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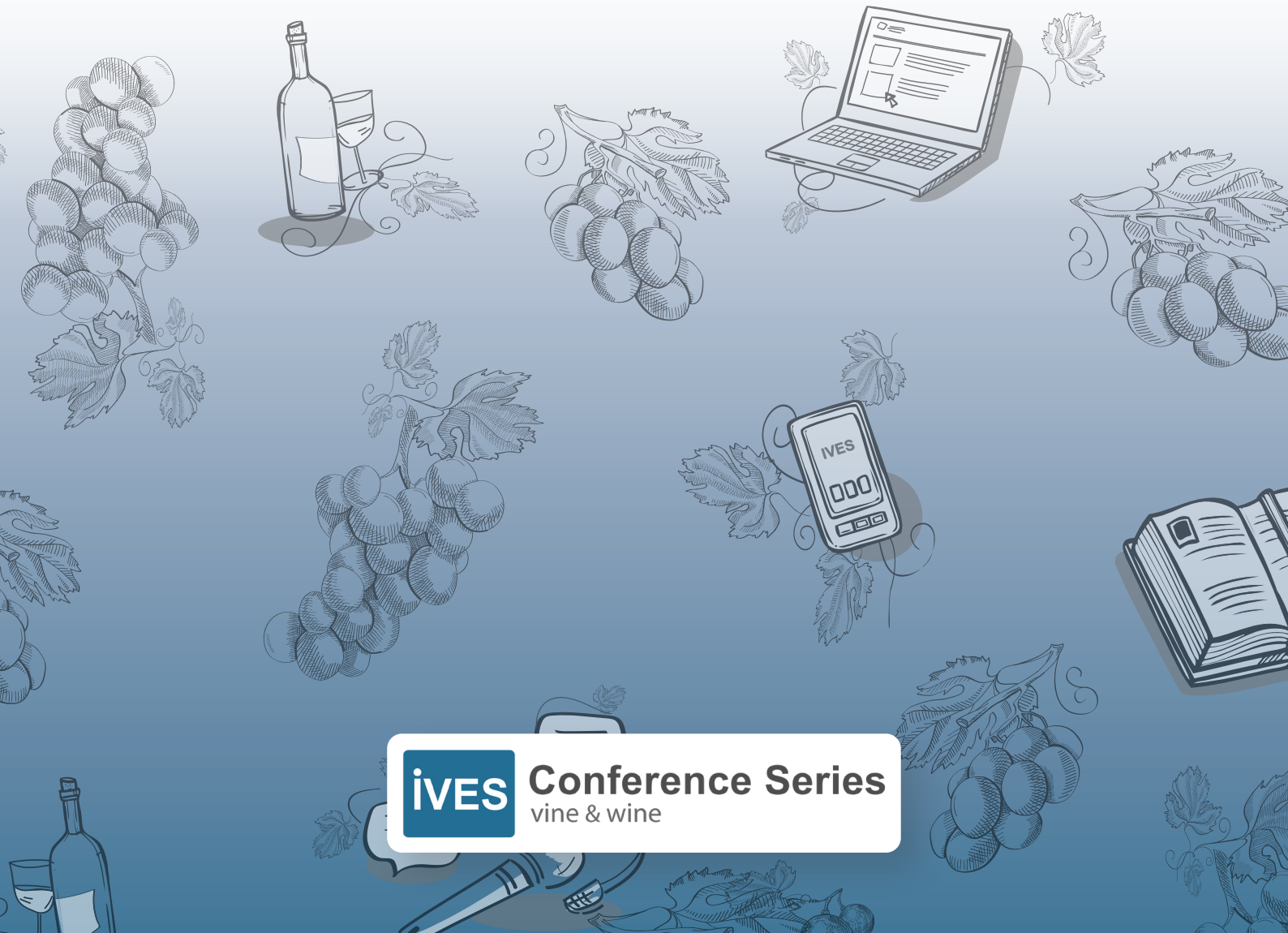
Green wine

SCIENCE for SUSTAINABLE PRODUCTION

19–20 May 2025 • Verona (Italy)

Book of Abstracts



iVES Conference Series
vine & wine

GreenWINE 2025

INFORMATIONS

This book of abstracts results from a collaboration between the GreenWINE 2025 congress (held from 19–20 May 2025 in Verona, Italy) and the International Viticulture and Enology Society (a not-for-profit organization). It is published online with open access on the *IVES Conference Series* platform.

Find the book and the abstracts at
https://ives-openscience.eu/category/greenwine/greenwine-2025/

DOI:
https://doi.org/10.58233/greenwine2025

ISSN of *IVES Conference Series*:
2777–9173

Editors-in-chief of *IVES Conference Series*:
Markus Rienth (Changins, Switzerland)
Andrii Tarasov (Hochschule Geisenheim University, Germany)

Layout:
Nicolas Ruault

Print and digital page layouts:
Nicolas Ruault and Lauranne Beret-Allemand

GreenWINE 2025

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EDITORIAL

Dear participants,

It is with great pleasure that, on behalf of the organizing committee, I welcome you to the first edition of GreenWINE. Like every new conference, GreenWINE started with the idea of filling an existing gap. In our case, the idea was to create a conference in which we could push the boundaries of the conventional wine science conference towards a new direction. We felt that the need to face novel challenges related to climate change and green transition would also require a new forum in which grape and wine scientist could discuss innovation for sustainable wine production in conjunction with environmental scientists, data scientists, and business experts. The results of this first call clearly indicate that this was certainly the case, as we received 112 proposals, from which a total of 36 oral presentations were selected, covering a variety of topics ranging from sustainable vineyard and winery practices to digital and sensing technologies, data modelling approaches, supply chain and consumer perception issues. The congress program is articulated across several sessions featuring a range of keynote speakers that will shed light on the most recent developments in these fields. Our ultimate objective is to establish GreenWINE as the reference scientific forum for innovation in sustainable wine production.

Maurizio UGLIANO

Leader of Spoke 7 – Consortium iNEST

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TOPIC 1

CLIMATE CHANGE RESILIENCE

ORAL

Effect of auxin treatment on delaying maturation of grape cultivars in the Valpolicella viticultural area

Giovanni Battista Tornielli[1,2], Ron Shmuleviz[3], Luca Cattaneo[3], Oscar Bellon[3], Alessandra Amato[3], Sara Zenoni[3], Marianna Fasoli[3]
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Keywords: grape ripening, climate change, auxin, harvest date, Valpolicella

ABSTRACT

The temperature increase related to ongoing climate changes is causing a progressive anticipation of the ripening time, negatively affecting grape quality at harvest. Various short-term adaptation strategies have been proposed to mitigate these effects. In this study, we collected data from multi-year auxin treatment trials aimed at delaying the ripening of some of the most important grape varieties cultivated in Valpolicella (Verona, Italy). We evaluated cultivar-specific responses in terms of ripening dynamics and berry composition. Additionally, we analyzed the effects of auxin on berry transcriptome rearrangements. The trials were conducted over several years in Guyot-trained vineyards located in Valpolicella. Clusters of cvs. Corvina, Corvinone and Rondinella were treated with 1-naphthaleneacetic acid (NAA) before veraison.

The dynamics of the main technological parameters were monitored from the time of treatment until harvest. A genome-wide gene expression analysis was performed on berry samples collected throughout the ripening period, and the genes modulated by the treatment at different time points were identified. The treatment of grape clusters with auxin strongly impacted the ripening dynamics, postponing sugar and anthocyanin accumulation and slowing the decrease in acidity, albeit with marked differences related to the grape variety. In some years, a positive re-balancing between sugars and anthocyanins was observed for cv. Corvina. However, for cv. Corvinone, the delay in ripening was consistently excessive, resulting in treated grapes failing to achieve acceptable maturity levels. Molecular analyses showed that the entire ripening program was postponed, and the longer stay of NAA-treated clusters on the vine appears to have had some effects on berry secondary metabolism. Moreover, we observed a strong modulation of numerous auxin-related genes, as well as genes related to gibberellin, ABA, ethylene, and brassinosteroids. This modulation began a few days after the treatment, confirming previous indications that crosstalk of multiple hormone signals controls grape ripening initiation. These results provide valuable insights for vineyard management strategies aimed at adapting viticulture to climate change in those areas where the grape varieties are part of the terroir paradigm.

ORAL

Factors affecting flavonols instability of red wines due to climate change

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Keywords: quercetin, deposits, risk instability, anthocyanins, tannins pH

ABSTRACT

Due to varietal factors, the formation of undesirable deposits of flavonols, especially quercetin (Q), occurs in several red wines. In recent years, this phenomenon has been aggravated by excessive exposure of grapes to UV radiation during the ripening process. This is an important issue that is difficult to address, especially since it is almost impossible to define the solubility of Q in red wine, given the complexity of the matrix and the Q crystallization process in wine solution. With the aim of understanding the factors affecting the solubility of Q in red wines, a first experiment was carried out in model solution and the data showed that the solubility of Q increased by increasing the concentration of anthocyanins, but the effect depended on the time. To understand if the data obtained in model solution were confirmed in real wines, in a second experiment the changes in flavonol composition of 32 red wines from 15 different grape varieties, obtained from the same vintage and not aged in contact with wood, were evaluated. The wines were selected to show the greatest differences in composition in terms of basic and phenolic parameters. The data showed that the most important factors influencing the formation of instability were not only anthocyanins, but also tannins, which improved the solubility of Q ($p<0.05$), and pH ($p<0.05$), which instead increased the formation of deposits containing Q in real wines after 8 months of aging under controlled conditions. These results may help to better determine the risk of Q instability in red wines and possible oenological strategies to counteract it.

ORAL

Enhancing viticulture sustainability with biochar: results of field experiments in Italy

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Keywords: biochar, viticulture, sustainability, climate change, precision agriculture, resilience

ABSTRACT

The increasing vulnerability of viticulture to climate change necessitates innovative solutions to improve its sustainability and resilience. The B-Wine project explored the use of biochar as a soil amendment to enhance soil fertility, optimize water and fertilizer use, and promote carbon sequestration, thereby reducing the sector's environmental footprint. We investigated the effect of biochar application (16 t ha-1), obtained from the carbonization of orchard pruning waste, on plant water relations of V. vinifera in tree field experiment in central Italy. Precision agriculture techniques, including drone-based monitoring, were employed to assess vegetative status and water stress levels. Complementary eco-physiological sampling and chemical-physical soil analyses were conducted. Environmental impacts and carbon dioxide emissions were evaluated using Life Cycle Assessment (LCA).

Results demonstrated that biochar significantly improves soil water retention and enhances the leaf area index (LAI) under climatic stress conditions. Treated plants exhibited reduced water stress, evidenced by higher leaf water potential values, and achieved up to a 28% productivity increase compared to control plots. Positive correlations were observed between spectral, vegetative, and eco-physiological indices, highlighting improved vegetative and productive conditions in the treated plots). Also, soil analyses indicated a substantial increase in soil available water content, decrease bulk density and increase the Soil physical and hydrological properties in biochar amended plots. These findings suggest that biochar is a promising tool for enhancing sustainability and resilience in viticulture, addressing climate change challenges. The integration of advanced monitoring technologies facilitated precise data collection, enabling further scalability and application.

ORAL

Unraveling grapevine resilience to water and nutrient limitations

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Keywords: grapevine, abiotic stress, rhizosphere, nutrients

ABSTRACT

Water and nutrient availability significantly impact crop yield, thus the application of sustainable strategies towards efficient water use and nutrient absorption by plants is needed. Moreover, it has been demonstrated that some microorganisms can promote plant fitness and tolerance to abiotic stresses. The aim of the present study is to assess the physiological and biochemical responses of two grapevine cultivars under different edaphic conditions, specifically water deficit and nutrient limitation, and the effect of arbuscular mycorrhizal fungi (AMF) application.

Two-year-old Cabernet Sauvignon and Grenache plants grafted on S.O.4. rootstocks were sown in 20-L soil pots under semi-environmental conditions. Plants were either maintained well-watered or subjected to a controlled water deficit irrigation and treated with different nitrogen (N) and potassium (K) fertilization doses. Grapevine resilience to water deficit was also assessed in a second trial in combination with AMF. During two growing seasons, leaves and roots were collected for physiological and molecular measurements. Roots from the second trial were collected for ionomic, metabolomic, and transcriptomic analyses, and the level of mycorrhization will be evaluated microscopically, whereas soil samples will be submitted for microbiome sequencing analyses. Water deficit caused a significant reduction in plant growth and several physiological parameters, such as transpiration rate and stem water potential. Multi-elemental data from ICP-OES and CHN-IRMS at flowering stage showed that plants mainly separated in response to irrigation treatment. Conversely, the nutrient composition at the maturity stage was strongly influenced by N fertilization. Finally, the effect of the mycorrhizal treatment has been shown to be more pronounced under water deficit conditions. Multi-omics data will be integrated with information obtained from µ-XRF analyses that provide spatial resolution of the elemental distribution of leaves and roots. The results obtained will improve the comprehension of the mechanisms involved in the signaling network of the interplay among water and nutrient acquisition.

ACKNOWLEDGEMENTS

Work supported by Prin 2022PNRR, M4C2 Inv.1.1 Finanziato dall'Unione Europea – Next generation EU, Spatial characterization of molecular responses to water deficit and nitrogen limitation in grapevine roots – P20222XJKY, CUP G53D23007660001; Agritech National Research Center that received funding from the European Union.

Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022).

