositional analysis again confirmed that fruit enclosed in activated carbon fabric was protected from smoke contamination, evidenced by significantly lower volatile phenol concentrations. Several shortcomings must be addressed before this mitigation strategy can be implemented by the industry for use in commercial vineyards, but results are highly promising.

Funding Support: Wine Australia, The University of Adelaide, Peter Michael winery

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Exploring the Influence of *S. cerevisiae* mannoproteins on Wine Astringency and the Impact of their Polysaccharide Part

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Mannoproteins (MPs) are proteoglycans from the outmost layer of yeast cell walls that are released into wine during alcoholic fermentation and aging on lees. The use of commercial MP preparations as additives to prevent precipitation/insolubility of tartaric salts and protein haze in white wines is widespread and regulated. However, MPs possess other properties. MPs can impact the colloidal stability of polyphenols and modulate the astringent effect of condensed tannins. The latter interact with

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salivary proteins, forming insoluble aggregates that cause loss of lubrication in the mouth and promote a drying and puckering sensation. However, the interaction mechanisms involved in the MP capacity to impact astringency are not fully understood, nor are the structure-function relationships of these macromolecules with this property. This study evaluated the impact of high molecular weight MPs in tannin-protein interactions. To this end, tannin-BSA aggregation kinetics (with or without MPs) were assessed through dynamic light scattering measurements over time. MPs clearly delayed tannin-BSA aggregation kinetics by preventing formation of micron-sized particles within one hour, but did not prevent precipitation after 24 hrs. This suggests that MPs interfere in tannin-BSA aggregation through formation of a tertiary system of MP-tannin-BSA. To examine structure-function relationships, four different kinds of MPs with specific polysaccharide structures were used to examine the impact of the polysaccharide moiety: A reference strain (BY4742), the two mutants ΔMnn4 (with no mannosyl-phosphorylation) and ΔMnn2 (linear N-glycosylation backbone), and a commercial enological strain (LMD47). To prevent tannin-BSA particle growth, the density/compactness of the polysaccharide moiety of MPs was a key factor.

Funding Support: Lallemand Oenology

Effects of Exogenous Acetaldehyde Additions on Tannin Elongation in Cabernet Sauvignon

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During wine aging, especially in barrel, small amounts of oxygen absorption cause cascading oxidation reactions, allowing tannin elongation. The reaction that causes this is the hydroxyl radical-mediated oxidation of ethanol in wine to acetaldehyde, which elongates polyphenols by adding an ethyl bridge between them. This elongation can positively affect the flavor and mouthfeel of a wine. While the importance of these reactions has been demonstrated, no method for catheterizing intact elongation products in wine exists. Additionally, all commercially used methods for inducing elongation rely on passively or actively inducing oxygen ingress rather than direct manipulation of acetaldehyde. Previous work demonstrated that direct addition of high levels of acetaldehyde acts to deplete catechin monomers by causing elongation. However, there has been no further optimization of the system or characterization of the products created. We developed an LC/MS method to measure products of the reaction using a transition of 605 to 289 *m/z*, which is the mass to charge of two catechins attached with an ethyl bridge and appears both in dimers (two catechins with an ethyl bridge) and other longer polymers that can be separated chromatographically. When adding exogenous acetaldehyde at low, high, and high divided into five doses (100, 500 and 100 ng/mL five) to a model wine solution after 18 days, the catechin product increased 2.5- and 11-fold in the low and high doses, respectively, while the control had no detectable ethyl-bridged catechin. The rates of creation of the catechin product varied between the different dose concentrations and the sequential additions. Having a method for product characterization will allow further optimization of dose rates so direct acetaldehyde addition becomes an easy tool for winemakers looking to directly and predictably induce phenolic elongation.

Funding Support: Pennsylvania Wine Marketing and Research Board

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Investigating the Impact of Aging on Chemical Parameters of Red Wines Made from Cold-hardy Grape Cultivars

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Sulfur dioxide is the most widely used preservative in wine to protect against microbial spoilage and oxidation. In red wines, phenolic compounds such as anthocyanins and tannins are extracted from grapes during the first days of alcoholic fermentation and are responsible for color stability, mouthfeel, and protection against oxidation. This study aimed to evaluate the evolution of quality in red wine made from the cold-hardy interspecific grape cultivars Marquette and Frontenac during aging. Wines of varying vintages from 2013 to 2020 provided by Iowa wineries with basic chemistry at bottling were chemically characterized. The pH, titratable acidity, color intensity, hue, phenolics, and tannin concentrations were quantified in triplicate using UV-vis spectrophotometry and HPLC-DAD, respectively. The amount of free and total SO_2 in the aged bottles was quantified by titration and compared with the amount of SO_2 added at bottling. The basic chemical parameters such as pH and titratable acidity were not impacted by aging time. Total phenolic concentration was the highest in 2013 wines. Tannin concentrations were <500 mg/L for all wines and vintages, reducing the level of protection against oxidation. The older the wines, the higher the hue of Frontenac wines, suggesting some oxidative browning in old Frontenac wines. However, aging time did not affect the hue of Marquette wines. As expected, the amount of free SO_2 after aging was less than at bottling, but there was no difference in SO_2 loss between cultivars. These results suggest that the color of Frontenac wines is less stable than that of Marquette wines during aging, probably due to a different ratio of tannins to anthocyanins. Ongoing research is currently focusing on red wine quality made from cold-hardy red grape cultivars after addition of three SO_2 concentrations at bottling.

Funding Support: USDA-AMS Specialty Crop Block Grant Program (SCBGP).

Environmental Drivers of Tannin Extractability in Pennsylvania Winegrapes

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Hybrid winegrapes exhibit positive growing properties such as cold-hardiness and resilience to common plant pests and pathogens. They are economically significant in the Midwest and Northeastern United States, where *Vitis vinifera* does not grow easily. The quality of hybrid wines is limited, however, by deficiencies in the extraction of important grape polyphenols. Condensed tannins contribute to the sensory and health-promoting qualities of dry red wine, but in hybrid wines these compounds are found at very low concentrations. The extractability of grape tannins has been shown to vary by location and vintage, indicating that grapevine environment likely modulates this key quality parameter. Hybrid grape varieties were not included in this study, however, and it remains unclear whether certain environmental conditions can mitigate or worsen the low tannin extractability observed in hybrids. To examine this question, we measured tannin extractability in one hybrid and one *V. vinifera* cultivar harvested from seven commercial vineyards in Pennsylvania. Tannins were extracted from each grape sample in triplicate using model wine and an exhaustive extraction, then quantified using RP-HPLC.

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Extractability was measured as the ratio of tannins extracted in model wine to total grape tannins. Grapevine environmental data was collected using on-site weather stations and correlated with phenolic extractability.

Funding Support: National Institute of Food and Agriculture, U.S. Department of Agriculture, through the Northeast Sustainable Agriculture Research and Education program

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Effect of Two Plant Growth Regulators on Phenolic Content of Grape Skins and Seeds

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Tannin concentration is related to red wine quality, but many factors influence it, including low extractability and/or low initial content in skins and seeds. This is a real challenge in non-*Vitis vinifera* grape cultivars. This study aimed to evaluate the effect of plant growth regulators on tannin content in Marquette grape skins and seeds. A complete block design was used to assign 24 Marquette vines as three-vine panels to eight treatments with three replicates. Prohexadione calcium was applied to change the cell wall thickness and structure that may reduce extractability of tannin. Phenylalanine is a precursor of tannin and anthocyanin biosynthesis. Those plant growth regulators were applied as foliar sprays five times and two times, respectively, from one week postbloom to one week postveraison. Berries were sampled five times, from one week post-fruit set to harvest. Grapes were crushed to make juice and berries were peeled and separated into skins and seeds; wine was also made at harvest maturity. Basic chemical parameters (pH, titratable acidity, color intensity, etc.) were measured on juice and wine. Tannin and iron-reactive phenolic concentrations were quantified on juice, wine, and extracts from skins and seeds by HPLC-DAD and UV-vis spectrophotometry, respectively. Preliminary results from juice showed no statistical differences among treatments for any parameters measured. This may be because plant growth regulator rates were too low to see drastic effects immediately in juice. Analysis of results from skins, seeds, and wine is ongoing. This study will be replicated in 2023 to investigate the effects of plant growth regulators over two growing seasons.

Funding Support: No funding source.

Sensory Analysis of Californian Petite Sirah (Durif): Does Price Affect the Sensory Attributes Of These Wines?

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We purchased 21 California Petite Sirah wines, all from vintages 2017 to 2020, from Lodi, Paso Robles, Napa Valley, Sonoma County, the Sierra Foothills, Mendocino, and California. Price ranges were high (H): more than $40 per 750 mL bottle (five wines), medium (M): $20 to $40 per bottle (nine wines), and low (L): less than $20 a bottle (seven wines). A trained panel of 10 judges evaluated each wine in triplicate in a balanced randomized order for 29 sensory attributes. All attributes were anchored with reference standards. The data were analyzed using XLSTAT and R-Studio. Nineteen attributes were significantly different across the wines. Most wines were quite similar, with some noted exceptions. These exceptional wines tended to be very high in the attributes barnyard, cooked vegetable, earthy, and smoky. The effect of price was only significant for three attributes: acetone with the L-wines had

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the lower acetone scores; sweet with the H-wines were perceived as sweeter; and hot with the H- and M-wines were perceived as hotter. The sweet perception was not supported by the glucose and fructose concentrations of the wines, since the L-wines had significantly more of these compounds. It is possible that the perceived sweetness was affected by the floral-fruity aromas in these wines. The hotness results were exactly in line with the alcohol concentrations of the wines, and the acetone perception results were in line with the volatile acidity data. We chose nine wines for a consumer hedonic study and found significant differences in liking, with the wine highest in barnyard odor being by far the least liked. Additionally, the internal preference map showed that the Northern California consumers overwhelmingly rejected wines high in barnyard and earthiness. We conclude that price is not a major driver for the sensory attributes of California Petite Sirah wines.