ORAL

Investigation on the potentiality of a biostimulant by *Fabaceae* tissues and rich in triacontanol to enhance grapevine resilience under drought stress

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Keywords: grapevine resilience, drought stress, triacontanol, grape quality, biostimulant

ABSTRACT

The primary objective of this research was to investigate the potential benefits of a Fabaceae-based product rich in triacontanol (a long-chain alcohol) applied to Vitis vinifera cv. Merlot, on key physiological and productive parameters of grapevines under controlled water stress conditions. Specifically, the study focused on evaluating parameters such as photosynthetic activity, water use efficiency, and yield quality, while also monitoring the grapevines' physiological responses to water stress. By elucidating the effects of this treatment, the findings aim to contribute to developing innovative and sustainable solutions for modern viticulture. The experiment involved 40 Merlot grapevines grafted onto Kober 5BB rootstock. The vines were divided into two experimental groups: untreated control (NT) and treatment (T1), with 20 plants per group (4 replicates per group; 52 m² per plot) following a randomized block design.

Net photosynthetic rate (A), stomatal conductance (gs), transpiration rate (E), and internal CO_2 concentration (ci) were measured on three replicates per treatment (8 leaves per treatment) between 8:30 and 10:30 a.m. on fully expanded, healthy leaves between the 5th and 10th internodes of a central shoot. A portable photosynthesis system (Li-6400XT, Li-Cor Inc.) was used with a photosynthetic photon flux density (PPFD) of 1,200 µmol m^{-2} s^{-1}, CO_2 concentration set to 400 µmol mol^{-1}, and relative humidity (RH) maintained at 65%. The qualitative parameters of the grape skin were also evaluated with rapid field spectroscopic and rheological systems.

T1 showed a significant improvement in WUE compared to NT, while NT recorded higher evapotranspiration (E), indicating greater water loss in untreated plants. Furthermore, all analysed genes exhibited significantly higher activation in T1 plants compared to NT. This suggests that the treatment triggered molecular mechanisms associated with water stress resistance. Finally, no differences were observed in total polyphenol concentration in grape skins between T1 and NT during the phenolic ripening curve, suggesting the treatment did not influence secondary metabolite accumulation under the tested conditions.

In conclusion, T1 (Fabaceae-based product rich in triacontanol) appears to offer significant advantages in managing water stress by improving WUE and activating stress-response genes, making it a promising tool for sustainable viticulture. However, its neutral impact on polyphenol content warrants further investigation to understand its broader implications for fruit quality and marketability.

ORAL

Enhancing vine resilience and protecting grape production in Mediterranean vineyards: the role of anti-hail shading nets and kaolin applications

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Keywords: climate change, heat stress, extreme weather events, grapevine, vineyard management, net application, kaolin, vine physiology, grape production, grape quality

ABSTRACT

Climate change and rising temperatures present a substantial challenge to viticulture, intensifying summer heat stress and accelerating berry ripening. Moreover, the increasing occurrence of extreme weather events, such as hailstorms, further threatens the sustainability of the sector. In Mediterranean regions, mitigating these impacts has become essential for enhancing vine tolerance and maintaining good levels of production and quality. This study evaluates two mitigation strategies—anti-hail shading nets (S) and kaolin spraying (K)—compared to untreated control vines (C) over three growing seasons, from 2021 to 2023. Key parameters assessed include vine physiology, berry ripening, grape production, and pruning weight.

Shading nets (S) significantly reduced light exposure in the fruiting zone and, despite limiting gas exchange, improved vine performance under extreme heat conditions. Kaolin spraying (K) alleviated heat stress and boosted photosynthetic activity. While maintaining good crop levels, both treatments enhanced grape quality by preserving higher acidity levels and reducing sugar content and pH. They also reduced fungal disease incidence, with shading nets providing additional hail protection.

Pruning weight remained stable across treatments, with treated vines showing no negative side effects concerning vine growth and a better balance between vegetative growth and production. In conclusion, both kaolin and shading nets are effective strategies for mitigating the impacts of climate change, improving vine resilience, and supporting high-quality grape production.

ORAL

Investigating the carbon sequestration potential in vineyard soils–the SUSTAIN project

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Keywords: soil, carbon sequestration, climate change, vineyards, digestate

ABSTRACT

The SUSTAIN project aims at assessing the soil organic carbon (SOC) stock and vulnerability in vineyard in a climate change scenario. The accumulation and stabilization mechanisms of SOC and its relative distribution between pools having a different turnover are investigated.

Three experimental vineyards located in the Valpolicella area (Veneto region, North of Italy) were investigated to understand of how parent material and plant cultivar interactively control SOC accumulation and stabilization. These sites were characterized by the same climatic conditions, and by soils developed from different parent materials.

Three additional study areas were also selected and, in each of them, a randomized block design, consisting of 3 blocks composed of 8 plots each, and two factors, i.e., digestate application (amendment, cover crop, bare soil) and climate manipulation (ambient temperature, warming), was set up. In order to increase the temperature by ~2 °C (SSP2-4.5), open top chambers (OTC) were used. Soil samples are collected at four times (i.e., after 0, 6, 12 and 18 months from the OTC placement) and at 3 depths (i.e., 0-15, 15-30, 30-45 cm), and characterized from the physical, chemical and biological point of view. SOC storage and potential vulnerability to climate change were achieved by separating SOC into functionally defined fractions, namely particulate (POM) and mineral-associated organic matter (MAOM). In fact, being more protected from microbial degradation by soil minerals, MAOM is generally expected to be less prone to disturbance compared to POM.

The results of this project will help implementing agro-environmental management practices supported by the new common agricultural policy (CAP), including carbon farming payment schemes based not only on the quantity of SOC stocked, but also on its turnover or susceptibility to global warming. Moreover, such a study will provide highlights on vineyard vulnerability and possible changes in wine quality in a climate change scenario.

ACKNOWLEDGEMENTS

This study was carried out within the SUSTAIN project "SeqUeSTro del cArbonio in vIgNeto: utilizzo di biomasse in uno scenario di cambiamento climatico" funded by the Ministero dell'agricoltura, della sovranità alimentare e delle foreste (Area 2 – Cambiamento climatico, biodiversità, funzionalità suoli e altri servizi ecologici e sociali dell'agricoltura; D.M n. 419782 del 14/08/2023 – Procedura di selezione per la concessione di contributi finalizzati alla realizzazione di progetti di ricerca pubblica nel settore vitivinicolo).

ORAL

Innovation in pre- and post-harvest biocontrol: novel strategies against *Botrytis cinerea* for grape preservation

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Keywords: bio-protection, grape, microorganisms, *Botrytis*, microbial consortia, *Metschnikowia*, *Aureobasidium*

ABSTRACT

Driven by the demand for sustainable agriculture, biocontrol is emerging as a crucial alternative to chemical fungicides for crop protection. This strategy focuses on the use of living microorganisms, their metabolites or other natural compounds, to counteract plant diseases and preserve food quality. A critical problem in the wine industry is Botrytis cinerea infection, which compromises grape quality. Current management is based on chemical fungicides, but their use is limited in pre-harvest stages to avoid residues in the final product, pushing towards natural solutions such as biocontrol. However, the number of microorganisms registered as active substances in the European Union is still limited, highlighting the need for improved selection and application processes [1].

In this context, the purpose of this work is to assess the performance of new microbial isolates (grapevine wood endophytes) as bioprotective microorganisms and comparing them with commercial agents already in use, such as Metschnikowia fructicola (currently reclassified as M. pulcherrima) [2,3] and Aureobasidium pullulans. The study firstly focuses on post-harvest application, with particular attention to the storage phase, which represents a critical moment for the protection of fruit quality.

The bio-protective potential of some bacterial isolates, primarily Actinobacteria [4], previously selected through in vitro assays [5], was evaluated on grape bunches. Initial trials conducted under controlled conditions (laboratory-scale treatment of table grapes with controlled Botrytis cinerea infections) allowed to evaluate the ability of different microbial strains to colonize the grape surface and maintain viability during storage, essential traits for effective biocontrol agents. Monitoring of disease incidence and severity indices revealed a significant reduction in the growth of Botrytis cinerea mycelium on treated bunches. In this context, the tested isolates demonstrated biocontrol efficacy comparable to that of reference microorganisms known for their bioprotective capacities [1], which were confirmed.

Further trials under industrial conditions (withering warehouses for passito wine production) were carried out for determining the most suitable application conditions to reduce the development of naturally present Botrytis cinerea. The experiments, conducted at two different wineries, tested the effectiveness of the microorganisms, both alone and in microbial consortia containing multiple strains, also considering the use of adhesives to improve the effectiveness of the treatments.

The results, particularly encouraging in contexts characterized by high botrytis pressure, indicate promising application as an alternative to chemical control.

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ORAL

Short-term canopy strategies to enhance grapevine adaptation to climate change

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Keywords: viticulture, temperature, photosynthesis, heatwave, wine

ABSTRACT

Context and purpose of the study – Viticulture faces significant challenges due to climate change, with increased frequency of extreme weather events impacting grapevine growth, grape quality, and wine production. These issues, once confined to warmer regions of southern Europe, now affect cooler areas like Northern Italy, where there is an increasing frequency of storms, heavy rainfall, and heatwaves which can lead to ripening arrest and quanti-qualitative losses. This issue affects both red and white grape varieties, with the latter particularly vulnerable due to reduced acidity levels, crucial for aromatic and sparkling wine production. To address the impact of high day and nighttime temperatures in the summer (from July until harvest), the present study was aimed at testing different short-term adaptation solutions including the use of shading nets and the spraying of particle films such as kaolin and zeolite, the first reducing overall incoming solar radiation and the latter increasing albedo while reducing the temperature of leaves and fruits.

Materials and Methods – The experiment was conducted in an organic vineyard of Vitis vinifera cv. Glera, cultivated for Prosecco wine production in Norther-East Italy. From pre-véraison (early July) until harvest, a complete randomized block design was applied with the following three treatments plus an untreated control: shading net (black 40%), kaolin and zeolite applied on both canopy sides of three adjacent vine rows per block. Throughout the experimental period, continuous monitoring of berry temperature and canopy microclimate, as well as physiological and morphological measurements, were carried out at regular intervals. At grape maturity, various cluster/berry morphometric parameters, yield variables and berry composition qualitative analyses were assessed to determine whether the treatments had significantly affected the chemical properties of grapes, must, and base wine.

Results – Treated vines exhibited sustained stomatal conductance compared to the control. This improved physiological activity in treated plants aligns with the average temperature data recorded by sensors on canopies and berries. Berry and canopy temperatures in the control plants were consistently higher than those of the treated plants. The treatments also had a significant effect on berry characteristics evaluated at harvest. Notable changes in acidity, calcium, copper content, and berry weight were obtained, suggesting the potential applicability of these short-term adaptation techniques not only for fostering vine adaptation to heatwaves in the field but also for preserving and in some cases improving berry chemical characteristics and wine quality.

ORAL

Release and perception of γ-nonalactone and massoia lactone in the red wine matrix: impact of ethanol and acidity

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Keywords: climate change, interactions, alcohol, pH/total acidity, aroma, wine sensory quality

ABSTRACT

Climate change (CC) is altering grape/wine composition, leading to challenges in maintaining wine sensory quality. Rising temperatures increase grape sugar levels, with higher wine ethanol (EtOH) contents, reduce total acidity (TA) converging with increased pH, modify the phenolic pattern, and lead to the accumulation of CC odorous markers such as gamma-nonalactone (C9) and massoia lactone (ML). These alterations often require interventive acidification to preserve microbial and chemical stability, and taste balance of wines. Previous studies addressed the effects of CC on wine proposing preventive and management strategies. The main objective of this study is to give a contribution by investigating for the first time the sensory impact of matrix-aromas interactions in wines representative of the main CC compositional effects in their whole.Model wine matrices (9) were reconstituted from a deodorized red wine, using a full factorial design based on 3 ethanol levels (12, 14, 16%), 3 pH/TA ratios (3.2/8=0.4, 3.6/6.5=0.55, 4/5=0.8) and spiked with C9 (155 ppb) and ML (26.8 ppb). The combinations simulated progressive CC impact from proper (12%, pH/TA=0.4, no CC effects), to alarm (14%, pH/TA=0.4, CC influencing EtOH levels with TA corrected by acidification) till dangerous (14%, pH/TA=0.8, CC affecting TA without correction; 16%, pH/TA=0.8, extreme CC effects) scenarios of wine quality. Discriminating (triangle test: TT) and descriptive (RATA) sensory tests and SPME/GC-MS quantitative analyses, were carried out to test the impact of compositional changes applied to the matrix on the perception and release of the two odorous CC markers and to explore perceptual interactions. TT showed significant differences in the perception of C9 and ML in wine considered dangerous for its alcohol content (16%) and corrected by acidification (pH/TA=0.4), indicating in this condition a combined effect of EtOH and acidic profile on their perception likely driven by physical-chemical phenomena. GC-MS analysis of wine headspace confirmed that this condition exhibited the highest release of C9 and ML. Moreover, RATA results showed that in the sample representative of extreme CC conditions (16% EtOH, pH/TA=0.8), the addition of C9 and ML led to a shift in aroma profile: red fruit notes, characteristic of the whole wine, were no longer perceived, while sweet notes became dominant, suggesting a significant matrix effect on the olfactory impact of these compounds. These findings highlight that CC and the corrective actions by winemakers can have a significant combined impact on the sensory quality of wine. Our study points out that adjusting the acidic profile of wine—an often-necessary step to improve stability and taste balance—may favor C9 and ML perception linked to CC and premature aroma aging. These results suggest that in a complex matrix such as red wine, adjusting a single parameter could be not enough and a holistic approach should be adopted.

ORAL

Water use efficiency of Chardonnay under different grafting combinations in the viticultural area of Franciacorta

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Keywords: rootstocks, drought, climate change, sparkling wines

ABSTRACT

Drought poses a challenge to future viticulture, exacerbated by climate change, which increases the frequency and severity of water shortages. The use of tolerant rootstocks is considered a sustainable strategy for facing drought, increasing water use efficiency (WUE) and maintaining the production and the quality of grapes and wines. In fact, under water-limited conditions rootstock induces stomatal closure, a critical strategy to minimize water loss, although it can also reduce photosynthesis and consequently vegetative growth or grape ripening. New promising rootstocks have been recently selected for facing abiotic stresses, i.e. M1, M2, M3 and M4, and their stress tolerance is currently under investigation, considering interactions with scion, climate and soil properties. The aim of this study is to investigate the effect of the new M-rootstocks on the water stress response of Chardonnay in the viticultural area of Franciacorta, and to explore their potential for sparkling wine production under changing climate scenarios. The experiment was conducted in 2023 and 2024 in a 10 years old pilot vineyard, characterized by loamy clay soils. Chardonnay vines were compared in 6 grafting combinations, including the four M rootstocks, SO4 and 1103 Paulsen. During the two analyzed vegetative seasons, physiological activity of vines was monitored, in terms of water potential, osmotic potential, gas exchange, WUE, and chlorophyll fluorescence. At harvest, productive and qualitative parameters of grapes were detected.

Under absent or mild water stress, M-rootstocks induced higher WUE to Chardonnay than traditional rootstock. Under moderate to severe stress, WUE was maximized by the grafting combinations with rootstocks M2 and 1103 Paulsen at midday. Different daily dynamics were observed for M4 and SO4, which induced stomatal closure at midday and high gas exchange and WUE in the morning. At harvest, a significant effect of the grafting combination was observed on grape acidity, which was higher for rootstocks M4 and SO4.

These results suggest that the use of new rootstocks in Franciacorta allows to reduce water use and to enhance the quality of grapes for sparkling wine production. Further studies on adaptive strategies of drought-tolerant rootstocks will provide better insights into their performance under different environmental conditions and grafting combinations.

ORAL

Application of remote and proximal sensors for precision vineyard management in Valpolicella

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Keywords: precision viticulture, sensors, trellis system, vineyard spatial variability, Valpolicella

ABSTRACT

The integration of sensor systems in viticulture is significantly improving vineyard management by enabling faster, comprehensive crop data collection across the entire vineyard, supporting more informed viticultural decision-making, and as a result promoting sustainability. Nevertheless, sensor information is highly sensitive to pedo-climatic and agronomic factors that characterize the vineyard context. Consequently, in different viticulture scenarios, a preliminary evaluation of sensor application methods is essential to tailor existing techniques to the unique conditions of each vineyard. This study conducted a systematic evaluation of remote and proximal sensing technologies in Valpolicella wine region (north-east Italy) where these approaches have not been previously applied, aiming to integrate these advanced methodologies into regional viticultural practices. Several vineyards representing Valpolicella viticulture characteristics were selected and monitored during 2021-2024. The vineyards featured varying altitudes, sizes, autochthonous cultivars and the two typical trellis systems: the vertical shoot positioning, Guyot, and the traditional overhead Pergola. These vineyards were studied using multispectral imagery from satellite and UAV platforms, as well as ground-based sensors operated in proximity to the canopy, to evaluate vine vigor and water status. Traditional agronomic measurements and berry quality parameters were collected and compared with sensor data to assess the methods' efficiency and precision. Multivariate analyses revealed that the informative potential of different sensor systems varies as a function of the trellis system and vineyard size. Finer correlation analyses of parameters measured in single vineyards revealed strong, stable relationships between sensor data and vine vigor, and moderate relationships with berry traits. An evaluation of interannual spatial stability in vine vigor showed relatively consistent patterns across years. This information confirms the potential of integrating sensor systems into Valpolicella viticulture, supporting viticultural decision-making in light of recent sustainability challenges while helping preserve the traditional characteristics of the local wines.

ORAL

Impact of copper residues in grape must on alcoholic fermentation: effects on yeast performance, acetaldehyde and SO_2 production

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Keywords: Cu^{2+}, SO_2, acetaldehyde, alcoholic fermentation, yeast

ABSTRACT

A relevant trend in winemaking is to reduce the use of chemical compounds in both the vineyard and winery. In organic productions, synthetic chemical fertilizers and pesticides must be avoided. The use of copper and sulphur-based molecules as an alternative to chemical pesticides, is a common practice in organic vineyards, but is in turn gradually decreasing, for several reasons. Beyond regulatory changes that impose lower limits, indeed, the use of high doses of copper seems to affect the composition of grape must, and therefore have an impact on the winemaking process. Previous studies have established that high concentrations of Cu2+ can be toxic to yeasts, inhibiting growth and activity, causing sluggish fermentation and reducing alcohol production. Nevertheless, with the objective to ascertain toxicity limits for yeasts, most of these works employed Cu2+ concentrations much higher than those normally found in grape juices (>20 mg/L), whereas very few information is available about lower copper amounts.

In this context, the aim of our work is to verify the potential effect of real copper contaminations from the vineyard on alcoholic fermentation. In fact, the goal of the trial was to compare different commercial strains of Saccharomyces cerevisiae in order to observe the effect of copper on their metabolism (in terms of: fermentation kinetics, production of free and total SO2 and production of acetaldehyde), rather than to verify at what copper concentration the fermentation goes sluggish or stuck. A second objective is also to identify the yeast strains whose behavior is less affected by the presence of copper.

For this reason, a first test was conducted on different natural white musts, contaminated or not with 10 mg/l of Cu2+, trying to mimic as much as possible what happens in the cellar. 15 active dry yeasts have been compared, outlining a common effect of acetaldehyde increase due to copper presence, but displaying a high strain and must-dependent individual behavior in terms of amounts of SO2 and acetaldehyde produced.

To investigate the impact of Cu2+ on yeast metabolism under more controlled conditions, a subset of relevant strains was compared in a synthetic must [5], added or not with Cu2+. The influence of fermentation temperature was also evaluated, carrying out the experiments at 16, 18 and 20°C. Fermentation kinetics, free and total SO2 production, and acetaldehyde production were monitored. The results confirm the common observation of increased acetaldehyde production in the presence of copper, while also confirming strain-specific responses which resulted more stable than in natural must. Regarding temperature effects, beyond the expected impact on fermentation duration, our initial findings suggest that temperature influences the magnitude of the difference between copper and control conditions.

POSTER

Use of minority grape varieties to mitigate climate change and achievement of balanced wines in Castilla y León (Spain)

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Keywords: minority varieties, balanced wines, climate adaptation

ABSTRACT

Castilla y León is the third longest region in the European Union, having more than 85.000 vineyard hectares. One of the most common problems facing wines due to climate change is the imbalance, as they show undue alcohol level and low organic acid concentration. This issue can be mitigated by choosing lesser-used of minority varieties. These varieties have almost become extinct, as some decades ago they did not meet winegrowers' quality standards, either because they were not productive or because they were unable to fully ripen in the climate conditions of decades ago.

This paper studies the agronomic, oenological and organoleptic behaviour of four red grape minority varieties and the wines elaborated with them in the Spanish region of Castilla y León: *Mandón* (Arribes del Duero, Salamanca), *Tinto Jeromo* (Arribes del Duero, Salamanca), *Cenicienta* (Rueda, Valladolid) y *Puesto Mayor* (Rueda, Valladolid) in 2024. This study was implemented in a vineyard located in Valladolid (698 MASL), managed in an organic way, common to the four studied varieties, to verify whether their potential, already demonstrated in their areas of origin, accomplish as well when cultivated under different soil and climate conditions. For this purpose, the following agronomic parameters have been selected: number of grape clusters per vine, cluster weight, berry weight and production per hectare. The parameters analysed to determine the grape quality are as follows: soluble solids concentration, pH, organic acids and total polyphenol index. Likewise, we present the main organoleptic characteristics of single-varietal wines produced using a common protocol in 2024 and evaluated by a panel of expert tasters.

The results achieved demonstrate good agronomic performance, with varying production levels depending on the variety studied. The grape quality shows very balanced values, demonstrating a high level of sugar concentration and, therefore, a probable moderate alcohol content (<13.5%), medium-low pH, medium-high acidity and a total polyphenol index that varies depending on the variety. The common organoleptic characteristics of the wines made from these four varieties show a very good alcohol-acid balance, with freshness sensations with fruity notes and varying palate structure depending on the variety studied.

The results suggest that these varieties may be very interesting in the current climate context. The recovery of minority varieties can be a key factor in preventing unbalanced wine composition and to increase the natural resilience of plants to climate change.

This project (0039_MINORSENS_2_E) is co-financed by the European Union through the Interreg VI-A Spain-Portugal (POCTEP) 2021-2027 program.

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POSTER

Vitis vinifera Manseng noir is an alternative red variety for low alcohol wines of strong structure and soft tannins

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Keywords: Manseng noir, Tannat, low alcohol, *Vitis*

ABSTRACT

In 2019, we have planted the red variety Manseng Noir, as it has been shown that it is the only sister of the Tannat grape. Tannat was introduced to Uruguay in 1870 from the south-western regions of France. Other varieties from this region have also been shown to produce very good wines, such as Arinarnoa introduced in 1995 and Petit Manseng in 2005, both of which are now considered excellent for high-end wines in Uruguay[1].

However, in 2013 it was discovered through genetic analysis that Manseng noir is not only from the same region as Tannat, but is the only sister identified among 2500 varieties studied[4]. This variety has virtually disappeared from the Pyrenees, probably due to the production of grapes with lower sugar content than Tannat or Cabernet Sauvignon. Today, when some markets are looking for varieties with a moderate alcohol content, some producers in this region have been encouraged to replant Manseng noir, thinking that it could help them to obtain wines with low alcohol content[5].

After several years, we have managed to plant the first vineyard outside the Pyrenees, in Uruguay, together with some of our Tannat clones, in order to compare the two varieties from a viticultural and oenological point of view[3]. In 2021, 2022, 2023, 2024 and 2025 harvests, their elaboration was achieved within this project, where agronomic, chemical and sensory analyses were carried out.

Sensory analyses show an early smoothness in Manseng noir tannins, allowing to obtain wines with lower alcohol and higher structure but less astringency in the mouth ($p<0.001$).

Enological results obtained show that its agronomic phenotype, acidity and colour intensity are similar to Tannat, but with the peculiarity of being grapes of moderate ripeness, 11.0-12.5% of alcohol. The flavanol polymerization was 8% more than that of the control Tannat at 14% alcohol and interesting differences were found in the anthocyanin characteristics of the skin.

Manseng noir complete genome was sequenced by Illumina technology and the results of the comparison of genes related to polyphenol biosynthesis between the two varieties are presented[2].

In reference to color composition, Manseng noir have a higher content of acylated anthocyanins and a higher malvidin/delphinidin relation that indicates increase flavonoid 3',5'-methyltransferase activity not related to gene copy number (as both genomes have 4 genes for this enzyme), this fact may contribute with an increase in color stability in this variety.

A comparative analysis of the metabolome of volatile compounds with GC-MS is also carried out during five harvests. The results are discussed to explain why Manseng noir is softer than Tannat by early polymerisation of the tannin fraction. Manseng Noir would be a variety more adapted to today's consumer preferences and new wine design trends, with lower alcohol content even under warmer climate, shorter ageing time in barrel and a successful grape to work with low input winemaking technologies.

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POSTER

Resilience analysis in viticulture: an approach based on expert knowledge elicitation

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Keywords: resilience, viticulture, EKE technique

ABSTRACT

The study aims to address the issue of resilience to climate change in viticulture through the adoption of the expert knowledge elicitation (EKE) approach. Elicitation consists of the application of techniques to extract knowledge or information from expert people on a specific topic. Specifically, elicitation consists of the process of expressing expert knowledge in a quantitative way, obtaining numbers and probability distributions. The study involved some experts operating in Franciacorta, an important wine-growing area in northern Italy. The experts were interviewed, subjecting to their evaluation the effect of different management strategies and their interaction on the ability of the vineyard system to cope with different pressures deriving from abiotic and biotic stressors, maximizing quantity and quality of production. To conduct the elicitation it was necessary to define the investigation context and different scenarios of years, that combined elements of water supply with elements of risk of the onset of phytopathologies. Technical management paths were also identified that combined soil management practices (fertilization and tillage) with canopy management practices (defoliation, shoots topping and thinning). The study, through the adoption of the EKE approach, allowed to summarize the results obtained from the shared opinion of the various experts, generating a system of synthesis of knowledge and translation of this in a quantitative key. Starting from the uncertainty distributions defined by the experts, the statistical approach adopted led to obtain a dataset of 96,000 observations. Statistical models were applied to this dataset allowing to detect the management variables which, within those included in the set of scenarios, were considered significant in influencing the yields and quality of the grapes. In particular, the positive effect on productivity of organic and mineral fertilizations, as well as inter-row and sub-row tillage, emerged as particularly significant. As regards the canopy management, the effect of shoots thinning, the method and timing of topping and defoliation had a significant effect only in some vintages and with diversified effects based on the specific scenario of year. This work has allowed us to carry out an integrated analysis of the effect of different management practices and their interaction on resilience in viticulture by enhancing the knowledge of experts through the EKE technique. This made it possible to enhance the role of different technical management paths in improving the resilience of the vineyard system by mitigating the negative effects of the stressors of the different vintages.

POSTER

The soil application of a plant-derived protein hydrolysate speeds up selectively the ripening-specific processes in table grape

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Keywords: biostimulant, protein hydrolysate, grape ripening, stress resilience

ABSTRACT

Grapevine is one of the most extensively cultivated fruit crops, playing a crucial role in the economies of many grape-growing regions around the world. However, grape production currently faces significant challenges due to climatic adversities and the pressing need to adopt sustainable production models. The use of plant biostimulants offers a promising and viable alternative to traditional practices, sustainably enhancing grape production and quality even under adverse conditions.