Funding Support: Ray Rossi Endowed Chair

Isolation and Characterization of the Yeast *Hanseniaspora uvarum* and Its Growth on Grape Surfaces

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Hanseniaspora uvarum, a non-pathogenic, weakly fermentative, and aroma-releasing epiphyte, is the predominant yeast on winegrapes at harvest and during early fermentation. We isolated *H. uvarum* from cold-hardy hybrid winegrapes in Iowa, developed methods to quantify its growth on the surface of grapes, measured sugars in exudate from those cultivars, and characterized *H. uvarum*'s carbon utilization and fungicide sensitivity. La Crescent and Marquette grapes were collected July and August 2021. Yeasts were isolated by shaking fruit clusters in water, then plating on selective media. From 70 preserved isolates, eight collected in late August were confirmed as *H. uvarum* by ITS sequencing. Preliminary phylogenetic analysis of the collected *H. uvarum* isolates, plus reference isolate YB-505 from USDA-ARS, did not indicate genetic clustering based on source cultivar. Table grapes were used to develop methods for surface sterilization, *H. uvarum* inoculation and incubation on grape skins, and yeast recovery and quantification. Ames isolates were inoculated onto La Crescent and Marquette berries in August 2022. Most Marquette berries split during incubation and were discarded, while growth on La Crescent was highly variable and showed no significant difference among isolates. Glucose plus fructose was measured in grape exudate from La Crescent and Marquette in August 2022, with large variation among berries, but no significant cultivar difference. Phenotype microarrays were conducted on YB-505 to evaluate its utilization of carbon sources and its chemical sensitivities. Notable for viticulturists and winemakers are its sensitivity to copper sulfate, metabolism of sorbate and pentoses, and low utilization of *Saccharomyces cerevisiae*-fermentable sugars such as raffinose, galactose, and maltose. This work confirms that *H. uvarum* is present on winegrapes in Iowa before harvest; preliminary work suggests it is also present on mummies in early spring. It also highlights substantial intracluster variation in the chemistry, morphology, physiology, and biotic interaction of individual berries.

Funding Support: Midwest Grape and Wine Industry Institute

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Collection and Analysis of Winemaking-related Microorganisms from Materials in Hokkaido, Japan

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In recent years, the number of wineries in Hokkaido, Japan, has increased significantly. Microorganisms are an important factor responsible for terroir. The purpose of this study was to collect wine-related microorganisms from various materials in Hokkaido and perform molecular identification of the isolates and their genetic and physiological characteristics. They can be used as starters in the future or as research materials. In this study, we focused on isolating yeasts and lactic acid bacteria such as *Saccharomyces cerevisiae* and *Oenococcus oeni*. We attempted to isolate them from various fruits, must under fermentation, and wine lees. For fruits with a lot of juice, such as grapes, the fruits were crushed in a plastic bag and allowed to ferment at room temperature. For strawberries, prunes, and other fruits with little juice, we added the fruit to commercial grape juice and waited for fermentation to occur at room temperature. Fermented samples were then spread on agar plates to form colonies. Colonies were isolated and identified by rDNA ITS or 16S rDNA. Strains isolated from the same sample and identified as *S. cerevisiae* and *O. oeni* were excluded from possible clones by SSR (Simple Sequence Repeat) analysis and RAPD (Random Amplified Polymorphic DNA) or SSR analysis, respectively, and were registered as AHU (Agriculture, Hokkaido University) collections. From 2016 to 2022, we collected 475 *Saccharomyces* strains and 143 *O. oeni* strains. Other LABs including *Leuconostoc mesenteroides*, *Lactococcus lactis*, *Lactobacillus plantarum*, and *Lactobacillus brevis* were isolated as well. We are currently analyzing the genetic and physiological characteristics of these collected strains.

Funding Support: Institution of Fermentation, Osaka/ Sapporo Bioscience Foundation

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Evaluation of Lot-to-lot Repeatability in Oak Alternative Products and Effect of Toasting Method on Volatile Composition

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Commercial oak barrel alternative products toasted using different methods (vacuum, double toast, convection, fire, and infrared) were analyzed for products of lignin and hemicellulose degradation formed during the toasting process. Oak extracts in model wine (14.5% v/v ethanol) were analyzed using headspace solid-phase microextraction gas chromatography-mass spectrometry (HS SPME-GC-MS). Samples from three separate lots of each product were analyzed for furfural, 5-methyl furfural (5MF), *trans*-oak lactone, *cis*-oak lactone, guaiacol, 4-ethyl guaiacol (4EG), 4-methyl guaiacol (4MG), syringol, eugenol, vanillin, *trans*-isoeugenol, and 4-methyl syringol (4MS). The repeatability coefficient and linear discriminant analysis were used to determine the lot-to-lot variation of each toasting method. In general, variation between lots increased in the medium and medium plus. The method with the least variability varies based on the toast level. Significant differences in volatile composition between products of the same nominal toast levels produced with different methods were found. Understanding how each toasting method varies, and the differences between them, will allow winemakers to have more control over their final product.

Funding Support: Scott Laboratories

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Investigating the Use of Barrel Microoxygenation for Accelerated Red Wine Aging

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Barrel-maturated wines are enriched in aromatic compounds, their color is more stable and mouthfeel complexity is improved. The extraction of oak phenolics is governed by diffusion kinetics: the rate of extraction is initially high, decreasing when the concentration in the wine approaches that on the surface of the barrel. Additionally, oxygen plays an important role in wine aging, stabilizing color, and more. Microoxygenation in combination with barrel aging could accelerate wine aging, reducing the time that wine spends in-barrel while still obtaining the benefit of oak aromatics. In this project, a red wine blend was aged in barrel and stainless steel vessels using different rates of O_2 dosing (0, 1, and 2 mg/L/month). The 2 mg/L/month treatment was stopped after three months, while the 1 mg/L/month treatment was applied for six months. The barrel treatments without MOX continued for 12 months. Dissolved oxygen (DO), volatile acidity, and free and total SO_2 levels were monitored weekly. Acetaldehyde-adducts and phenolics were determined by RP-HPLC. Results showed that wines reached similar levels of acetaldehyde at the end of each treatment, independent of MOX level. Total tannins increased over time, particularly in the wines aged in barrels, and total anthocyanins decreased over time, paired with an increase in polymeric pigments in all wines. PCA of all the chemical data indicated that the six months O_2 treatment at 1 mg/L/month showed comparable aging to the barrel treatment without MOX after 12 months; however, during consumer studies, judges preferred the barrel aged wines with no MOX during 12 months over the rest of the treatments. No significant differences were found hedonically among the rest of the wines, suggesting that MOX could be used to shorten aging time in barrel, but must be studied further, as its impact is very specific to the wine.

Funding Support: Lyon-Cisneros Family Research Fund

Enhancement of 4-Hydroxy-2,5-dimethyl-3(*2H*)-furanone in Muscat Bailey A Wines by Vinification of Shade-Dried Grapes

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Muscat Bailey A is a hybrid grape variety (*Vitis labruscana* [Bailey] *Vitis vinifera* [Muscat Hamburg]) that was hybridized in Japan in 1927. This variety has been cultivated since then and is one of the most popular red wine varieties in Japan. The inclusion of Muscat Bailey A on the International List of Vine and Varieties and their Synonyms managed by the International Organisation of Vine and Wine in 2013 has further fueled its popularity among winemakers and researchers around the world. Most Muscat Bailey A wines have unique characteristics, such as light mouth feel and strawberry-like, fruity aroma. Our previous reports demonstrated that Muscat Bailey A grapes biosynthesize and accumulate 4-hydroxy-2,5-dimethyl-3(*2H*)-furanone (HDMF), suggesting that HDMF may be responsible for the characteristic strawberry-like aroma of the wine. In addition, we identified HDMF glucopyranoside in Muscat Bailey A juice as the aroma precursor of HDMF. Here, we investigated the effect of shade-dried grapes vinification on the concentration of HDMF in Muscat Baliey A wines to enhance this characteristic aroma. The concentration of HDMF

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glucopyranoside in Muscat Bailey A juice increased remarkably with the shade-dried treatment. The result of real-time RT-PCR showed that the expression level of the HDMF glucosyltransferase gene (*UGT85K14*) in Muscat bailey A berries was much greater after the shade-dried treatment than before. These findings are expected to contribute to the understanding of the metabolism of HDMF in grapes and the control of the characteristic strawberry-like aroma of Muscat Bailey A wines.

Funding Support: Kirin Holdings Company, Limited

Malvasia de Sitges: an Ancient Grape Adapted to Climate Change

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Viticulture and winemaking are confronted with the challenges of climate and market trends. At this crossroad, one option is to study old varieties that may increase the array of varieties available. Among these old varieties, Malvasia de Sitges is deeply rooted in the traditions of Catalonia and other Mediterranean sites. These roots have generated a web of cultural heritage, such as mythological stories, artistic pieces, and an imagery unique to our coasts. Since its arrival, around the thirteenth century, it has developed some interesting features that make survival easier in an increasingly warm environment. It has the rare capacity to maintain low pH and high acidity and aroma even in recent, warmer decades, when most varieties have increased pH, lowered acidity and aroma, or both. Malvasia de Sitges has a long maturity cycle, good drought resistance, and has long, loose clusters with small berries that avoid botrytis development. On the negative side, it is as sensitive to powdery mildew as other Muscat grape varieties. It is used for concentrated juice and wine in the studied area. It may be used for still, sparkling, or dessert style wines. We compared Malvasia de Sitges to other common varieties in juice composition, wine aroma compounds, and growth in planted area in the last decade in the production area in Garraf and Penedes, 40 km South of Barcelona, Spain.