In this context, we tested a maize gluten-derived protein hydrolysate (GDPH) on the Black Magic early table grapevine variety. The product, obtained from the enzymatic hydrolysis of the wet-milling process by-products, was applied at the soil by drenching to evaluate its effects on yield, grape ripening, and fruit quality.

The GDPH, administered at veraison, positively affected many parameters as early as 14 days post-application. It increased anthocyanin and sugar concentrations and berry diameter while maintaining optimal levels of berry firmness. Through transcriptomic analysis of the berries, we found that the GDPH accelerated the berry ripening process by up-regulating the expression of genes involved in anthocyanin biosynthesis and enhancing the modulation of key developmental regulators in berries. Furthermore, the selective modulation of genes related to cell wall metabolism explained the observed preservation of berry firmness. Our findings suggest that GDPH treatments may boost grapevines resilience by increasing the tolerance to both abiotic and biotic stresses, as evidenced by the impact on several genes related in such responses. Taken together our results highlight the efficacy of this plant-derived biostimulant in enhancing berry coloration with minimal impact on fruit texture, which is particularly important for table grape production. The demonstrated positive effects on berry pigmentation and the ability to enhance quality parameters emphasize the need for further research to elucidate its mechanisms of action. Ultimately, optimizing its application in agricultural practice will help unlock its full potential as a plant biostimulant.

POSTER

Effects of the synergy between *T. delbrueckii* and *S. cerevisiae* in the winemaking of traditional cultivars from southeastern Italy

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Keywords: *Torulaspora delbrueckii*, *Saccharomyces cerevisiae*, sequential fermentation, aromatic profile, southern Italy wines

ABSTRACT

The combination of *Torulaspora delbrueckii* and *Saccharomyces cerevisiae* in co-inoculation and sequential inoculation in winemaking was investigated as an innovative strategy to increase the aromatic profile of wines like Verdeca and Nero di Troia wines, two traditional varieties from south-eastern Italy (Apulia Region). The study was conducted on a pilot scale with the objective of evaluating the effect of different inoculation methods on fermentation kinetics, enological parameters and sensory quality of the wines produced. The results show that sequential inoculation with *T. delbrueckii* produced less volatile acidity and positively modulated sugar metabolism, promoting a more balanced fermentation. Analysis of the volatile profile of the wines produced in this study revealed particularly interesting results, with significant sensory differentiation between the samples. Among these, a marked increase in ethyl esters derived from saturated and unsaturated fatty acids was observed in the samples obtained through sequential inoculation with S. cerevisiae and T. delbrueckii. These compounds played a key role in the aromatic characterisation of the wines, contributing significantly to the distinction between the different fermentation conditions analysed. The increased presence of these esters, known for their positive impact on wine sensory characteristics, suggests that the combined use of these yeasts may represent an effective approach to modulate the aromatic profile and improve the olfactory complexity of the final product.

Sensory analysis showed a significant impact on aromatic complexity, with an enhancement of fruity notes, particularly in rosé wines made from Nero di Troia. In these samples, fermentations with *T. delbrueckii* intensified the desirable red fruit characters, giving greater freshness and taste-olfactory persistence. These results confirm the potential of non-*Saccharomyces* yeasts in the vinification of Apulian native varieties, offering new opportunities to enhance territorial identity and improve the sensory quality of these wines. The integration of *T. delbrueckii* in oenological protocols could represent an effective strategy to respond to the needs of a market increasingly oriented towards distinctive, high-quality products.


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TOPIC 2

LOW-INPUT PRODUCTION

ORAL

Application of new genomic technologies to improve the pathogen resistance of two local cultivars from Veneto region: Corvina and Garganega

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Keywords: grapevine, Corvina, Garganega, DNA-free genome editing, S-genes, NGT plants

ABSTRACT

Grapevine (*Vitis spp.*) is a globally significant fruit crop and enhancing its agronomic and oenological traits is crucial to meet changing agricultural conditions and consumer demands.

The control of pathogens in viticulture often relies on the application of massive amounts of pesticides, especially fungicides, which comes at great costs for viticulture and poses a considerable risk for human health and the environment. Conventional breeding has played a key role in domesticating grapevine varieties, but it is a time-consuming process to develop new cultivars with desirable traits for cultivation, such as pathogen resistances. New plant genomic techniques (NGTs) offer a potential revolution in grapevine cultivation, and genome editing has shown promise for targeted mutagenesis. The success of these biotechnological approaches relies on efficient *in vitro* regeneration protocols, particularly through somatic embryogenesis (SE). This method has proven successful in some *Vitis vinifera* species, but its effectiveness varies due to the genotype-dependent nature of many cultivars. Moreover, protoplasts, cells without a cell wall, have proven to be particularly suitable for genome editing applications, but protoplasts regeneration remains generally considered challenging in grapevine. This approach preserves the genetic identity of the cultivars, which would otherwise be altered through crossing.

The focus of this study is to enhance *in vitro* plant regeneration process *via* SE and isolate and regenerate plants from protoplasts derived from embryogenic calli of Corvina and Garganega, two grapevine varieties of significant economic importance for wine production in the Veneto region. Protoplasts serve as a platform for DNA-free genome editing using CRISPR/Cas9 system to target *MLO* and *DMR* Susceptibility S-genes associated with downy mildew and powdery mildew susceptibility in grapevine. The study includes a preliminary phenotypic characterization of powdery mildew and downy mildew infections to evaluate the reduction of susceptibility to pathogens in the edited-regenerated plants. This research aims to accelerate the development of grapevine varieties with improved traits, overcoming the limitation of conventional breeding methods and this advancement aligns with European legislative demand about NGT plants.

ORAL

Potential use of the yeast *Starmerella bacillaris* as a sustainable biocontrol agent against gray mold disease in viticulture

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Keywords: *Botrytis*, grapes, fermentation, wine

ABSTRACT

Pest biocontrol strategies are gaining attention as eco-friendly alternatives to the use of synthetic pesticides, including in viticulture.

The yeast *Starmerella bacillaris* strain FRI751 was previously proven *in vitro* and *in vivo* to exhibit antagonistic activity against *Botrytis cinerea*, the etiological agent of gray mold disease in grapes. The study presents the first evaluation of the biocontrol potential of this strain against *B. cinerea*, as a defense treatment in vineyards.

S. bacillaris was sprayed on Pinot gris grapes during the pre-bunch closure, veraison, and pre-harvest phenological stages. Trends of *S. bacillaris* and *B. cinerea* on grapes surface were monitored through qPCR. Each application of *S. bacillaris* established an initial estimated population that was one to two logs lower than the concentration of the sprayed culture, with a subsequent decline over time. *B. cinerea* growth was detected in untreated bunches but was absent in those treated with *S. bacillaris*. The use of conventional antibotrytic pesticides showed, instead, a slight reduction in detected *B. cinerea* over time.

Metabarcoding analysis of the whole ITS region on grape surface fungal communities further supported the biocontrol effect of *S. bacillaris*. Additionally, *S. bacillaris* was still present in the must derived from sprayed grapes, and the wine produced from this must exhibited a higher glycerol content and a similar acetic acid content compared to controls, supporting the known positive contributions of this yeast during fermentation.

This study highlights the potential of *S. bacillaris* FRI751 as a sustainable option for grape protection from gray mold disease and for improving wine quality.

ORAL

Efficacy of tannins of different botanical origin as partial or total substitute of SO_2 to preserve a Cortese white wine during storage in cellar

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Keywords: white wines, SO_2, tannins, oxigen consumption rate, linear sweep voltammetry

ABSTRACT

While SO_2 is one of the oldest and widest additive used in enology for its well-known antioxidant, anti-laccase and antimicrobial properties, it can cause health problems in some individuals. Nowadays, the antioxidant and antiradical qualities of alternative oenological practices or additives are currently being investigated, and several papers have been published that thoroughly examine the mechanisms governing the oxidation reactions to establish the theoretical basis for lowering the use of SO_2 in wines. Currently, the risk of a shorter shelf life is increased by the complete lack of sulfur dioxide, particularly for white wines. Although oenological tannins are one of the most suitable substitute products for antioxidant activity, the majority of researches have been done using model wine solutions or wines with sulfites. In this study a Cortese white wine vinified in the absence of SO_2, was divided in two parts: one with 30 mg/L of free sulfur dioxide (+SO_2) and one without (-SO_2). Each group was further divided into four samples and treated with different tannins (25 mg/L): ellagic tannin (American oak, A), condensed tannin (green tea, T and mimosa, M), gallotannin (chinese gall, G). The aim of the work was to study the efficacy of different tannins as partial or total substitute of SO_2 to preserve white wines during storage in cellar. Parameters related to oxidation were measured during storage: changes in color (CIELab) and polyphenols (total polyphenols and flavans), acetaldehyde, free and total SO_2, oxygen consumption rate (OCR), redox properties (linear sweep voltammetry - LSV), sensory profile. At the beginning of storage, the + SO_2 had a significantly lower OCR compared to the - SO_2. This is because the Fenton reaction, a rapid oxidation reaction, is favored in the absence of sulfites. The addition of tannins reduced the OCR, with the extent of reduction varying depending on the type of tannin. These findings, which contradict previous research on tannins in model solutions, may be attributed to the tannins' chelating and anti-radical properties. LSV revealed that SO_2 had a protective effect at the beginning of storage (increase in oxidizable compounds). However, this effect diminished after six months as the SO_2 levels decreased. conversely, tannins appeared to exhibit a protective effect only after six months, particularly T. Throughout storage, a significant increase in acetaldehyde was observed in all the +SO2 wines, especially when free SO_2 levels dropped below 10 mg/L. Wines treated with hydrolysable tannins had higher acetaldehyde content. Sensory analysis indicated significantly higher oxidized notes in the samples treated with ellagic tannin (E), both in the + SO_2 and - SO_2 groups. These samples also exhibited the highest levels of acetaldehyde. LSV results confirmed these sensory findings, suggesting that LSV could be a quick, user-friendly, and suitable technique for evaluating the oxidative evolution of wines over time.

ORAL

Can fungoid chitosan help to produce sulfite-free wines? Ten years of investigation on its antioxidant properties

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Keywords: chitosan, antioxidant activity wine, sulfites, browning

ABSTRACT

Chitosan is a natural polymeric saccharide admitted by EU since 2011 for must and wine clarification, the reduction of some contaminants (e.g. ochratoxin A) and to prevent the development of wine microbialspoilage due to lactic acid bacteria or Dekkera/Brettanomyces yeasts.

Scientific evidence is increasingly emerging about additional antioxidant and antiradical features for this polysaccharide when used as adjuvant in food, even if the vast majority of the research was conducted in food systems considerably different from wine for composition, pH and way of utilization.

Indeed, the confirmation of such antioxidant activities in a "wine-like" environment would be highly interesting in view of finding a technological tool suitable to vicariate sulfur dioxide and boost the research toward the production of wines with low or nil level of allergenic sulfites.

This presentation illustrates the main results obtained in the last decade by our group at the University of Bologna and other colleagues, aiming to evaluate the antioxidant features of fungoid chitosans in model solution and wines, together with the underlying mechanisms involved in these activities.

A short overview of the main antimicrobial properties of chitosan will introduce the main subject of the presentation, focused on the physical-chemical mechanisms which govern the antioxidant/antiradical/antibrowning properties of chitosan. The impact of the addition of the polysaccharides on the composition and sensory characteristics of both red and white wines will be also outlined at the light of the technological trials performed at laboratory and industrial scale.

ORAL

SO_2 consumption in white wine oxidation: approaches to low-input vinifications based on rapid electrochemical analyses and predictive enology

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Keywords: oxidation, SO_2, electrochemistry, predictive enology

ABSTRACT

Oxidative stability is a critical factor in wine shelf-life. SO_2 is commonly added to wine due to its strong antioxidant activity, although there is a general push to reduce SO_2 use in vinification. Reducing the reliance on SO_2 while maintaining oxidative stability is a pressing challenge for winemakers, emphasizing the need for predictive tools to optimize wine oxidation management.

In this study, the relationship between O_2 and SO_2 consumption of 71 Lugana white wines was studied. Samples underwent controlled oxidation (oxygen consumed ~ 5ppm at 20°C), while control anoxic samples were stored in the same conditions. Samples were characterized for SO_2 content before and after oxygen consumption, ammonia, primary amino nitrogen (PAN), polyphenols, ascorbic acid, and catechins. Cyclic voltammetry was used to obtain information on the redox-active compounds present in the wines.

Oxygen consumption rate followed first-order kinetics, with half-lives ranging from 2.1 to 18.1 days Wines with ascorbic acid >10 mg/L showed half-lives consistently below 9 days. In contrast, wines with low ascorbic acid <10 mg/L exhibited high variability, with some consuming oxygen rapidly, reaching half-lives as low as 4 days. SO_2 consumption ranged from 1.4 to 18 mg/L in the oxygenated samples and from 0.6 mg/L to 14.9 mg/L in the anoxic samples. Final free SO_2 concentrations showed a strong correlation with their initial values in both oxygenated and anoxic samples. On average, oxygenated samples consumed 4.6 mg/L more free SO_2 compared to anoxic samples, with a ratio of 0.92 mg of free SO_2 consumed per mg of O_2. Notably, variability among individual samples was substantial, with ratios ranging from 0.62 to 1.95 mg free SO_2/mg O_2.

The amount of free SO_2 consumed in oxygenated samples was significantly inversely correlated with the half-life, suggesting that, under equal oxygen availability, wines with faster oxygen consumption tend to consume less free SO_2. Electrochemical profiles also revealed significant variability among the redox-active compounds of the different wines, particularly in the voltametric regions located around 420mV 820mV.

Different modelling approaches were explored to identify opportunities for the development of predictive tools for SO_2 stability. Results of these investigations will be presented, with particular emphasis on the possibility to leverage electrochemical data to develop a rapid and reliable method to estimate oxidative stability without the need for extensive chemical analyses.

By combining rapid electrochemical analysis and predictive modelling, more rational use of SO_2 appears possible, contributing to more efficient and sustainable wine management practices.

ORAL

Membrane contactor: A sustainable technology to remove dissolved oxygen from wine and preserve wine aroma

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Keywords: oxygen, membrane contactor, wine, sensory profiles, VOCs

ABSTRACT

Oxygen management in wine is one of the most significant challenging issues for winemakers. Excessive dissolved oxygen can prematurely age wine, leading to the development of organoleptic defects. Membrane contactors (MC) composed of hydrophobic hollow microporous fibers are emerging as a promising technology for managing dissolved gases during winemaking. Operating at ambient temperature and atmospheric pressure, this technology offers a sustainable approach to controlling dissolved oxygen in wine, particularly in pre-bottling. However, concerns often arise regarding the potential impact of membrane technologies on the wine aroma Volatile Organic Compounds (VOCs). Currently, limited data exist on the effects of deoxygenating white and red wine using MC technology on their aromatic profiles. In this study, deoxygenation experiments were conducted on a white wine (cv. Greco) and a red wine (cv. Aglianico), both initially oxygenated to approximately 6 mg/L of dissolved oxygen. Deoxygenation was performed using two methods: polypropylene hollow fiber MC and the conventional technique of nitrogen sparging. In both treatments, the target dissolved oxygen level was set at 0.7 mg/L. Analyses of free and bound SO_2, acetaldehyde, and VOCs were conducted shortly after the treatments. After six months of bottle ageing, free and total SO_2 and total acetaldehyde were measured, and sensory analyses were performed. The odor profiles of the wines were assessed using the Rate All That Apply (RATA) method. Both Aglianico and Greco wines treated with deoxygenation exhibited lower acetaldehyde content and higher levels of free and total SO_2 compared to the control wines. This demonstrates the effectiveness of the deoxygenation treatment in preventing chemical oxidation and extending the protective action of SO_2. Among the VOCs analyzed - 43 in the white wine and 48 in the red one - none showed significant changes in concentration following the MC treatment. However, after six months of bottle ageing, differences in the odor profiles of treated and untreated wines became apparent. In the white wine, pre-bottling deoxygenated resulted in higher intensity scores for descriptors such as “exotic fruits” and “thiolic”, particularly when MC was used. Conversely, the control wine exhibited stronger intensities for “sweet odors” (e.g. honey, vanilla) and “dried fruits”. For the red wine, deoxygenation enhanced “red fruits” odors, compared to untreated wine. With its advantages in automation, precision, in-line integration, and gas efficiency, MC technology proves to be a viable alternative to sparging for oxygen management in winemaking, effectively preserving wine aroma compounds.

ORAL

Chitosan from sustainable source: antimicrobial activity against undesirable yeasts for production of low-sulphite wine

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Keywords: non-*Saccharomyces* wine yeasts, insect-based chitosan, wine fermentation, sulphur dioxide

ABSTRACT

The addition of sulphur dioxide (SO_2) is the method traditionally used for wine stabilisation, due to its broad spectrum of action against unwanted microorganisms and its ability to prevent oxidative phenomena. However, in recent years, interest toward alternatives to SO_2 has grown significantly due to concerns over its negative health effects on sensitive consumers and its impact on wine organoleptic properties (Li et al., 2008). For these reasons, the research has focused on alternative methods to reduce or eliminate the use of SO_2, while maintaining wine microbiological stability (Tedesco et al., 2022). Among the different alternatives proposed, chitosan, a natural polysaccharide obtained from the deacetylation process of chitin, has emerged as a promising SO_2-alternative. The OIV (International Organization of Vine and Wine) has already authorised the use of chitosan extracted from the fungus *Aspergillus niger* for different oenological purposes. However, other sources of chitin, and consequently of chitosan, are available. The aim of this research activity was to investigate the potential use of an innovative and sustainable chitosan, which is insect-based chitosan, for the control of unwanted wine microorganisms. Insects can be reared on different substrates and can be used for bioconversion of wastes; this allows to obtain the chitin during the whole year with a sustainable process (van Huis, 2013; Scala et al., 2020). Furthermore, the low molecular weight and high deacetylation degree of insect-based chitosan (Triunfo et al., 2022) are characteristics potentially correlated with high antimicrobial activity (Poznanski et al. 2023). The first step of this study was addressed to evaluate the antimicrobial activity of chitosan extracted from three different sources, which were shrimps shells (commercial chitosan), *A. niger* (chitosan approved for oenological use) and the insect *Hermetia illucens*, against different non-*Saccharomyces* species, such as *Metschnikowia pulcherrima*, *Candida zemplinina*, *Hanseniaspora uvarum*, *H. guilliermondii*, *H. osmophila*, *Torulaspora delbrueckii*, *Zygosaccharomyces bailii*, *Lachancea thermotolerans*, *Pichia kluyveri*, *P. kudriavzevii*, *P. anomala.* The second step of the research was addressed to evaluate the effect of the three chitosan types against *Brettanomyces bruxellensis* in comparison to *Saccharomyces cerevisiae* by flow cytometry, in order to obtain information on cell viability and damage at the cellular membrane level. The aim of this step was to elucidate the mechanism of antimicrobial action of chitosan, which is not yet well understood.

The obtained results showed that the antimicrobial activity is correlated to chitosan source and the effect is species/strain dependant; however, insect-based chitosan resulted very active against *B. bruxellensis*, promoting itself as an effective alternative to oenological chitosan.

ORAL

A deep learning object detection approach for smart pest identification in vineyards

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Keywords: insect detection, deep learning, pest management, precision agriculture, yellow sticky traps

ABSTRACT

Flavescence dorée (FD) poses a significant threat to grapevine health, with the American grapevine leafhopper, *Scaphoideus titanus*, serving as the primary vector. The disease causes yield losses and high production costs every year due to mandatory insecticide treatments, infected plant uprooting, and replanting. Another potential FD vector is the mosaic leafhopper, *Orientus ishidae*, commonly found in agroecosystems. The current monitoring approach, which involves periodic human identification of yellow sticky traps, is labor-intensive and time-consuming. Therefore, there is a compelling need to develop an automatic pest detection system leveraging recent advances in computer vision and deep learning techniques. However, the development of such a system has been hindered by the lack of effective datasets for training.

To fill this gap, we created a comprehensive dataset of digitized traps and conducted a detailed labeling process with the assistance of entomologists. Then, we used state-of-the-art architectures, including YOLOv8 and Faster R-CNN, to train object detection models capable of accurately identifying these vectors on yellow sticky traps. Image pre-processing involved automatic cropping to remove irrelevant background information and feature enhancement to improve dataset quality. Our tests evaluated the impact of various factors, such as image resolution, data augmentation and class-specific detection performance.

Results showed the superiority of the YOLO detector in both accuracy and speed, achieving an mAP@0.5 of 92%, an F1-score of approximately 90%, and an mAP@[0.5:0.95] of 66%.

The best-performing model was deployed into the DigiAgriApp platform, an open-source client-server application for centralized farming data management. This application offers farmers a user-friendly tool for real-time vector identification via smartphones while enabling continuous updates to the dataset through citizen science contribution.

ORAL

Novel biorefinery step for grape marc valorisation: polysaccharides extraction by subcritical water

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Keywords: polysaccharides, grape marc, subcritical water, biorefinery, green technologies

ABSTRACT

The exploitation of food by-products has garnered significant attention over the past few decades, particularly within the framework of the European Green Deal. This strategic initiative emphasizes sustainability and resource efficiency, promoting the use of innovative technologies to transform food by-products into valuable resources. This aligns with the principles of a circular economy, aiming to reduce waste and improve the overall environmental footprint of industrial processes. The winemaking process generates a large amount of by-products, mainly represented by grape marc. It is estimated that 8-9 million tons of grape marc are generated worldwide each year. It is evident that these quantities pose enormous storage and management challenges. In this context, the biorefinery approach, aimed at valorising biomass through multiple sequential steps to obtain several products, has attracted significant interest. Generally, the biorefinery approach involves various technologies[1]. The development of a multi-purpose four step-cascading biorefinery scheme for the valorization of red grape pomace (GP. An innovative alternative could be the application of a biorefinery strategy based solely on the sequential extraction of different classes of high-value bioactive compounds by a unique, versatile and green technology. The extraction technology using pressurized fluids, particularly supercritical and subcritical fluids, may represent the best solution in this context[2].

The aim of the present work is to investigate another step towards the complete valorisation of grape marc by extracting polysaccharides using subcritical water (SCW). Subcritical water refers to liquid water at a temperature above its boiling point and below its critical point (Tc= 374°C, Pc= 221 bar). The increased temperature and pressure conditions enhance extraction mechanisms in solid matrices. SCW can be exploited not only as a solvent, but also as an outstanding and sustainable reaction medium, making it an environmentally friendly method for biomass conversion[3]. Several experimental trials at different temperatures (120, 160, and 200°C), adding different carboxylic acids (tartaric, malic and citric acid) at different percentages (0, 5 and 10%) were performed.

The extraction yield of polysaccharides, as well as their chemical characteristics, are significantly affected by SCW conditions. It is important to note that not only extraction phenomena but also chemical processes occur during the process, primarily hydrolysis, which lead to depolymerization of polysaccharides, formation of monosaccharides, and also their degradation products[4]. These degradation products can still add value as they are defined as biobased platform chemicals, which have a significant market demand for several purposes. The comparison with the conventional process highlighted an outstanding efficiency of SCW. At optimal conditions, SCW allowed an extraction yield (13.2±0.3%) that was 4 times higher than the conventional process (3.2±0.2%), with a 30-fold decrease in extraction time.

ORAL

Non-*saccharomyces* yeasts in the biocontrol of grape molds in vineyards to reduce the use of pesticides

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Keywords: antifungal, non-*saccharomyces* yeasts, botrytis cinerea, phytosanitary compounds

ABSTRACT

The wide diffusion of organic cultivation of vineyards and the need to reduce the use of pesticides highlights the urgent need for alternative and sustainable methods of vine protection by pathogen molds. Biocontrol of molds by wine yeast species has been suggested as a promising tool to avoid or limit the chemical fungicides. The present study aims to evaluate and characterize the antifungal activity of several non-*Saccharomyces* yeast species isolated from different environmental and food sources against *Botrytis cinerea* and other spoilage fungi of grapes such as *Aspergillus carbonarius, Penicillium expansum, Penicillium digitatum* and *Cladosporium*. A preliminary evaluation of metabolites and volatile compounds with antimicrobial action was carried out. Several yeast strains mainly belonging to *Brettanomyces bruxellensis* and *Metschnikowia pulcherrima* but also to other species showed a wide antifungal activity. A selected strain of *M. pulcherrima* was then evaluated in the field. Fifteen days before harvest, the strain was sprayed on both red and white grape batches. At vintage time (after 15 days) the batches were evaluated for biocontrol and grape colonization. Results showed significant colonization of the *M. pulcherrima* strain and valuable mold control. These findings highlight the potential of yeast-based biocontrol strategies as sustainable and effective tools for vineyard management.

ORAL

Innovative approach to energy efficiency benchmarking in the wine sector

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Keywords: energy performance indicators (EnPIs), sustainability, wine sector

ABSTRACT

The wine industry, a key sector for the European Union's economy, exhibits significant energy consumption, amounting to approximately 1,750 million kWh annually within this geographic context, with major contributions from Italy, France, Spain, and Portugal (Fuentes Pila et al., 2015). According to Vela et al. (2017), the primary source of energy is electricity (around 90%). Fossil fuels are also consumed for thermal processes (e.g., water heating before bottling), accounting approximately for the remaining 10% of the total energy consumption. In this context, reducing wineries primary energy consumption and related greenhouse gas (GHG) emissions through energy efficiency improvement and the increase of the share of energy needs covered by renewable sources is crucial to fit the objectives of the 2050 European Union strategy (EU Commission, 2019).

Following a thorough review of existing research on energy use in the sector (de Castro et al., 2024; Bietresato et al., 2023), our research introduces an innovative method to foster energy efficiency in the wine industry, focusing on the benchmarking of Energy Performance Indicators (EnPIs) (Ciotti et al., 2024). It facilitates the evaluation and monitoring of wineries' performances over time, allowing for comparisons with similar entities. The methodology categorizes wineries into eleven distinct reference models based on their process types, enhancing the understanding of energy use. Additionally, three "outsourcing" indices are introduced to identify significant energy consumption in key production stages. Designed for simplicity, the methodology requires only basic input and product output data, which are readily available to companies.

The proposed approach has been validated through a survey of 20 Italian wineries, ranging from small producers to large-scale operations; a specially developed data collection form was used to gather relevant data. Results revealed important limitations in methods that rely solely on EnPIs for energy performance benchmarking. Such methods may lead to inaccurate conclusions without a deeper understanding of energy use related to specific production processes. The categorization and outsourcing indices introduced in this study enable a more comprehensive analysis of energy consumption, offering insights beyond traditional EnPI-based evaluations. Interestingly, some companies initially perceived as efficient exhibited critical performance issues, highlighting the need for further analysis.

Correlation analyses confirmed the robustness and efficacy of the proposed methodology, demonstrating its potential to significantly support stakeholders in improving sustainability practices. This innovative approach not only facilitates internal energy performance improvements but also supports the establishment of certification standards in the wine sector, promoting the sharing of best practices.