Funding Support: INCAVI

Climate Projections for Ripening Potential for Alternative Cultivars in California and Oregon Pinot noir-Producing AVAs

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This analysis is a follow-up to two recent studies that separately examined the ripening potential of Pinot noir in Northern California's Fort Ross-Seaview, Los Carneros, Petaluma Gap and Russian River Valley American Viticultural Areas (AVAs) and in Oregon's Willamette Valley AVA. Each study involved computations of the growing season average temperature viticulture climate classification index and Pinot noir-specific applications of the grapevine sugar ripeness (GSR) model on a mean decadal basis from the 1950s to the 2090s using coupled model intercomparison project phase 5 (CMIP5), RCP4.5, and RCP8.5 projections of minimum and maximum daily temperature. The California study used the second version of the multivariate adaptive constructed analogs downscaled CMIP5 model archive, which accounts for the onshore penetration of the marine layer in the coastal zone and cold-air pooling in complex terrain. The Oregon study applied the localized constructed analogs downscaled CMIP5 model archive. Both studies showed a progressive trend of decreasing area to support an optimal harvest window (10 Sept to 10 Oct) for Pinot

noir in each AVA and for each RCP-emission scenario, which was more pronounced for the RCP8.5 scenario projections. This study applies the temperature-based GSR phenology models that were developed in each of the two noted studies to evaluate alternative cultivars that may be more suitable for ripening in each AVA due to climate change.

Funding Support: No external funding

Impact of Pruning Severity on Fruit Sunburn Damage and Its Relation with Berry Aromatic Compound Concentrations

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Vines from the Itata Valley, in the Ñuble region of Chile, are head-trained and not irrigated during the growing season. This means that severe water stress often occurs from veraison to harvest, which may compromise fruit quality and carbohydrate accumulation in roots and shoots. Muscat of Alexandria vines from this viticultural region exhibit low vegetative growth, inducing over-exposition of berries to high solar radiation and elevated air temperature. High percentages of sunburn-damaged clusters are usually observed at harvest (350%), which may impact wine quality. Severe pruning could increase shoot length, reducing the amount of intercepted solar radiation and affecting plant water status and fruit and wine quality. A study was conducted in a non-irrigated Muscat of Alexandria vineyard under the traditional cultural management of the Itata Valley. Three pruning intensities (mild, moderate, and severe, leaving 21, 16, or 12 buds per plant, respectively) were applied in the vineyard. Reproductive growth and development, plant water status, microclimate conditions, and fruit and wine chemical quality were evaluated during the 2020 to 2021 season. At harvest, all vines showed severe levels of water stress, but pruning treatments had no effect on plant water status parameters. Pruning severity changed sunlight penetration at the fruit zone before veraison, which was probably responsible for treatment differences in sunburn incidence and severity. Greater severity of sunburn was associated with a lower concentration of herbaceous aroma compounds. These results indicated that sunburn in berries may be induced by pruning at different severities, generating important changes in the aromatic profile of berries and wines. Consequently, changing pruning practices may be a practical tool to face the consequences of global warming and water scarcity in commercial winegrape production.

Funding Support: "Centro de Extensión Vitivinícola del Sur" and the "Cooperativa Agrícola y Vitivinícola Cerro Negro - Quillón Ltda (COOVICEN)"

Turning Trash into Treasure: The Economic Potential of trans-Resveratrol Extraction from Cabernet Sauvignon Grape Cane

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Trans-resveratrol is a stilbenoid that is produced when grapevines are attacked by pathogens, under stress, or injured. The health benefits of *trans*-resveratrol make it a prime target of the cosmetic and medical business sectors. The California grape and wine industry generates a large amount of agricultural waste, some in the form of grape canes. Previous studies found that grape canes can contain notable amounts of *trans*-resveratrol. Therefore, thousands of dollars' worth of this high-

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value compound are potentially being burned or left to dry out in the vineyards each season. A series of Cabernet Sauvignon vineyards in California were investigated for their *trans*-resveratrol concentrations in grape canes to demonstrate the potential of *trans*-resveratrol as an additional source of revenue for California grapegrowers. Grape canes were analyzed for *trans*-resveratrol content under different extraction conditions, and the influence of selected pre-extraction parameters on *trans*-resveratrol concentrations was investigated, including time of storage, age of vineyard, location, and water stress level. High-performance liquid chromatography analysis found significant differences in *trans*-resveratrol concentrations from year 1 to year 2 and from the five different locations across California. There were also significant differences in *trans*-resveratrol concentrations at different ethanol extraction rates. To further investigate the suitability of the material to be used as fertilizer, a combustion analyzer was employed to determine the content of carbon and nitrogen in the grape canes before and after extraction. A microwave-induced atomic emission spectrometer was used to analyze the drought stress markers calcium, magnesium, sodium, and potassium in the grape canes. Overall, the market analysis demonstrated a high demand for the anti-oxidant compound *trans*-resveratrol which, supported by the laboratory analysis, indicates the potential for significant additional revenue for California grapegrowers.

Funding Support: None

Assessing the Variability of Soil Health Indicators Across California Vineyards

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Vineyard soils are strongly vulnerable to degradation from intense climate events like heavy rainfall and droughts. Soil health (SH) plays an essential role in building vineyard resilience, climate regulation, and sustainable winegrape production. From previous interviews, growers identified static soil properties (like parental material and texture) as the most important soil components of terroir. However, SH involves dynamic soil properties (organic matter, nutrients, and biota, among others), which are sensitive to management and can impact vine health and productivity. Our goal was to identify what SH indicators are most relevant for winegrape production and how they vary across soil types through collaborative research with growers in the Napa and Paso Robles regions of California. Growers identified two contrasting soils and rated them as "ideal" and "challenging" for achieving their vineyard goals. We collected soil samples from the tractor and vine rows at two depth intervals (0 to 10 and 10 to 20 cm) across 32 vineyards in the Napa Valley AVA and 30 vineyards in the Paso Robles AVA. The SH indicators evaluated were total C, active C, microbial respiration, MBC, PLFAs, PMN, inorganic N, pH, bulk density, penetration resistance, wet aggregate stability, and infiltration rate. Data analysis included descriptive statistics, generalized mixed model, and Pearson correlations. We expect to see a significant difference between growers' ratings, with ideal soils having higher levels of organic matter pools, biodiversity and biological activity, aggregate stability, and

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infiltration rates. We also expect lower levels of compaction in the ideal soils, as well as trends and significant differences across different soil types (i.e., textural classes) with clay % being a potential driver of SH indicator levels. This research will help us identify what soil health indicators are most relevant for vineyards and provide ranges of soil health indicator variability by soil type for growers.

Funding Support: American Vineyard Foundation, Western SARE

Assessing the Efficacy of Regenerative Agriculture to Sequester C and Support Soil Health in Vineyards

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Aware of the importance of soils for climate change mitigation and consumer demands for sustainability, winegrape producers are seeking to increase soil health using regenerative agriculture (RA) practices. Soil health is directly associated with soil organic matter (SOM) and C contents, constituting a pathway for climate change mitigation. Increased SOM may also improve soil water holding capacity, helping with climate change adaptation. Increasing soil C stocks could be economically advantageous for growers, allowing them to participate in C markets and facilitating access to certifications. Nonetheless, several uncertainties exist regarding how to build up C and SOM in different soils and how this will affect the yield and quality of the grapes. With support from the Foundation for Food and Agriculture Research and the California Department of Food and Agriculture, a new project will determine the efficacy of RA in building soil C and soil health, improving the long-term environmental and economic resiliency of the winegrape industry. We will follow a multi-scale approach ranging from a high-density sampling of soil C within single vineyards to large-scale sampling across 100 vineyards and 12 controlled trials along an edaphoclimatic gradient from Oregon to California. This project will generate 1) a protocol with the minimum sampling intensity needed to estimate soil C stocks in a specific area accurately; 2) an estimate of the C abatement potential of RA in vineyards, positioning the grapegrowing industry in the rapidly growing landscape of C markets and incentive programs for climate mitigation; 3) site-specific best management practices for RA in winegrapes, including improved understanding of the impacts of livestock integration on vineyard soil health; 4) understanding of the effects of RA practices in vine yield and nutrition; 5) realistic targets and expectations of the benefits and cost of RA; and 6) educational materials for growers to measure soil health and understand its costs and benefits.

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

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Initial Impacts of Biochar and Compost on Soil Health and Grapevine Performance in a Napa Cabernet Sauvignon Vineyard

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The objective of this trial was to determine the effects of a biochar (10 tons per acre), a compost application (20 tons per acre), and a combined application of biochar and compost (10 + 20 tons per acre) on soil health and vine performance in a Cabernet Sauvignon vineyard in Napa. Soil amendments were applied in fall of 2021. The average level or soil organic matter (SOM) for control treatment was 2.13%. There was a tendency for SOM to increase with either biochar (2.29%) or compost application (2.31%), and the SOM of combined application was 2.69%. Neither total carbon nor active carbon increased significantly with either biochar or compost application. Soil respiration rates were not significantly impacted by either application, although there was an indication that biochar depressed soil respiration rates. Total nitrogen (%) was not significantly increased by any treatment, but potentially mineralizable N was significantly increased by compost application. The percentage of water-stable aggregates was not influenced by either the biochar or compost application. There were no significant treatment effects on soil pH, CEC, or EC. Neither application of biochar or compost affected bloom petiole macronutrient (N, P, K, Mg, Ca) concentrations the following spring, but there were significantly lower concentrations of petiole Na, S, Al, and Zn where biochar was applied. There was no significant yield response to either a biochar of compost this first year after application, nor was there a significant impact of either biochar or compost on vine pruning weights in 2022. There were significantly lower total soluble solids (TSS) near harvest in plots with compost application. The average TSS (Brix) of fruit from plots with biochar (25.6), compost (25.2), or biochar + compost (24.5) was 1 to 2 Brix lower than in fruit from control plots (26.7) at harvest.

Funding Support: The National Institute of Food and Agriculture and the Western Sustainable Agriculture Research and Education program

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New Winegrape Cultivars for Warm Growing Regions from the University of Arkansas System Division of Agriculture

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The University of Arkansas System Division of Agriculture has released four new cultivars (*Vitis* hybrid) of winegrapes that can be grown in warm regions. Opportunity (white) and Enchantment (red, teinturier) were released in 2016 and Indulgence (white) and Dazzle (white) were released in 2021. These cultivars have shown good adaptation, productivity, and winter hardiness in Arkansas. Opportunity is a cross of Cayuga Ark. 1754 made in 1987, Enchantment is a cross of Ark. 1628 Ark. 1481 made in 1990, Indulgence is a cross of Seyval Muscat Ottonel made in 1989, and Dazzle is a cross of Gewürztraminer Melody made in 1992. The average harvest date for these cultivars is mid- to late-August in Arkansas. Opportunity produced 11 kg/vine with 234 g clusters and 2.7 g berries. Enchantment produced 10 kg/vine with 178 g clusters and 1.5 g berries. Indulgence produced 17 kg/vine with 153 g clusters and 2.5 g berries. Dazzle produced 10 kg/vine with 162 g clusters and 1.9 g berries. The soluble solids (%), pH, and titratable acidities (% tartaric acid) at

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harvest was 17.3%, 3.5, and 0.5%, respectively, for Opportunity; 18.9%, 3.4, and 0.8%, respectively, for Enchantment; 16.9%, 3.3, and 0.64%, respectively, for Indulgence; and 19.9%, 3.3, and 0.7%, respectively, for Dazzle. The evaluations of the grape, juice, and wine showed that Opportunity had citrus, peach, and green apple attributes; Enchantment had smoky and cherry-like attributes; Indulgence had citrus, grapefruit, and muscat-like attributes; and Dazzle had floral and stone fruit attributes. Enological evaluations showed that these cultivars produced high-quality wines from fruit grown in Arkansas. These cultivars produced wines with unique and pleasant aroma and flavor characteristics that could provide new opportunities for grapegrowers and winemakers and can expand winegrape options for Arkansas and other warm growing regions.

Funding Support: none

Association Study of Cold Hardiness in Interspecific Winegrapes

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Cold tolerance of grapevines (*Vitis* spp.) varies significantly over the dormant season, especially in response to temperature fluctuations. Extreme temperature fluctuations are ubiquitous in North Dakota, negatively affecting grapevine cold hardiness. Therefore, identifying genes/genomic regions involved in cold hardiness is needed to aid grapevine cultivar development. An incomplete diallel population of 1064 F1 individuals was developed to estimate cold tolerance through differential thermal analysis (DTA). In December and February 2020 to 2023, dormant canes were collected from the field on consecutive days until all individuals were sampled. Buds were removed from the canes, placed in thermoelectric modules with sensors, and placed in a programmed freezer. When a grapevine bud freezes quickly under freezing conditions, we can determine the freezing point or low-temperature exotherm (LTE). LTE obtained from DTA was used as phenotypic data. In addition, we used rhamseq markers (2100) as genotypic data. This study aims to identify the genomic regions associated with complex traits such as acclimation and cold hardiness through a genome-wide association study using this phenotypic and genotypic data. The results have identified significant SNPs on different chromosomes that could be linked to cold hardiness in our population.

Funding Support: Specialty crop

Efficacy of Trunk Renewal Against the Trunk Disease Esca in Susceptible Sauvignon blanc and its Impacts on Fruit Chemistry

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Esca can cause spotting and cracking of the fruit, which typically drops before harvest. We evaluated trunk renewal as a treatment for symptomatic vines in a 17-year-old Sauvignon blanc vineyard in Kelseyville, California, in terms of presence/absence of leaf symptoms after four years and fruit chemistry. The approach is to cut away the canopy (and infected wood) and then retrain a new canopy from a sucker that grows from presumably healthy wood at the base of the trunk. In October 2017, we mapped the locations of 97 symptomatic vines, which were

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distributed in a randomized complete block design within three experimental blocks. Immediately after pruning in February 2018, we cut off all 97 vines above the graft union. In the freshly cut trunk wood, 96 vines had wood symptoms of Esca (black spots and/or white rot) and one vine had wood cankers, but we isolated Esca pathogens from only a small proportion of vines: *Fomitiporia polymorpha* in 17 vines, *Phaeomoniella chlamydospora* in 15 vines, and *Phaeoacremonium minimum* in two vines. In 2022, the status of the 97 retrained vines was as follows: 73 vines had no leaf or fruit symptoms ('asymptomatic-retrained vines'), 23 vines were replanted (i.e., produced no sucker after the trunk was cut in 2018), and one vine had leaf and fruit symptoms ('symptomatic-retrained'). At harvest in September 2022, we examined asymptomatic fruit from both asymptomatic-retrained vines and from healthy vines (not retrained). We also examined asymptomatic and symptomatic fruit from symptomatic vines (not retrained). Asymptomatic fruit from asymptomatic-retrained vines had the lowest levels of monomeric flavan-3-ols, compared to asymptomatic fruit from healthy vines (not retrained) or asymptomatic fruit from symptomatic vines (not retrained). In comparison, symptomatic fruit from symptomatic vines had the highest levels of monomeric flavan-3-ols, potentially indicating a plant-derived defense response to Esca.

Funding Support: American Vineyard Foundation

Microbial Communities Associated with Invasive Pest *Drosophila suzukii* to Control Sour Rot in Grape Vineyards

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The invasive pest *Drosophila suzukii* causes significant economic losses in grape vineyards. *D. suzukii* carries acetic acid bacteria that are important to the development of the fly and are a source of grape sour rot in vineyards. The goal of this study is to understand the microbial interactions with the fly host and community assembly that contribute to the development of sour rot. Using ecological modeling techniques, we analyzed the microbial community structure and diversity associated with *D. suzukii* in vineyards to identify critical taxa within the microbiome and their potential to prevent the spread of acetic acid bacteria. Network analysis enables us to identify microbial interactions that may help prevent or mitigate sour rot in grape vineyards. This research improves our understanding of the complex ecological relationships between insects and their microbes and will ultimately lead to the development of novel strategies for sustainably controlling sour rot in grape vineyards.

Funding Support: Missouri Grape and Wine Institute

Grapevine Red Blotch Virus Latency and Its Effect on Grapevine Fruit Quality

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Foliar symptoms of grapevine red blotch disease (GRBD) are characterized by interveinal red blotching on the leaf blades of red-fruited cultivars and chlorotic blotching on some white-fruited cultivars. These foliar symptoms are reportedly

associated with reduced photosynthesis and carbon translocation in the leaf, resulting in reduced sugars and anthocyanins in the fruit. It is also seldomly reported that asymptomatic grapevines can test positive for grapevine red blotch virus; therefore, it was hypothesized that grapevines that are GRBV-infected, but do not express foliar symptoms, may not exhibit typical fruit quality symptoms of GRBD. In 2021, four 100-vine blocks were selected from a commercial vineyard located in southern Oregon with *Vitis vinifera* L. cv. Merlot and Cabernet franc. Altogether, 400 vines were recorded for symptoms and dormant canes were tested for GRBV using qPCR. In the 2022 growing season, fruit was sampled from 10 symptomatic and 20 asymptomatic Merlot grapevines to evaluate the effects of GRBV and expression of GRBD symptoms on juice chemistry. Dormant canes from these 30 vines were also tested for GRBV following the growing season in 2022 by qPCR. The incidence of GRBD symptoms was 19.5 and 14.4% in 2021 and 98.5 and 99.8% in 2022 for Merlot and Cabernet franc, respectively. Berry total soluble solids were reduced in symptomatic, GRBV-positive grapevines (22.8 Brix) compared to asymptomatic, GRBV-positive grapevines (25.7 Brix) and asymptomatic, GRBV-negative grapevines (25.8 Brix). Similarly, titratable acidity increased in symptomatic, GRBV-positive grapevines (7.00 g/L) compared to asymptomatic, GRBV-positive grapevines (5.68 g/L) and asymptomatic, GRBV-negative grapevines (5.74 g/L). This study suggests that even with GRBV-infection, the fruit quality of infected vines may not be severely impacted if foliar symptoms are absent. This finding requires further validation and provides an important proof of concept in potentially managing highly infected vineyards by managing foliar symptoms.

Funding Support: OSU-Agriculture Research Foundation and Kandu Ranch, Ashland, OR

Short-Term Effects of Germicidal Ultraviolet-C Radiation on Immature Grape Mealybugs (*Pseudococcus maritimus*)

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Ultraviolet-C (UVC) radiation has been used to effectively suppress grapevine powdery mildew (*Erysiphe necator*), though its effect on pests such as the grape mealybug (*Pseudococcus maritimus*) is unknown. Our objective was to determine the potential lethal effects of UVC treatments to grape mealybug. We exposed *P. maritimus* nymphs to UVC doses of 100, 200, 500, or 1000 J/m^2 using a laboratory UVC lamp array. There was no dark period after treatment. UVC treatments were compared to an untreated control and a positive control (2% v/v horticultural oil PureSpray Green). Bioassays were assembled using groups of ten first instar nymphs per grapevine leaf disc; individual leaf discs were placed on a moistened cotton round in a petri dish. Bioassays were maintained in an incubator with a day:night ratio of 16:8 hr at 21°C. Treatments were replicated five times and the experiment was repeated three times. At 2, 24, and 48 hrs after treatments, the mortality of the nymphs was assessed and recorded. Mortality of nymphs was measured by their response to prodding. Post-prodding movement indicated viability; lack of movement was assumed to indicate mortality. No UVC treatments increased acute nymph mortality over the untreated control. Even a UVC dose of 1000 J/m^2, which is five to 10 times higher than doses used against *E. necator*, did not increase nymph mortality compared to the untreated control (p = 0.57, 0.99, and 0.43 for 2, 24, and 48 hrs posttreatment, respectively). Although UVC did not increase acute mortality

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in grape mealybug nymphs, longer-term and multigenerational effects have been observed in other arthropod systems (e.g., phytophagous mites). Further studies on the chronic and potential sublethal effects (e.g., fecundity or longevity), or effects of multiple UVC exposures, are warranted.