ORAL

Chemical and sensory quality, environmental sustainability, and consumer acceptance of South Tyrolean wines produced from hybrid grape varieties

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Keywords: DRHGC wines, red wine, volatile compounds, polyphenols, sensory profile

ABSTRACT

Disease-resistant hybrid grape cultivars (DRHGCs) are hybrids of *Vitis vinifera* varieties with other *Vitis* species, and they are endowed with greater resistance to specific fungal diseases, enabling a potential reduction in the application of pesticides in the vineyard. However, DRHGC wines can present unusual chemical and sensory properties, which might influence the consumer perception and their placement on the market.

This study has examined the links between the chemical and sensory properties of DRHGC red wine productions from South Tyrol (Northern Italy) by applying a combination of sensory methodologies, analytical techniques, and statistical analysis. The polyphenol and volatile profiles of DRHGCs were distinctive; for instance, the profiles of macrocyclic oligomeric proanthocyanidins were confirmed to be suitable varietal markers [1]. *V. vinifera* red wines were in general more astringent, with higher 'strawberry' and 'jam' aromas, than the DRHGC wines; the DRHGC wines had stronger 'green bell pepper' flavour and aroma. The sensory panel rated the DRHGC wines as high quality, and the *V. vinifera* wines were not inevitably preferred. From a sustainability point of view, the vineyard interested by DRHGC grapes production displayed a significant lower consumption of energy, while also hinting at a possible beneficial effect in terms of lower carbon emissions and lower air pollution.

Finally, the result of a survey conducted in three European countries with established DRHCG wines productions and markets are reported, to investigate the knowledge, the motivation, and willingness to pay for these products by consumers, in the frame of the added value derived from these sustainable productions.

ORAL

Monitoring of alcoholic fermentation: development of an applicable in-line system

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Keywords: alcoholic fermentation, sugars, VIS/NIR sensor, modelling, precision oenology

ABSTRACT

Alcoholic fermentation plays a crucial role in the winemaking process. In addition to producing ethanol, it results in the formation of various secondary metabolites that significantly influence the wine's characteristics. Proper management of alcoholic fermentation ensures it occurs over a sufficient duration, promoting the release of varietal aromas and the development of fermentative aromas. Preventing stuck fermentation is essential, as it can degrade the wine and lead to the formation of unwanted aromas. Generally, in-line process monitoring, enabled by sensors, facilitates prompt interventions, helping to avoid the emergence of defects. Today, a wide range of sensors is used throughout the wine production process, from monitoring grape ripening to bottling (Thanasi et al., 2022). However, the adoption of sensors becomes viable when their cost is competitive, making them a sustainable tool for wineries. The aim of this research was to develop a low-cost prototype for monitoring the fermentation process using VIS/NIR optical sensors. The prototype is equipped with sensors that operate in the wavelength range of 340 to 1050 nm, which are readily available on the market. Some parts of the prototype were created using 3D printing. The prototype was tested for monitoring fermentation at both (i) the laboratory scale (microvinifications) and (ii) the industrial scale. For the industrial scale, three types of must were used (white, red, and rosé), sourced from three different batches of grapes, for a total of nine fermentation processes monitored. Samples were collected daily to measure sugar concentration through enzymatic analysis and for optical analysis. The enzymatic analysis results served as reference parameters for developing predictive models using chemometric analysis, specifically partial least squares (PLS) regression. The models developed on the laboratory scale (internally validated via cross-validation) demonstrated the device's ability to capture, both directly and indirectly, the chemical information related to the sugar concentration in the analyzed must samples. Preliminary results from monitoring fermentation on an industrial scale indicate a strong correlation between the sugar concentrations determined by optical and enzymatic analyses, similar to the laboratory scale findings. Thus, the prototype provides a foundation for developing an effective and cost-efficient instrument that, when combined with widely used temperature and carbon dioxide sensors, could optimize fermentation monitoring and processes.

POSTER

Waste valorization in winery and distillery industry by producing biofertilizers and organic amendments

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Keywords: valorization, composting, anaerobic digestion, winemaking by-products, biofertilizer, organic amendment, humic substances, organic viticulture

ABSTRACT

The winery and distilling spirits industry generate a remarkable amount of by-products and wasted, that are not properly managed, posing socioeconomic problems and environmental risks, due to its seasonal and polluting characteristics. Traditionally, valorization strategies have focused on composting. for direct use as a soil organic amendment. However, this process requires a long period and a large free surface (aerobic), generating an effluent (leachate) and could cause phytotoxicity and an antimicrobial effect. An alternative treatment strategy for these organic wasted is anaerobic digestion, which period less than 25 days and in a reduced work area, two digestates are obtained (liquid and solid), suitable for agricultural use. This work aims at evaluating the feasibility of using winemaking lees and distillation vinasses, together with composting leachate in the obtaining of biofertilizers and organic amendments by anaerobic digestion using a microbial consortium and estimating their economic valorization for a winery in Peru. The evolution of the digestion process (pH, Electrical Conductivity and Temperature) was monitored, and then to characterize the digestates with a physicochemical and microbiological analysis. The results of both products obtained show a significant concentration of organic matter, phytonutrients (nitrogen, phosphorus, potassium, etc.) and humic substances in a slightly acidic medium (pH value of between 3.8 and 5), due to the presence of some lactic acid bacteria and Bacillus species, which could confer properties as biostimulators and biocontrol agents. Their stability (pH, color and odor) was evaluated for an additional 30 days, showing excellent hygienic conditions, due to the absence of pathogenic microorganisms, could make it possible to incorporate them together with others agricultural inputs during the viticultural season. Therefore, the valorization of winemaking and wasted by-products by producing biofertilizers and organic amendments for agricultural use could largely replace the use of synthetic fertilization and recover soil fertility. The socioeconomic and environmental benefits would be multiple, within an agroecological transition and circular economy approach.

POSTER

Phenolic profile of fungus-resistant varieties (PIWIs) for red wine production

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Keywords: fungus-resistant varieties, PIWIs, red wine, phenolic profile

ABSTRACT

Context and Purpose of the Study. PIWI grape varieties (*Pilzwiderstandsfähig*, fungus-resistant) offer innovative solutions for sustainable viticulture by addressing environmental challenges faced by traditional *Vitis vinifera*. Resistant or tolerant to fungal diseases such as downy and powdery mildew, growing PIWIs enable the reduction of chemical treatments by ca. 60-80%, lowering costs and labor while promoting eco-friendly vineyard management and economic efficiency. Despite their potential, PIWIs are underexplored regarding their oenological traits, which differ in some characteristics from traditional varieties. This study aimed to evaluate the phenolic profiles of German-bred PIWIs for red wine production, focusing on their potential for sustainable winemaking.

Materials and Methods. Over three vintages (2022–2024), twelve PIWI red varieties (Accent, Baron, Cabertin, Cabernet Cortis, Cabernet Cantor, Levitage, Monarch, Pinotin, Prior, Regent, Rondo, Satin Noir) and four traditional varieties (Bl. Trollinger, Bl Limberger, Pinot noir, Cabernet-Sauvignon) were analysed at the LVWO Weinsberg (Germany). Grapes, harvested at technological ripeness, were analyzed for juice parameters using FTIR spectrophotometry. Micro-scale fermentations enabled the three field replicates to be separately fermented, and wine phenolic composition was determined using the Harbertson-Adams assay.

Results. Significant differences were observed in the phenolic profiles of PIWI wines. Tannin concentrations were up to three times higher in Cabernet Cortis and Rondo wines, with Monarch and Accent showing doubled levels compared to Pinot noir and Bl. Limberger. Conversely, Pinotin, Prior, and Levitage had significant lower tannin concentrations comparable to Bl. Trollinger. Anthocyanin levels in PIWIs wines exceeded those of traditional varieties, ranging from 500 mg/L to 3000 mg/L, with Rondo and Accent showing the highest values. Differences in polymeric pigment content among PIWIs indicated varying color stability abilities. Multivariate analysis of phenolic profiles grouped the varieties into four distinct clusters, reflecting their diversity and oenological potential.

Conclusion. Evaluating the phenolic profiles of PIWIs is essential to understanding their potential for red wine production and optimizing winemaking strategies according to tannin and color extraction potential. These findings provide a foundation for integrating PIWIs into sustainable winemaking practices, supporting both environmental and quality goals.

POSTER

Classification and prediction of tannin botanical origin through voltammetry and machine learning approach

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ABSTRACT

The classification of enological tannins has gained importance following the OIV's requirement to include their botanical origin on product labels (OIV-OENO 624-2022). A rapid classification method would be particularly valuable for producers and retailers, enabling them to quickly determine the origin of tannins. This study explores a novel approach using linear sweep voltammetry (LSV) coupled with machine learning algorithms to classify enological tannins. While traditional methods such as LC-MS, UV-Vis, and FTIR provide detailed chemical information, they are often time-consuming, costly, and require skilled personnel. In contrast, voltammetry offers a rapid, cost-effective alternative, albeit with challenges in interpreting the resulting voltammograms due to signal overlaps from various electrochemical processes. Interpreting these results may require advanced data processing, such as signal deconvolution (Ugliano, 2016) and machine learning algorithms to extract insights from voltammetric patterns (Choi et al., 2022). However, the efficiency of machine learning algorithms is closely linked to a large availability of data. To address these limitations, a Generative Adversarial Network (GAN) was employed to generate synthetic voltammograms, combined with experimental data to expand the training dataset. This augmented dataset was used to train machine learning models, including Random Forest, Extreme Gradient Boosting, and Support Vector Machine (SVM), with the latter achieving the best classification results. The SVM model demonstrated high accuracy (94%) and excellent discrimination between tannin classes, as indicated by an AUC-ROC of 0.9971.

The study also integrated feature importance and Recursive Feature Elimination (RFE) analyses to identify key voltammetric features contributing to the classification. Features around 0.3 V, 0.57–0.65 V, and 1.11–1.17 V were found to be critical for distinguishing between tannin types. While the proposed method highlights the potential of combining voltammetry and machine learning for rapid tannin classification, further studies on model solutions are required to generalize the approach to different wine matrices.

This workflow provides a promising tool for the wine industry, offering a rapid, cost-effective method to classify tannins and optimize their enological applications.

POSTER

Integrating RO concentrate in viticultural irrigation for sustainable urban water reclamation

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ABSTRACT

Grapevines (*Vitis vinifera L.)* require precise irrigation to maintain yield and quality, and the increasing use of reclaimed desalinated water for irrigation raises concerns about the accumulation of reverse osmosis concentrate (ROC), a high-salinity byproduct with no sustainable disposal solution. This study explores the potential of ROC concentrates as a fertigation alternative, evaluating its effects on soil chemistry and vine adaptation. Using a CE 530 RO desalinator, we assessed grapevine responses under four irrigation treatments: tap water, tertiary-treated wastewater with low salinity and organic content, and tertiary-treated wastewater concentrated two times (2X) and four times (4X). By repurposing desalination by-products for viticulture, this study examines controlled salinity exposure to determine vine adaptation thresholds and improve irrigation sustainability. Irrigation with desalination-derived effluents significantly impacted soil chemistry and plant growth. Moderate salinity (2X Effluents) imposed the greatest stress, with the highest leachate EC in Barbera (7.35 mS/cm at 105DAT) and increased soil EC in both cultivars, leading to reduced root length density (RLD), root volume, root surface area, and root biomass. These reductions indicate that moderate salinity disrupts root development and nutrient acquisition, impairing plant vigor. In contrast, vines under 4X Effluents exhibited partial adaptation, showing improved root biomass, root volume, and shoot elongation compared to 2X Effluents. This suggests that grapevines can activate physiological responses to tolerate extreme salinity better than moderate salinity stress. Muscat exhibited greater resilience than Barbera, maintaining higher root and shoot biomass, RLD, and shoot elongation across treatments. The superior performance of Muscat suggests an inherent genetic advantage in salinity tolerance mechanisms compared to Barbera. However, 4X Effluents caused significant soil EC accumulation, particularly in Muscat (3.10 mS/cm), which raises concerns about long-term soil degradation and potential salt toxicity effects in vineyard soils. Comprehensive elemental analysis of soil and leaf tissues is underway to determine ion accumulation patterns and their role in salinity tolerance, while metabolite profiling of roots and leaves investigates biochemical pathways underlying adaptive stress responses.

POSTER

Effects of ethanol removal techniques on Nero d'Avola wine

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Keywords: dealcoholisation, Nero d'Avola, phenolics, wine evolution

ABSTRACT

Over the past two decades, climate change has contributed to an increase in sugar content in grape must, and consequently, in the ethanol levels of wines. This trend contrasts with the growing consumer demand for wines with lower alcohol content or alcohol-free, a market segment that has continued to expand. Various technologies are currently available to partially or completely remove ethanol from wine, including distillation, vacuum evaporation, and membrane-based systems. However, the effects of these processes on wine composition vary depending on the technique used, the degree of ethanol removal, and the characteristics of the wine itself. Therefore, further research is necessary to deepen our understanding of how dealcoholisation influences different wine profiles.

This study aimed to assess the impact of removing ethanol on the chemical and sensory properties of Nero d'Avola wine. Nero d'Avola wines (vintage 2024, Sicily, Italy) were collected from four different wineries after malolactic transformation. These wines underwent dealcoholisation using a combined membrane technology based on nanofiltration and reverse osmosis, with ethanol reduction of -2% and -4% (v/v). Moreover, one of these wines was also dealcoholised by a contactor membrane system. The low-alcohol wines were bottled and stored at 15±1°C for up to six months, with additional sampling conducted one-month post-bottling. Untreated wines were bottled as controls under the same conditions. The wines were analysed for general chemical composition, phenolic content, colour intensity, procyanidins, and tannins.