Funding Support: Washington State Wine Commission

Impact of Grapevine Red Blotch Disease on Grape and Wine Composition and Wine Sensory Attributes

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Grapevine red blotch virus (GRBV), the causal agent of grapevine red blotch disease, is of huge concern in the winegrape industry. When a laboratory test confirms that a vine has GRBV, the only solution for grapegrowers is to remove the vine and replant. Furthermore, the virus is spread by an insect vector. This leads to a massive financial burden without completely eliminating the problem. To understand the extent of the impact of GRBV in California, data was captured for two consecutive vintages, 2020 and 2021, from three vineyards in Northern and Central California. These included Cabernet Sauvignon from two sites in Napa and Merlot from one site in Paso Robles. Grapes from both healthy RB (-) (tested GRBV negative by qPCR and asymptomatic) and diseased RB (+) (tested GRBV positive by qPCR and symptomatic) were harvested concurrently when the RB (-) grapes reached 27 Brix. Basic chemical parameters, phenolic composition by RP-HPLC and volatile composition by HS-SPME-GC-MS were determined for the grapes and wines. Results showed that sugar accumulation and total phenolic, anthocyanin, and tannin concentrations were significantly reduced in RB (+) grapes and wines for both vintages, which is consistent with previous research. Additionally, sensory data has shown that RB (-) wines possess a strong alcohol hotness mouthfeel, which is directly correlated with the higher sugar content at harvest. Panelists also attributed aromas related to greater fruit ripeness, such as dark and dried fruits, to the RB (-) wines. On the other hand, RB (+) wines tended to be more bitter and had aromas related to red fruits and greenness. Most importantly, panelists could distinguish wines based on virus status, suggesting significant differences based on organoleptic characteristics.

Funding Support: USDA NIFA SCRI

Table Grape Clamshell Packaging Opens New Doors for Fungal Decay Control Liquid Applications

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Retail preferences have increased table grape clamshell packaging and moved away from standard polyethylene bags (polybags). While still the minority, this shift in industry practice opens new opportunities for postharvest control of fungal decay pathogens. Current harvesting and handling practice include field-packing into polybags to minimize handling of the grapes. This practice helps manage humidity

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while reducing hairline cracking and mechanical damage to the grape skin. Clamshell packaging in packing houses allows inclusion of liquid fungicide with forced-air tunnel drying to control postharvest pathogens. Fungicide Candidate A (FCA) is a novel fungicide that was evaluated in a liquid application compatible with clamshell packaging as an alternative to potassium metabisulfite (KMBS) pads or sulfur dioxide fumigation. Ivory and Autumn King cultivars were artificially inoculated by spraying a spore suspension of 1 10^5 spores/mL *Botrytis cinerea* or 2 10^4 spores/mL *Penicillium expansum* uniformly to the fruit surface. An air-assisted research sprayer replicating commercial packing lines was used to apply FCA to unlidded clamshells of freshly-harvested grapes. FCA was evaluated in rates from 0 to 10 mg active ingredient per kg fruit compared to the commercial fungicide standard of KMBS pads. FCA treatments significantly improved disease control over the KMBS pad, with high rates producing 100% control. No phytotoxicity was observed from application of FCA and there was no grape rachis browning after 21 days in cold storage and 14 days at shelf life. As customer preferences change from current standard practices, it is crucial to understand the benefits of new packaging and how the industry can adjust quickly to meet growing demands. FCA is only one of many potential candidates for new liquid applications for fungal decay control as commercial handling practices of table grapes move from field to the packing line.

Funding Support: AgroFresh Solutions, Inc

A Comprehensive Evaluation of 12 SDI and RDI Schedules to Irrigate Cabernet Sauvignon in the San Joaquin Valley

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As drought conditions become more familiar to San Joaquin Valley grapevine growers, the need for effective water management solutions has heightened. Understanding the physiological responses of the plant at various intensities and timings can still provide great context for more advanced developments.

The purpose of this study was to determine the primary effects of sustained and regulated deficit irrigation on plant water status, gas exchange, berry composition, and yield components. We used a single commercial Cabernet Sauvignon 1103P vineyard located in the West San Joaquin Valley. Irrigation treatments were applied nine times weekly from bunch closure to harvest. Irrigation was applied using a semi-autonomous irrigation approach and actual amounts were recorded through flow meters. The plants were sampled biweekly, starting the week before the first irrigation event. Irrigation treatments were calculated as fractions of the grower's water allocation, which roughly corresponded to 60% crop evapotranspiration in the middle of the summer. Treatments included sustained deficit irrigation schedules with 40, 60, 80, and 100% of the grower allocation and regulated deficit irrigation strategies with different amounts before and after veraison. RDI treatments were 100/40, 80/60, 60/100, 100/60, 60/80, 80/40, 40/100, and 40/80, where figures express percentages of the grower allocation and are formatted as preveraison allocation/postveraison allocation). In the dry conditions of our study, limited to one single season of observation, we found little to no effect of irrigation amounts on plant physiology, yield, and grape composition. The results of this study did follow the general trends for grapevines in semiarid environments, although continued data acquisition is required to validate the results and observe carryover effects. We also

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infer that implementing automated irrigation can be effective for irrigating remotely and monitoring true amounts; we do, however, discuss several limitations associated with precision in large blocks.

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

Using Cover Crops to Mitigate the Effect of Winery Wastewater Application on Soil, Yield, and Grape Quality

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San Joaquin Valley is facing drought and saline soil conditions, which adversely affect vine growth and yield. There are ~3000 to 5000 L of wastewater generated per metric tonne of crushed grapes every year. Winery wastewater has high organic load, low pH, and variable salinity and nitrogen levels, which can harm soil physical and chemical properties and reduce grape yield and fruit quality. Excessive N can also be leached into the groundwater, causing contamination. The objectives of this study were to examine the effects of cover crop on soil properties; determine the impact of cover crop on vine canopy growth, yield, and grape quality; and promote effective water and soil management in the framework of sustainable viticulture. Mature Ruby Cabernet vines (8-years-old) near Fresno, CA, were trained on quadrilateral cordons using a spur-pruned trellising system. Vines were grafted on Freedom rootstock and planted at 4' by 10' with the cordon height at 52" above the vineyard floor. Randomized complete block design was applied, with eight treatments replicated four times. Treatments were 1) Control: no-tilled with residential vegetation; 2) Tilled; 3) UC 937 Barley; 4) WB Patron Wheat; 5) Pacheco Triticale; 6) Sierra Oats; 7) Rye grass; and 8) Dairyland Magnum Salt Alfalfa. Each experimental unit consisted of one quarter-mile long vine row. The vineyard was furrow-irrigated using wastewater before planting the cover crop. Based on the first year's study, cover crop significantly affected soil chemical composition. Barley, oat, rye grass, triticale, and wheat sequestered carbon more than the control, by 200 to 400 kg/acre. Oat, rye grass, triticale, and wheat absorbed N more than the control, by 6 to 10 kg/acre. Barley and rye grass absorbed sodium more than the control. Triticale and wheat reduced soil EC. Rye grass, triticale, and wheat lowered soil Na. No treatment affected microbial biomass in the first year. The project is still ongoing, and additional data will be provided in the next two seasons.

Funding Support: Agricultural Research Institute

Cordon Height and Irrigation Interact to Affect Yield and Fruit Quality of Two Winegrape Cultivars in a Hot Climate

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Cabernet Sauvignon and Petite Sirah are the top red winegrape cultivars in CA; however, the hot climate in Fresno is not ideal for red *Vitis vinifera*, particularly for berry color development. Mechanical pruning and water deficit have been studied previously in this region, but there is a lack of research on cordon height and irrigation in mechanically-pruned vineyards. A two-way (2 2) factorial split block design, replicated three times, was implemented in Fresno in 2021 and 2022, with

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the same experimental design applied to both cultivars. The two levels of water deficit were regulated deficit irrigation (RDI) and sustained deficit irrigation (SDI). Water deficit in RDI plots was maintained at 60% ETc from berry set to veraison and 80% ETc from veraison to harvest, while water deficit in SDI plots was maintained at 80% ETc from berry set to harvest. The two cordon heights were 52 and 68 inches above the vineyard floor. In Cabernet Sauvignon, the high cordon, with >20% more leaf area, increased total soluble solids (TSS) by 2 Brix and anthocyanins by 11% above the low cordon without affecting yield. The effect of water deficit was mainly on berry size and the yield reduction was due to smaller berry size in RDI. There was no interactive effect of cordon height and water deficit on yield performance and berry chemistry. Similar results were found in Petite Sirah, with high cordon increasing berry anthocyanins by 30%. High cordon and water deficit can be used in mechanically-pruned vineyard systems in a hot climate; however, given the potential yield reduction from RDI, a high-cordon trellising system is preferred to improve berry TSS and anthocyanins, with no negative impact on yield.

Funding Support: No external funding

VIS/SWIR Hyperspectral Imaging for On-the-go Mapping of Grape Composition in the Field During Ripening

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Assessing grape composition is essential in vineyard management to decide harvest date and to optimize cultural practices toward achieving production goals. Grape composition is variable in time and space, as it is affected by the ripening process and depends on soil and climate conditions. Our work focused on developing a system to assess and map grape composition directly in the field. For this study, a UTV was specially adapted to lift the canopy and expose the fruits, and two hyperspectral cameras covering the 500 to 1700 nm range were mounted with GPS systems and halogen lights for night imaging. We imaged a Merlot vineyard located in Madera, California during the 2022 growing season. At the same time, we sampled grapes from 160 vine locations that were analyzed in the laboratory for total soluble solids, titratable acidity, pH, and anthocyanin profile. About 1000 samples were collected. For the analysis, the images were segmented to extract the grape's signal from sampled vines. Then, the reflectance of the grapes was used to look for correlations with grape composition using machine learning models. Evaluation of models was performed using RMSE, and R2 in k-fold cross-validation and through the use of hold-out test sets. The interpretation of the model was conducted through feature importance and partial dependence plots to understand the relationship between wavelength predictors and outcome. This project is the first to use a SWIR camera mounted on a UTV to assess grape composition. Our results demonstrate that SWIR images can be used to perform a classification to extract the grape signal with a mean error of 2.2% using the spectral signature of each class represented in the image (grape, leaves, and background). The prediction of grape compounds from the refined spectral signal shows promising results.

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

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Assessing Within-Vineyard Variability in Grapevine Water Status Through Landsat 8 Images in the San Joaquin Valley, California

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Satellite imagery is a powerful tool to assess vineyard characteristics such as vigor or water content. To explore the ability to link satellite information with vineyard characteristics, we set up an experiment in 2020 and 2021 in a Merlot vineyard in the Bakersfield area. A total of 24 experimental units were distributed spatially according to the grid created from the pixels of a Landsat 8 image. Water status was assessed every two weeks in both years, from June to August, measuring midday stem water potentials (Ψstem); we also measured leaf stomatal conductance (g_s) and net carbon assimilation rate (AN). Berry weight, pH, total soluble solids (Brix), and titratable acidity (TA) were measured every two weeks from July to August. Landsat 8 images of the same periods were downloaded and reflectance values of each experimental unit were extracted and averaged. Maximum temperature (T_{max}) and minimum relative humidity (RH_{min}) were also extracted for the location of the vineyard. Machine learning models were applied to predict water status or berry information using band reflectance values alone or with Tmax and RH_{min}, using a block-out validation method. The first results show an R^2 of 0.8 for predictions of Ψstem, AN, and g_s using band values. Adding T_{max} and RH_{min} as predictors increases R^2 to 0.9 for AN and 0.85 for g_s. Using feature importance extraction, it was determined that the near-infrared (NIR) and shortwave-infrared (SWIR) spectral domains are most effective for predicting water status or grape characteristics. Previous research established that these spectral domains are closely associated with plant water status or cellular composition. These findings validate the potential of satellite imagery as a means of monitoring vineyards on a broad scale and with a high level of temporal resolution.

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

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Developing a Simple Light Interception Model to Assist Water Stress Monitoring

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The majority of vineyards in British Columbia are located in the Okanagan Valley. Vineyards are often located on the slopes between lakes and mountains in this area. North-south row orientation is not always suitable for vineyard sites with slopes facing east or west. The highly diverse row orientations in the valley makes a complex puzzle for researchers and growers to comprehend the dynamic light environment at canopy level. Since solar energy drives transpiration by heating leaves and increasing vapor pressure deficit, a better understanding of light conditions might facilitate water stress monitoring. A simple model was developed in Excel for calculating and visualizing solar energy intercepted by the canopy. In this model, the canopy is simplified as a box with infinite length, and the row orientation, row spacing, height, and width of a canopy are entered as canopy structural characteristics. Other data inputs include vineyard latitude, longitude, time zone, date, and solar radiation. The model simulates sun position, shaded area, and intercepted solar energy in a

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vineyard within an hour interval on a designated date. The simulation suggested that a canopy with east-west orientation intercepted the highest amount of incident solar energy at noon, while a north-south orientated canopy intercepted more energy at 0900 hr and 1500 hr on a day in late July. When incident light direction paralleled with the row orientation, the canopy might intercept less energy in a vertical shoot-positioning canopy. To validate the model, solar panels will be used to estimate solar energy intercepted by the canopy in different vineyards. Whether the model can predict the optimum timing for measuring maximum stem water potential will be tested. This model may help growers adjust water potential measurement timing precisely, based on the day of year and row orientation.

Funding Support: Sustainable Canadian Agricultural Partnership - Wine & Grape Cluster

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Impact of Soil- and Foliar-Applied Nitrogen on Grape and Wine Composition

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This study aims to determine if foliar-applied urea at veraison can supplement or substitute for early-season soil-applied nitrogen (N) to maximize berry quality and increase yeast assimilable nitrogen (YAN) for red wine grape production in an arid climate. Previous studies showed that foliar application of urea at veraison did not impact vigor, increased grape and wine aroma composition and YAN, but the response of phenolics was contradictory. We hypothesized that foliar urea application at veraison increases berry phenolic compounds and YAN in red grapes and wine relative to soil-applied N. A field trial was conducted in a commercial, drip-irrigated, own-rooted Syrah vineyard in arid eastern Washington in 2021 and 2022. We compared four treatments of soil-applied liquid urea ammonium nitrate (0, 22.5, 45, 90 kg N/ha), split at the five to six leaf stage, bloom, and fruit set, with a 15 kg N/ha foliar urea treatment, split into three applications at veraison. Berries were analyzed and wine was produced from all treatments. Results were consistent across the two vintages. Berry weight, cluster number, yield, juice total soluble solids, pH, titratable acidity, and malic acid were similar among N treatments. However, while must YAN increased with increasing soil-applied N, the foliar N treatment was much more effective at increasing YAN. The phenolics concentration in the juice at the beginning of fermentation was similar among treatments. Tannin concentrations were low in wines at pressing and were lowest in the foliar N treatment, contrary to our hypothesis. The fertilizer treatments did not affect wine anthocyanins and total phenolics. Results from plant tissue and berry analysis will be presented once they have been completed. The application of N at veraison increased YAN in the juice and decreased tannins in the wine in the eastern Washington Syrah vineyard.

Funding Support: USDA-NIFA SCRI, Washington State Grape and Wine Research Program, Ste. Michelle Wine Estates (in-kind)

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ABA, Ethephon, and Their Interactions with Water Stress on Table Grape Vine Physiology, Fruit Composition, and Texture

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The table grape market is ever-changing due to pandemic developments, issues with transportation, and emerging competitive markets. As growers are expected to produce grapes of extraordinary standards to obtain decent prices and export quality, many have turned to plant growth regulators (PGRs). PGRs are hormonal biostimulant chemicals that, when used correctly, can improve fruit size, color development, root growth, and cell division. Applied incorrectly, they can have devastating effects on fruit quality, yield, and flavor profile. We examined the independent effect and interaction of two PGRs: abscissic acid (ABA) and ethephon, (2-chloroethyl) phosphonic acid, crossed with water stress or its lack at veraison. The PGRs were applied using the maximum allowed rate at the onset of veraison, in conjunction with the water deficit treatment, which consisted of three weeks without irrigation until plants reached a midday stem water potential of -1.5 MPa, followed by rewatering until the stem water potential was equivalent to the non-stressed control. The trial was a complete randomized block design, with eight treatments including control and four replicates per treatment. The research was conducted in a commercial table grape vineyard planted with Sheegene 12 x Freedom located in Madera, California. The vineyard was five years old, cane pruned, and trellised on a gable system with a 4 2 m spacing between rows and plants, respectively. Ethephon produced the greatest amount of packed fruit at the end of the experiment. Water deficit treatments, followed by ethephon treatments, ranked higher on the spectrum for culls. Berry firmness and weight were better in the non-water deficit treatments. No clear disparities in berry length or width were noted. First-pass fruit was larger than the second-picked fruit and was consistently heavier.

Funding Support: None to disclose

Investigating Preharvest Berry Softening in San Joaquin Valley Table Grapes

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Well-developed color, desirable level of firmness, and sufficient sugar content are important quality attributes of table grapes. However, in warm production areas like the San Joaquin Valley, CA, these three qualities are often unbalanced. As a result, growers have observed that berries of some table grape varieties become overly soft before they are well colored, even though the concentration of total soluble solids (TSS) reached harvest standards. To better understand the onset of berry softening and investigate potential mitigation solutions, we conducted two experiments in 2022 with a midseason red proprietary variety. In the first experiment, we sampled fruit periodically in three vineyards (two in Kern County and one in Fresno County) during fruit ripening (June to August) to assess the correlation between TSS, berry

color, and berry firmness. We found that berry color improved with increased TSS, and ideal color was found when the berries reached ~20 to 21 Brix. However, some berries started to turn soft when TSS was >19 Brix. The results suggest a possible disconnect between color development, firmness, and sugar accumulation. Thus, in the second experiment, we investigated the possibilities of using ethephon ((2-chloroethyl)-phosphonic acid)) spray, basal leaf removal, and cluster thinning at 10 Brix to mitigate this disconnect. We monitored TSS, berry firmness, and berry color weekly from the onset of veraison to harvest. Then we collected yield data. We found that none of the treatments promoted color development or influenced berry softening. Interestingly, cluster thinning did not decrease harvestable yield, but seemed to enhance ripening uniformity. Based on knowledge gained in 2022, we plan to look into this issue in the coming year while adjusting treatments to include earlier leaf removal and products that may increase firmness or accelerate coloration.