The results showed that a -2% (v/v) ethanol reduction caused moderate decreases in titratable acidity (up to -14%) and tartaric acid (up to -10%). However, a -4% (v/v) reduction resulted in more significant losses (up to -31% and -34%, respectively for titratable acidity and tartaric acid). Acetaldehyde content dropped notably (up to -68%) at the -4% ethanol level in most samples. A -4% ethanol reduction led to a significant drop in flavonoids (up to -46%) and anthocyanins (about 50%) compared to control wines. Nevertheless, two wines showed only minimal decreases (flavonoids -11%, anthocyanins -13%), suggesting that the response to dealcoholisation may depend on wine-specific characteristics. Colour intensity decreased consistently with anthocyanin loss. The use of contactor membrane system led to only limited changes in wine composition. Sensory analysis revealed that wines with -2% ethanol were perceived as fruitier and more floral, with greater aromatic intensity than those with a -4% reduction.

This research provides new insights into the impact of membrane-based dealcoholisation on Nero d'Avola wine, a grape variety not previously studied in this context, to the best of our knowledge. Further investigations are ongoing to monitor the evolution of partially dealcoholised Nero d'Avola wines, a key variety in Sicilian viticulture.

FUNDING

InnoNDA project is funded by Regione Sicilia, PROGRAMMA DI SVILUPPO RURALE SICILIA 2014-2022, SOTTOMISURA 16.1 "Sostegno per la costituzione e la gestione dei gruppi operativi del PEI in materia di produttività e sostenibilità dell'agricoltura".

POSTER

Aging in amphorae with different porosity for sustainable production of Nero d'Avola wine

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Keywords: Nero d'Avola, aging, amphorae, porosity

ABSTRACT

In recent years, the use of amphorae in winemaking has become more frequent, symbolizing a return to the origins of vinification to broaden the availability of wines with different style. Made from clay or other ceramic materials, amphorae can offer an alternative to traditional wood containers or stainless-steel tanks, particularly for the wine aging. Thanks to their porosity, these clay vessels allow for natural micro-oxygenation without releasing secondary aromatic and non-aromatic compounds, as would occur with wood. This feature makes them particularly attractive for enhancing the varietal expression of wines while preserving a high degree of aromatic purity.

This study aims to evaluate and promote innovative and sustainable winemaking practices for Nero d'Avola production by exploring the effects of aging in amphorae with different porosity levels.

Nero d'Avola wines (vintage 2024, Sicily, Italy) from three different wineries were collected after the malolactic transformation. Each wine was aged in amphorae having three distinct porosity levels coded as medium (M), low (L), and very low (VL). Control wines (CT) were kept in stainless-steel tank. The wines were analysed for their general chemical composition, phenolic content, procyanidins, tannins and colour intensity. The sensory analysis was carried out.

The comparison between wines aged in amphorae and CT samples revealed differences. Most of the general chemical parameters resulted stable up to 3-months aging. A slight increase of titratable acidity was found for two wines aged in amphorae, while a slight decrease of glycerol was observed in wines aged in VL amphorae. Acetic acid tended to rise, especially in wines aged in M amphorae. Flavonoid and anthocyanin concentrations generally increased in two of the wines considered in this study. In particular, the anthocyanin content increased up to about 30% in wines aged in M amphorae. The sensory analysis highlighted the influence of amphora aging on the aromatic and flavour profiles, with clear distinctions among the wines. Control wines got the highest scores for red and jammy fruit aromas, but they received lower ratings for complexity. Wines aged in M amphorae were rated highest for persistence, typicity, and overall liking. L amphorae produced wines with well-balanced profile with strong floral and spicy notes. Wines aged in VL amphorae enhanced fruity notes, but exhibited slightly lower scores for floral and spicy attributes.

These findings reinforce the potential of amphorae as a valuable oenological tool for wine differentiation. Their impact on wine character can be significantly affected by the porosity of clay as well as the wine characteristics, offering a possible winemaking chance for wine production. The investigation is still running to clarify the evolution of Nero d'Avola wines during aging in amphorae.

FUNDING

InnoNDA project is funded by Regione Sicilia, PROGRAMMA DI SVILUPPO RURALE SICILIA 2014-2022, SOTTOMISURA 16.1 "Sostegno per la costituzione e la gestione dei gruppi operativi del PEI in materia di produttività e sostenibilità dell'agricoltura".

POSTER

Starmerella bacillaris grape treatment as a sustainable approach to manage *Botrytis cinerea* during the withering process

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Keywords: non-*Saccharomyces*, fermentation, biocontrol

ABSTRACT

Growing concerns over the environmental and health risks posed by chemical pesticides have highlighted the need to reduce their use in the agri-food sector. The fruit post-harvest management is a critical stage for implementing strategies to prevent pesticides from reaching the consumers table. A promising alternative seems the use of microorganisms as biocontrol agents.

This study explored the biocontrol activity of the yeast *Starmerella bacillaris*, applied on drying grapes, against the spoilage fungus *Botrytis cinerea*. Two different grape varieties were tested: Garganega and Raboso. During the withering process, the trend of the population of *S. bacillaris* released on grapes and the growth dynamics of *B. cinerea* have been monitored by real-time quantitative PCR (qPCR) to evaluate the impact of the treatment. Additionally, DNA metabarcoding was employed to compare the microbial biodiversity associated with grapes surface and to assess how it was influenced by the treatment. At the end of the withering process, grapes were pressed and the must was fermented to evaluate the effect of *S. bacillaris* on alcoholic fermentation.

The development of a successful qPCR-based method for the identification and quantification of the selected *S. bacillaris* strain provided evidence of its persistence on the grape surface until the end of the withering process. DNA metabarcoding showed that the application of *S. bacillaris* on the surface of the Raboso grapes caused an increase in the biodiversity of fungal communities and a decrease in the proportions of filamentous fungi, such as *B. cinerea*. This result was confirmed also by qPCR results which confirmed that the application of *S. bacillaris* effectively inhibited the growth of *B. cinerea* on Raboso grape bunches.

POSTER

Effect of ozone application for low-input postharvest dehydration of wine grapes

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Keywords: grape, postharvest dehydration, ozone, metabolomics, transcriptomics

ABSTRACT

The postharvest dehydration of grapes is a traditional practice to obtain wines with unique traits (e.g., sweet, dry/reinforced). The modern dehydrating rooms are equipped with systems for artificially controlling the inside environment parameters to obtain the desired dehydration kinetic and preserve the grapes from grey mold infection. However, the conditioning systems are extremely energy-demanding and the identification of practical solutions effectively controlling/reducing the postharvest decay would lower the operational costs. To this end, we explored the potential of ozone-based treatments on harvested grapes and preliminarily tested if the treatment could impact the normal behavior and metabolism/composition of grapes during the traditional dehydration practice. Harvested cv. Corvina and Sangiovese grapes were treated with ozone (ozonated water or gas at different concentrations) and partially dehydrated in a dedicated room under controlled temperature and humidity conditions. Technological, metabolomic, and transcriptomic analyses were performed on berry samples collected at different times during the post-treatment dehydration.

Weak differences regarding the dehydration kinetics and the main technological parameter dynamics were detected between treated and untreated grapes. Analyses of phenolic compound content of the cv. Sangiovese berries revealed that the treatment with the gas resulted in higher levels of phenolic acids, flavanols, flavonols and flavanones after 7 days of dehydration. Phenolic acids and stilbenes were higher in ozonated berries at the final stages (40 and 54 days) of the process. The ozone treatment induced only limited changes in the phenol compound profiles of the cv. Corvina berries. In both cultivars, the treatment modified the amino-acid pool of the berries. The transcriptomic analysis revealed that stress-response genes, including those coding for peroxidases, phytosulfokines, and pathogenesis-related proteins, were slightly upregulated shortly after exposure to the higher ozone concentration. Subsequently, modulation of transcripts related to secondary metabolism was weakly detectable.

Overall, the results will shed light on grape physiological response to ozone during the postharvest dehydration process. Sanitizing grapes using ozone will significantly increase their capacity to withstand higher temperature and humidity conditions, reducing spoilage and production losses.

POSTER

Bio-based fertilisers from fruit and vegetable residues for improving soil fertility and vine status in degraded vineyards

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Keywords: organic wastes recycling, soil organic matter, soil quality, circular economy

ABSTRACT

The H2020 RUSTICA project aims to propose, demonstrate, and implement technical solutions to convert organic residues from fruit and vegetables into high-quality novel bio-based fertilisers (BBF). These fertilisers address the needs of modern agriculture and close the nutrient cycles on a regional level, fostering a circular economy and promoting sustainability.

Bio-based fertilisers applied individually to the soil are effective in meeting specific functions, however their potential can be fully exploited utilizing them in blends, which leads to fertilisers with multiple functionalities, mitigates negative side effects of blend components, and enables the creation of fertilising products tailored to specific crops and pedoclimatic regions. Furthermore, blending associated with integration of fertiliser manufacturing processes reduces cost and environmental negative impacts of fertilisers production.

In viticulture, BBF blends represent an effective tool for improving vineyards on degraded soils, as they can enhance the quality of the soil and the homogeneity in the vegetative status of vines, while providing environmental services such as climate change mitigation.

This study evaluates three blends prepared with different proportions of BBF, such as microbial protein, insect biomass, insect frass, compost and biochar. Blends' impact on soil quality and vine status was compared against a control (no fertilization) and two reference treatments (manure and organo-mineral fertiliser) in a degraded vineyard located in the eastern hilly area of Friuli Venezia Giulia region (Italy).

Results of the trial showed that the application of RUSTICA blends had a positive effect on soil and crop traits such as:

- significant enhancement of soil properties (organic C content, N availability, soil microbial pool size and activity)
- improvement of cluster compactness and berry size
- plant productivity comparable to that of organo-mineral fertiliser
- clear effect on the must chemical properties (total N, acidity, pH and soluble solids), with values of maturation indexes within or close to the optimal ranges

Results show that BBF blends represent an effective and viable alternative to usual fertilisers in terms of vine productivity, while improving soil ecosystem functions and grapevine quality in degraded soils. Since they are produced from the upcycling of fruit and vegetable residues, their use in the vineyards can significatively contribute to the sustainability of the wine production.

POSTER

Feasibility of pre-fermentative oenological tannins addition to enhance volatile composition and aroma perception in white wines

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Keywords: white wines, oenological tannins, volatile organic compounds (VOCs), sensory analysis

ABSTRACT

Oenological tannins (OETs) are an alternative to sulphur dioxide due to their antioxidant and antioxidase properties in the early phase of winemaking [1,2]. The addition of OETs can affect both the concentration and perception of volatile organic compounds (VOCs) contributing to wine aroma. This study aimed to evaluate the impact of pre-fermentative addition of OET formulations from different origin on sensory descriptors and VOCs of wines from the *Vitis vinifera* L. white grape varieties 'Favorita' and 'Erbaluce'.

Six OET formulations were selected and characterised: exotic woods Acacia (AC) and Quebracho (QB), grape seeds (SD), grape skins (SK), wood hydrolysable tannins based on gallic acid (GL) and ellagic acid (EL). OETs were added to grape must before alcoholic fermentation at equal polyphenol concentrations (calculated on absorbance at 280 nm, TPI) and compared to a control without addition (CT). Basic compositional parameters, total polyphenols and antioxidant capacity (spectrophotometric indexes), CIELab coordinates were investigated pre- and post-fermentation [3,4]. VOCs were quantified using HS-SPME GC-MS on final wines [5]. Sensory analysis was performed by a trained panel for mouthfeel and aroma attributes by descriptive analysis (DA) and check-all-that-apply (CATA), respectively [4].

The fermentation kinetics were not affected by using OETs. TPI increased uniformly across treatments after OETs addition, but antioxidant capacity and colour varied depending on the OET formulation (AC, SD, and SK musts showing higher values). In Favorita treated wines, colour was not different from CT ($\Delta E<3$) and the final TPI was slightly influenced by OETs. Instead, Erbaluce AC, EL, and SD wines showed $\Delta E>3$ (compared to CT) and higher TPI value. Sensorially, *bitterness* was not affected, but *astringency* intensity increased in EL-treated wines in both varieties, and in SD-treated wines for Erbaluce, but not differently from CT. *Aroma intensity* significantly differed ($p<0.05$) in Favorita, with QB and EL wines showing the highest value, and AC the higher *overall quality* ($p<0.05$). For Erbaluce, SK and QB wines resulted in higher *overall quality* ($p<0.01$). In Favorita, differences among samples were found in *pineapple* ($p<0.05$) and *banana* ($p<0.1$) descriptors. AC-Favorita and SK-Erbaluce shared high frequency of *pineapple,* and QB-Favorita of *green apple* and *banana* descriptors, which rely on individual ethyl esters over perception thresholds. Indeed, for both varieties total VOCs did not significantly change by OETs addition, but specific classes did. In Favorita, the SD tasted wine showed higher concentrations of terpenes and volatile acids compared to CT, while OET-added Erbaluce wine presented lower benzenoid content.

The addition of OETs can influence the aroma profile of white wines in different extent depending on the formulations and the varietal composition without compromising negatively the mouthfeel properties.