Funding Support: UC ANR

Grapevine Nutrition: Alternative Early-Season Sampling Protocols and Nutrient Budgets for Vineyards

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Vineyard nutrient management is critical to reach quality standards, yet timely evaluation of nutrient status remains challenging. The existing sampling protocol of collecting leaf blades and/or petioles at bloom or veraison is late for in-season fertilizer applications. Early-season protocols are necessary to predict seasonal vine nutrient demand. This project aims to 1) optimize tissue sampling protocols; and 2) determine the amount of nutrients removed at the end of the growing season. Field trials were initiated in 2020 and conducted in 2021 and 2022 in commercial vineyards in arid eastern Washington. Three rates of K were applied in Chardonnay, and three and two rates of N were applied in Syrah and Concord, respectively. Dormant canes, shoots (five to six-leaf stage), leaves (blades and petioles) at bloom and veraison, fruit at lag phase and harvest, and all leaves at leaf fall were collected for nutrient analysis. Yield components and fruit composition were determined at harvest. Fertilizer treatments did not affect tissue nutrient status, except that Chardonnay blades at veraison had lower K where no K was applied. In Chardonnay, Syrah, and Concord, P and K concentrations in shoots correlated with those in blades and petioles at bloom in 2021, but not in 2022. More work is required to draw firm conclusions regarding early-season sampling. Fruit harvest and leaf fall removed significant amounts of nutrients. The harvested fruit contained more N in 2021 than in 2020 and 2022, and N and K in Concord was much higher than in winegrapes in 2021 and 2022, but not in 2020. Leaf fall removed lower amounts of nutrients after a long, frost-free postharvest period (2021) than when leaves were killed by frost (2022). Seasonal differences should be considered when developing vineyard nutrient budgets for fertilizer recommendations based on harvested fruit and potential nutrient removal from vineyards by wind.

Funding Support: USDA-NIFA-SCRI, Washington State Grape and Wine Research Program, Washington State Concord Grape Research Council

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Evaluating Fruit Zone Leaf Removal Across Seven Interspecific Hybrid Winegrapes in Western Montana

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Commercial grapevine production is relatively new to Montana. Cultivar planting decisions and crop management are key concerns for new grapegrowers and winemakers. Two cultural practices, cluster thinning and fruit zone leaf removal (FZLR), are employed by producers attempting to improve fruit chemistry in western Montana, where vineyard sites rarely exceed 1100 accumulated growing degree days (base 10°C). Due to producer and winery interest, FZLR was examined during the 2022 growing season within a replicated grapevine variety trial located in Corvallis, MT, using seven interspecific cultivars of grapevine (*Vitis* spp.). Five were red wine grapevines (Crimson Pearl, Hasansky Sladky, Frontenac, Petite Pearl, and Verona) and two were white wine grapevines (Frontenac gris and La Crescent). FZLR was conducted two weeks after full bloom for each cultivar by removing leaves and laterals from nodes one to six within the fruit zone of treated vines. Across all genotypes, Crimson Pearl had the lowest soluble solids content (16.7) and Hasansky Sladky had the greatest (24.2). FZLR treatments altered pH, with control vines having higher pH (3.31) than treated (3.25). Titratable acidity, a key concern for winemakers, was not altered by canopy management during the 2022 season. Crimson Pearl, Hasansky Sladky, Frontenac, and Verona were fermented to assess the effect of FZLR on final wine chemistry. FZLR negatively impacted ethanol content while increasing glycerol and total polyphenol content of red wines. While FZLR is a common cultural practice employed by grapegrowers in Montana targeting reduction of acidity, there was no clear evidence of this desired outcome in the variety trial evaluated. However, further examination of wine may reveal chemical outcomes that justify continued examination of canopy management practices for western Montana.

Funding Support: Specialty Crop Block Grant

Genome-wide Association Study of Basic Fruit Chemistry in Cold Climate Winegrapes (*Vitis* spp.)

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Grapegrowers in North Dakota face multiple constraints such as winter injury, short growing season, frost damage, and poor fruit quality. To overcome some of these challenges, native North American *Vitis*-derived varieties have been used for production. Despite the advantageous environmental resilience provided by wild crosses, their fruit chemistry parameters such as acidity, sugar, and pH concentrations often deviate from traditional expectations. Identifying the role of genetics in the expression of these traits in interspecific hybrid populations will greatly benefit the process of new hybrid cultivar development. For this purpose, an incomplete diallel mapping population of ~1000 F1 individuals derived from three interspecific breeding lines from the North Dakota State University Grape Germplasm Enhancement Project was created in 2016 and field-planted in 2017 in Fargo, ND. The population is genotyped with ~36,000 GBS markers and ~2000

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rhAmpSeq markers. Phenotypic data pertaining to three different traits, Brix, pH, and acidity, were measured during three consecutive growing seasons (2020 to 2022). Genome-wide association analysis was performed using the GAPIT3 package in R statistical software to identify associations between measured traits and the markers. A significant association was detected in the population on chromosomes 6 and 16 for all three traits measured during multiple years. Candidate gene scanning at the region of significant markers revealed several genes related to carbohydrate and acid metabolism. The stable significant markers identified in this study will serve as a resource in continued selection and development of new hybrid lines with improved fruit chemistry through marker-assisted selection and genomic prediction methods.

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Impact of Chitosan on Must as a Sulfite Alternative: Evaluation of Microbial Populations Using Targeted Metagenomics

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Reducing sulfite additions in enology has been a core technical concern for several years. To date, there is no existing product or process that alone is technically capable of fully replacing SO_2. Chitosan, a molecule with well-known anti-microbial properties, has been particularly interesting. However, there were no enological or scientific studies on the impact of chitosan on native grape microorganisms. Sofralab Group has conducted several trials on two vintages to identify the bacteria and yeasts impacted by a chitosan-based treatment on musts, thanks to targeted metagenomics. To do so, a purification protocol was specifically developed by the R&D team of the company. Using Oenovegan Micro FA, a product based on chitosan, makes it possible to secure alcoholic fermentations, while guaranteeing biocontrol of spoilage microorganisms and preserving the organoleptic qualities of musts and wines. Chitosan has greater impact on diversity and abundance of microorganisms than sulfites and a much faster efficacy, making it a perfect substitute or complement to sulfites for antimicrobial activity in winemaking.

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Mitigating the Effects of Climate Change on Wine Production using Activated Chitosan

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Pre-activated chitosan of fungal origin has demonstrated potential in controlling a wide spectrum of bacteria, non-*Saccharomyces* yeast, *Brettanomyces*, *Botrytis cinerea*, volatile acidity, and volatile sulfur compounds (VSCs) during wine production, particularly in light of the challenges posed by climate change. The increasing pH levels in wine due to climate change increase the risk of microbial spoilage and reduce the efficacy of sulfur dioxide (SO_2). A wine with a pH of 4 requires up to four times as much SO_2 as a wine with a pH of 3.2. EnartisStab Micro M is a preparation of pre-activated chitosan that offers an alternative to SO_2. It provides antioxidant, antioxidasic, and antimicrobial protection comparable to SO_2,

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but is independent of wine pH. Even at pH of 3.9, it effectively controls microbes. Furthermore, it can limit oxidation reactions by chelating metals such as copper and iron, which are catalysts of enzymatic and non-enzymatic oxidation reactions. This is useful as climate chaos and organic farming causes increased copper use in vineyards. Furthermore, low quantities of available free SO2 can result in a higher risk of oxidation and a shorter shelf life of the finished product. This is where the addition of Hideki, an innovative tannin, can be particularly beneficial. With its high degree of purification and strong antioxidant protection, Hideki allows free SO2 to last longer.

Using pre-activated chitosan of fungal origin in conjunction with Hideki offers a promising solution for controlling bacteria, yeast, fungus, volatile acidity, and VSCs during wine production. With its effectiveness, allergen-free and vegan-friendly status, and improved sensory qualities of the final product, it provides a sustainable and effective alternative to traditional winemaking techniques. This is especially crucial in light of the challenges posed by climate change to wine production.

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Prise De Mousse with a Shortened One-step Yeast Starter Preparation

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The "prise de mousse (PDM)" or secondary fermentation is the step that allows a base wine to become sparkling or effervescent. It requires the preparation of a yeast starter known as "pied de cuve (PDC)" made of yeasts capable of consuming all the fermentable sugars and transforming them into alcohol and carbon dioxide, the gas that drives the effervescence. The quality of the PDC is therefore essential to a successful PDM. Traditionally, the PDC is prepared over three days, but this study showed that the preparation time can be reduced by half (36 hrs) and to a single step. This work is based on optimization of the existing protocol by adjusting the contents of sugars and assimilable nitrogen. It allows us to propose a new technical solution for a yeast starter preparation able to perform a PDM in a time equivalent to the protocol traditionally used (72 hrs). This study was performed with three "Champagne" yeast strains and two PDM temperatures (14 and 18°C). Twelve months after the start of the PDM, the bottles were riddled and disgorged. Tasting showed no sensory differences between sparkling wines made from the two yeast preparation methods. This technical progress in the preparation of the PDC allows a 50% reduction in the downtime of the yeast tanks, as well as a reduction in the associated energy costs (electricity).

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Quantitation of Wine Color Additives with Absorbance-Transmittance Excitation Emission Matrix (A-TEEM) Spectroscopy

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Commercial additive concentrates (CAC) derived from grapes with intensely colored skins and flesh (teinturier grapes) has become more commonplace, primarily to enhance color in finished wines. The target concentration is usually ≤0.2% by volume. Rarely is the use of CAC disclosed or discussed by the manufacturer, owing to a perceived stigma concerning the quality of the primary grapes used for winemaking. Malvidin-3,5-diglucoside is used as a specific chemical marker associated with CAC because it occurs naturally at much lower concentrations in the *Vitis vinfera* sp. grapes used for winemaking. The patented A-TEEM method acquires complete optical fingerprints in under one minute and facilitates linear calibration using the on-the-fly inner-filter effect correction of absorbance distortion. For wine, all A-TEEM measurements are collected under Beer-Lambert linear absorbance conditions at a constant temperature (20°C) using a standard solvent (50% EtOH, pH 2) and filtration protocol (0.45 mM pore size). The A-TEEM accurately quantifies most major anthocyanin compounds (including malvidin, cyanidin, peonidin, and petunidin), their most common monoglucosides, and their acylated and coumyralted forms from V. vinfera varieties, based on their unique optical properties for absorbance extinction and spectra, their fluorescence yields, and excitation and emission spectra. Anthocyanin quantification with A-TEEM is independent of grape variety and growth region and conditions. We validated that detection limits of CAC in wines, derived from partial least squares and extreme gradient boost regression methods from several *V. vinifera* varieties, are <0.03% v:v. We will report on our test results for validation of a variety-independent model. We conclude the A-TEEM method can be an effective tool to quantify CAC, which can be important for winemaking formulation and quality evaluation, including competitive products.

Funding Support: N/A

Volatile and Glycosylated Markers of Smoke Impact: Evolution in Bottled Wine

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Smoke impact in wines is caused by volatile phenols found in wildfire smoke. These compounds are absorbed by berries, where they may also become glycosylated. Both volatile and glycosylated forms eventually cause off-flavors in wines. To assess smoke impact, a selection of volatile and glycosylated phenols is proposed, mainly based on Australian research. It includes guaiacol, 4-methylguaiacol, cresols, phenol, syringol, and 4-methylsyringol, and their glycosylated forms guaiacol rutinoside, 4-methylguaiacol rutinoside, cresol rutinoside, phenol rutinoside, syringol gentiobioside, and 4-methylsyringol gentiobioside. The accurate and reproducible measurement of these compounds is now possible, due to the commercial availability of standards and isotopic analogues. Over two years, we investigated the stability of these markers in bottled wines. Wines monitored were a Chenin blanc and a Chardonnay (whites), a Grenache (rosé), two Cabernet Sauvignons, a Zinfandel, and a Grenache (reds). No significant increases in guaiacol were observed in the white or

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rosé wines. Slight increases (2 to 3 µg/L) were observed in red wines, with a larger increase in Pinot noir (9 µg/L). Non-significant to slight increases were observed for phenol, with a larger increase in the Zinfandel (10 µg/L). Large increases in syringol were found in red wines only, especially Cabernet Sauvignon (up to 60 µg/L). No significant increases were observed in the other volatile phenols. All glycosylated markers were stable. Therefore, increases in volatile phenols, when they happened, were not explained by hydrolysis of glycosylated forms measured. The observed increases in guaiacol and syringol and the stability of the glycosylated forms measured, are consistent with a previous study. The stability of glycosylated markers makes them relevant in identifying wines from smoke-exposed grapes, possibly for many years after bottling. A limitation is that some smoke-impacted wines may show normal or non-detectable levels.

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How Resonance Waves Improve Red Grape Extraction, Saving Energy and Manpower: The Case of Airmixing M.I.TM by Parsec SRL

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Resonance waves are very diffuse. A resonance wave promotes movement of liquid (or gas) with a continuous, constant wavelength until creating a paroxysmal liquid movement that provokes wave fracture or, in the presence of solid material, its disintegration. The AIRMIXING M.I technique for grape maceration is based on this physical principle, creating resonance waves in the must within the tank. A well-identified sequence of air-jet pulsing with studied pressure creates this soft, sustainable, maceration technique. Soft because there is no contact between metallic components and must (punch-down), thus no friction effect; no invasive movement (pumping-over); and sustainable because racking is simplified and neither push down nor pumping over are required. This saves energy and labor: very little energy is required to activate the air nozzles. In this paper we report collected data from different applications of AIRMIXING M.I. around the world. If pumping-over during fermentation/maceration requires ~1700 min of cooling plant running, AIRMIXING M.I. requires only ~420 min, saving 75% of the electricity, and facilitates a more uniform must temperature in the vessel. A comparison in racking time shows that AIRMIXING M.I. needs 2 hrs for a 3000 hL vessel versus 6 hrs with pumping over. Beyond the sustainability aspect, the quality of extraction is excellent because of the uniform temperature in the vessel and can be modulated by adjusting the jet air nozzle sequence and opening time.

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Yeast Rehydration and Protection: A Revolutionary Approach to an Essential Practice

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Yeast rehydration requires particular care and attention to properly prepare the cells for the harsh conditions of juice and must. Instances where yeast is mishandled can lead to sluggish and stuck fermentations, then sub-optimal wine quality. This important, but time-consuming, step has resulted in winemakers taking short-cuts and looking at alternative methods for inoculation. Juice and must chemistry is changing, in part due to climate change, increasing the frequency of difficult fermentations. To address both issues, the Lallemand Oenology R&D team developed Go-Ferm Sterol Flash (GFSF), a microagglomerated yeast protectant used during yeast rehydration that is non-powdery and dissolves instantly, even at cellar temperatures, resulting in a simplified yeast rehydration protocol. Additionally, based on the unique yeast autolysate selected for GFSF, the sterol content has been considerably increased. Therefore, the provided highly concentrated, instantly dissolving sterols are immediately bioavailable to the rehydrating yeast, protecting it immediately upon contact. With such properties, this protection is so efficient that no water heating or yeast acclimation is needed. This revolutionary approach saves energy, time, and operations in the cellar.

Funding Support: Lallemand

Control of Algae in Irrigation Water Ultrasonically, Without Using Chemicals

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The latest ultrasonic algae control technology eliminates algae growth without chemicals. The technique works on 95% of known algae species by causing internal damage to the cells, causing them to lose buoyancy and thus light availability, or to lose natural internal cell wall protection from bacterial attack. This simplifies irrigation without having to worry about chemicals impacting the harvest. A single sound-producing head can control green algae and diatoms out to 150 m radially (~17.5 acres) and blue-green algae with gas vesicles out to 400 m radially (~120 acres). The process uses thousands of frequencies generated with enough sound volume to cause internal damage to the various types of algae. The process is called critical structural resonance and operates in two ultrasonic bandwidths where this phenomenon occurs in these algae types. Power consumption is less than $100 per year and can be delivered at 24, 120, or 240 volts AC or with solar power. Viticulture irrigation practitioners can hear the impact and benefit ultrasound can bring to their irrigation water quality while minimizing the use of chemicals and lowering operational costs.

Funding Support: Water IQ Technologies

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Surface Water and Groundwater Interaction In The Vineyard

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Regulatory drivers for a scientific approach to understanding the interaction of surface water and groundwater are increasing as competition for limited resources and climatic changes become more recognized globally. This has prompted detailed analysis, modeling, and testing of a common resource. Demonstration of surface and groundwater connectivity - or lack thereof - is often oversimplified, but must consider a multidimensional approach to be defensible. Geologic and hydrologic connectivity is often the first tier of understanding and can be undertaken using an accurate review of vineyard irrigation or winery well location, design, and construction, and correlation of subsurface strata or rock types to springs, creeks, or rivers, and their sources. As the tiered approach becomes more complex, water levels below ground and surface water flows or locations aboveground and changes to both due to pumping or diversion, require more detailed temporal monitoring and model efforts. Since a model must be anchored in reality to be useful, site-specific data is imperative to inform the calculations. Where multiple wells are present in a correlative aquifer, pump testing can provide invaluable subsurface information on aquifer parameters. At the highest tier of investigation, surface water-groundwater interaction evaluation should include high frequency and long-term monitoring of several data points: water levels in wells, production rates, creek stage heights, precipitation, air temperature and pressure, and other climate factors. Water quality is often the most important filament of connectivity, and must be considered in mineralogical, physical, and biogeochemical phases. Water temperature and changes over time at multiple scales are one of the most key components of an interaction study.

Funding Support: Private Consultancy

Opti-Panels Palliate Effects of Heatwaves and Drought by Improving Leaf Gas Exchange and Arresting Flavonoid Degradation

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Partial solar radiation exclusion has emerged as a viable technology to mitigate the effects of global change in winegrape production. A factorially arranged experiment consisting of Opti-Panel and irrigation was conducted in the Napa Valley of California. Treatments consisted of Opti-Panel, a recently developed product of Opti-Harvest, and an uncovered control that were completely crossed with irrigation replacements of 100% and 25% of crop evapotranspiration replacement (ET_c) starting at engustment. Opti-Panels consistently maintained ~17% greater net carbon assimilation (A_{net}) and stomatal conductance (g_s), regardless of irrigation treatment or measurement date, than the uncovered control throughout the growing season. Likewise, irrigating with 100% ETc increased A_{net} and g_s ~17% over that of the 25% ET_c treatment. Components of yield were not adversely affected by Opti-Panel application, but 25% ET_c irrigation reduced berry and cluster mass as well as yield per plant. Berry titratable acidity increased with Opti-Panel application, while irrigating with 25% ET_c reduced it. Berry total soluble solids increased when Opti-Panel was not applied, indicating dehydration. Likewise, berry total skin anthocyanins were 21% greater with Opti-Panel application, while irrigating to 100% ET_c reduced

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it by a similar amount, indicating Opti-Panel application was arresting anthocyanin degradation. Berry skin flavonol content increased 45% when Opti-Panel was not applied and increased by a similar amount when 25% ET_c was applied, indicating overexposure of the fruit zone. The molar abundance of kaempferol in berry skin, a biomarker for exposure to solar radiation, was ~250% higher in the uncovered control than in Opti-Panel, regardless of irrigation treatment. Results indicated that Opti-Panel was a useful cultural practice and technology that maintained yield without adversely affecting berry composition and increased berry anthocyanin content without having to increase applied water amounts in a hot climate prone to frequent heat waves.

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