POSTER

Impact of *Metschnikowia pulcherrima* and *Saccharomyces cerevisiae* in mixed fermentation on volatile compounds and energy sustainability in Lugana wine

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Keywords: *Metschnikowia pulcherrima*, *Saccharomyces cerevisiae*, multistarter fermentation, fermentation temperature, white wine, volatile compounds, energy efficiency, sustainability

ABSTRACT

In recent years, heightened awareness of the environmental impact has led to sustainability as a key issue for the winemaking sector. During white wine production, the primary process affecting wineries' energy consumption is temperature control during fermentation (de Castro *et al*, 2024). Since the fermentation temperature substantially influences yeast metabolism and aroma retention in the final product, we evaluated the effects of high (20°C) and low (16°C) temperatures and multistarter fermentations on the volatile profile of Lugana wine. Indeed, Giovenzana *et al* (2016) demonstrated that using selected yeasts at higher temperatures fermentation could reduce the energy requirements by 65 %. Furthermore, Castrillo *et al* (2019) indicated the oenological potential of non-*Saccharomyces* yeasts to mitigate the effects of climate change in winemaking. These findings can help develop new strategies for sustainability. In this context, we conducted micro-fermentation trials using two commercial strains of *Metschnikowia pulcherrima* (Level[2] Flavia and Level[2] Initia) and *Saccharomyces cerevisiae* EC 1118 in a natural thiol-rich white must from Trebbiano variety. The *M. pulcherrima* strains were mainly selected for their remarkable β-glucosidase and β-lyase activities, which can significantly enhance the aromatic complexity of wines, increasing the terpene and thiols contents (Binati *et al*, 2020). Each *M. pulcherrima* strain was inoculated at the beginning of fermentation and *S. cerevisiae* 48 h later. A single inoculum of *S. cerevisiae* was used as a control. The sequential fermentations and the control conducted at 20°C finished faster (within 11 days) than at 16°C, which concluded the process in 16 days. The wines obtained at the two temperatures differed in their concentration of volatile compounds, showing marked differences in esters, thiols, and alcohols content. Differences were also detected by sensory analysis. Wines fermented at 20°C showed more intense tropical and fruity aromas due to a significantly higher thiol content, while higher levels of ethyl esters and fatty acids characterized those at 16°C. The temperature had a more pronounced impact on the volatile compounds of wine than the specific *M. pulcherrima* strain used. However, sequential fermentations at 20°C led to significantly higher thiol concentrations than the control singly inoculated with *S. cerevisiae*. In conclusion, using *M. pulcherrima* with *S. cerevisiae* at higher, non-traditional temperatures modulates the aromatic compounds, giving remarkable differentiation of wines while improving energy efficiency and supporting more sustainable winemaking practices.

FUNDING

This study was financially supported by the Italian Ministry of Agriculture, Food Sovereignty and Forestry (MASAF), project WINERED, Innovative interdisciplinary approaches for reducing the environmental impact of vinification.

POSTER

Bioprospecting of native *Metschnikowia pulcherrima* strains for biocontrol and aroma enhancement in the wine production chain

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Keywords: *Metschnikowia pulcherrima*, enzymatic activity, pulcherrimin production, gray mold biocontrol, sustainability

ABSTRACT

Metschnikowia pulcherrima is a well-studied non-conventional oenological yeast due to its positive contributions to winemaking as a bioprotective agent and as an aroma-enhancing starter in sequential fermentations with *Saccharomyces cerevisiae* (Binati *et al*., 2023; Canonico *et al*., 2023). The primary antagonistic property of this yeast is attributed to the production of pulcherrimin; it is effective against a wide range of spoilage yeasts and filamentous fungi, including *Botrytis cinerea* (Morata *et al*., 2019). In addition to its antimicrobial capabilities, *M. pulcherrima* also exhibits notable extracellular enzymatic activity, such as β-glucosidase and β-lyase activities, which enhance the aromatic compounds concentrations, improving the sensory profile of the wine (Canonico *et al*., 2023). Within this framework, the present study aimed to select novel *M. pulcherrima* strains exhibiting specific traits that could enhance wine aroma and serve as an effective and sustainable tool for managing fungal diseases in vineyards. Indeed, the vast phenotypic variability observed within these species of these technological characteristics required a bioprospecting strategy to find the most promising candidates. Here, we analyzed a collection of 136 native *M. pulcherrima* strains from different origins to evaluate their β-glucosidase and β-lyase activities, pulcherrimin production, and H_2S generation through targeted enzymatic assays. Three commercial strains were used for comparison. The results confirmed considerable strain-to-strain variability, particularly in β-glucosidase and β-lyase patterns, suggesting diverse biotechnological potential. The five high-performing native strains with superior aromatic release capabilities were then tested *in vitro* and *in vivo* to assess their effectiveness in controlling *B. cinerea* and their potential application on grapes. The intense biocontrol activity of the yeasts against the phytopathogen observed in the trials supports their use as protective agents during grape maturation to reduce fungal contamination risks. In conclusion, native *M. pulcherrima* strains emerge as promising multifunctional organisms, offering vineyard and winemaking management advantages. Their antimicrobial, enzymatic, and aromatic potential aligns with the growing demand for sustainable and environmentally friendly practices, making them a valuable natural alternative to chemical treatments in agricultural and oenological contexts.

FUNDING

This study was financially supported by the Italian Ministry of Agriculture, Food Sovereignty and Forestry (MASAF), project WINERED, Innovative interdisciplinary approaches for reducing the environmental impact of vinification.

POSTER

Metschnikowia pulcherrima as biocontrol agent in white winemaking

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Keywords: *Metschnikowia pulcherrima*, biocontrol, non-*Saccharomyces* yeasts, antimicrobial activity, white winemaking

ABSTRACT

Biocontrol using non-*Saccharomyces* yeasts is an alternative strategy to chemical additives to prevent the growth of spoilage microorganisms. *Metschnikowia pulcherrima* exhibits strain-dependent antagonistic activity against undesired yeast populations in wine fermentations, effectively inhibiting their growth and preserving must quality. This study evaluates the antimicrobial capacity of three *Metschnikowia pulcherrima* indigenous strains (previously selected by *in vitro* antimicrobial assays) inoculated in single and co-culture in a Chardonnay must fermentation. The experimental trials involved inoculating the three strains and co-culture at 1×10^6 cells/mL in must at 18°C, after a contamination with a mixed population of undesirable non-*Saccharomyces* yeasts (*Brettanomyces bruxellensis, Kloeckera apiculata,* and *Starmerella bacillaris*) at two initial concentrations (10^4 or 10^6 cells/mL) to mimic healthy and damaged grape conditions. After 48 hours, a commercial strain of *Saccharomyces cerevisiae* (EC1118 Lalvin) was inoculated to complete fermentation. The experiment was conducted in duplicate, daily monitoring CO_2 production (by weight loss), viable cell kinetics (plate counts on WL agar), and fermentation metabolites. The results showed that single and co-culture *M. pulcherrima* strains grew at concentrations ranging from to 6×10^6 to 9×10^6 cells/mL, inhibiting non-*Saccharomyces* yeasts. In particular, the highest antimicrobial activity was expressed by strain 27 and the co-culture that effectively inhibited the development of undesirable yeast species, allowing the *S. cerevisiae* strain to complete the fermentation in significantly shorter times than the trials inoculated by the other two *M. pulcherrima* strains. In conclusion, *M. pulcherrima* significantly contributed to preserving wine quality, reducing the growth of undesirable non-*Saccharomyces* yeasts in white winemaking.


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TOPIC 3

SUSTAINABLE BUSINESS MANAGEMENT

ORAL

The impact of postharvest cooling of Sauvignon blanc grapes on the sensory profile and the chemical composition of the wines

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ABSTRACT

Rapid processing of grapes after harvest has always been considered essential for achieving a balanced sensory wine profile. However, the immediate postharvest period represents a particularly labor intensive phase for wineries, often requiring weekend work and overtime hours. Sauvignon Blanc is among the 20 most widely cultivated grape varieties globally and is grown on approximately 500 hectares in South Tyrol, Italy. During the harvest season, the region's fragmented wine industry faces challenges due to limited human resources.

To mitigate the workload during the postharvest period, our study investigated various shortterm storage conditions and their impact on the sensory and chemical profile of Sauvignon Blanc wines. The focus was placed on sensory aspects, but quality parameters and volatile aroma compounds were also analyzed. Additionally, the effect of cold maceration following the grape storage process was examined.

Cooling grapes in harvest bins at 8 °C for 48 hours had only a minor impact on the sensory profile of the wine, whereas storage at 20 °C resulted in significant negative changes. An additional cold maceration of the must at 8 °C for 16 hours had a more pronounced sensory effect than cooling the entire grapes. Our results show that cooling grapes postharvest is a feasible solution to reduce the workload during the harvest period without significantly compromising wine quality, provided temperature conditions are controlled. A subsequent cold maceration period should be evaluated on a case-by-case basis for its relevance.

ORAL

Predicting consumers' organic wine consumption behaviour

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Keywords: benefit appeal, construal mindset, message framing, organic wine promotion and consumption

ABSTRACT

Organic wine production and consumption is one of the sustainable practices contributing to a number of sustainable development goals (SDGs). Effective message framing and promotional strategies can substantially enhance sustainable wine consumption behaviour. The present study attempted to demonstrate how marketers might effectively match different advertising appeals and construal mindset to boost organic wine consumption. Expanding upon benefit association and construal level theory (CLT) research streams, this study investigated the interaction of benefit type and construal level in determining consumers' organic wine purchase behaviour in North America. The study tested the overarching hypothesis that the self-benefit appeal is more effective in eliciting positive consumer response when a low-level or concrete construal message is paired. Conversely, the other-benefit appeal leads to more favourable consumer response when abstract or high-level construal message is matched. Two hundred and one participants were recruited through online platform Prolific. A 2 × 2 between-subjects design was employed and respondents viewed one of the four randomly assigned labels of organic wine to indicate their purchase intention, willingness to pay, attitude toward the label and attitude toward the brand. As hypothesized, the statistical findings of this research demonstrated a greater amount of interplay between benefit appeal and construal level in eliciting consumers' favourable responses toward organically grown wine. The outcome of the study suggested that wineries, producers, and marketers should efficiently communicate and design promotional messages of the organic wine, and winemaking process to encourage the consumption of organically grown wine. The findings revealed that wine marketers who wish to promote self-benefits of the organic wine may write the promotional messages at a concrete level with more specific and detailed information. On the other hand, practitioners who attempt to highlight the other-benefit features of organic wine may focus on designing the advertisements at a more abstract level, instead of using the concrete and detailed information. Theoretically, this research contributes to the existing literature of CLT by reconciling the congruency effect of benefit types and construal mindset within the context of organic wine consumption. The study also provides actionable suggestions for wine marketers and producers to develop promotional strategies to effectively communicate with consumers and to contribute to the healthy vineyard ecosystem. Most importantly, the study's findings put forward several compelling insights and recommendations that will assist decision-makers, organizations, and legislative bodies seeking to achieve certain SDGs within the boundary of food safety, sustainable food production, and consumption processes.

ORAL

Laying footprints on a new path: proper accounting of biogenic fluxes makes viticulture carbon neutral

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ABSTRACT

To limit the acceleration of global warming we need to reduce greenhouse gases emissions (GHG), making our production processes more carbon-efficient and optimizing absorptions. Viticulture, and agriculture in general, is a sector with great and real possibilities of improving its environmental impact, with significant and cost effective GHG mitigation potential.

Recently, vineyards, and in general orchards, have been shown to be a significant carbon sinks in the short and medium term, especially due to the peculiar management of the soil in a life cycle of decades. But are these sinks comparable to the GHG emissions by field management? This was the first multi-annual study combining carbon footprint (emissions of CO2) and vineyard Net Ecosystem Exchange (CO2 absorptions, assessed by eddy covariance) of wine making field phase.

The results indicate high variability in the comprehensive annual carbon balance and its components (anthropogenic emissions, vineyard absorption and harvest), with usually, but not always, negative net balance (i.e. absorptions greater than emissions). This study suggests that optimizing processes in agriculture, at least tree crops, with strategies focused on C management that minimize emissions and optimize absorption, is a possible, effective and high value option. The calculation of the complete C footprint in the agricultural sector can be very useful in the perspective of carbon farming initiatives and for directing the management of perennial cropstowards neutrality, with a better addressing of environmental issues.

ORAL

What strategies do wine firms adopt to integrate CSR into their activities? An analysis among Italian wineries

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Keywords: corporate social responsibility, wine firms, sustainable practices, environmental sustainability, social sustainability, economic sustainability

ABSTRACT

Corporate Social Responsibility (CSR), as defined by the European Commission, is a strategic framework through which companies integrate social, environmental, and economic sustainability into their operations (European Commission, 2001). In recent years, the agricultural sector has increasingly adopted sustainable practices, driven by challenges such as climate change, the depletion of ecosystems, welfare and inclusion issues, etc... Within the agri-food industry, the wine sector holds significant importance (Pinto da Silva and Esteves da Silva, 2022; OIV, 2022) also in relation to the adoption of sustainability practices (De Steur et al. 2020; Forbes et al., 2009; Pomarici et al., 2016).

This study investigates the sustainable practices adopted by Italian wine firms within the CSR framework, focusing on firms' perceptions of sustainability, motivations driving the adoption of these practices, and barriers hindering their implementation. An ad hoc questionnaire was developed, incorporating open and closed questions about firm details, perceptions of sustainability, and drivers and barriers, with most responses quantified on a 1–5 scale.

Data were collected through a self-reported survey involving a convenience sample of 131 Italian wine firms. The analysis examined the adoption of sustainability practices across the three pillars of sustainability: environmental, economic, and social dimensions.

The results indicate that the most adopted practice by firms in our sample is related to the product sphere, namely obtaining DOC/DOCG quality certifications (84% of companies do this predominantly). Secondly, firms indicate various practices in the sphere of social sustainability: courses on worker safety, attention to legality (i.e., regular billing, contract regularity, activities in areas confiscated from the mafia), adopted by over 80% of companies. Also relevant in the social sphere is attention to working conditions (i.e, workplace safety, flexibility in scheduling) (72%), attention to contractual stability (62%), integration of young workers (62%), initiatives to reduce workplace discrimination (58%).

The practices in the environmental sphere are mostly related to cultivation and production practices that reduce the use of chemicals (74%), waste reduction/promotion of recycling (60%), monitoring of water and electricity consumption, etc. (55%), and improvement of energy efficiency (53%), adherence to internationally recognized certification programs (52%).

The study suggests some general patterns on how Italian wine firms seem to adopt sustainable practices within the CSR framework. The most adopted practices highlight a focus on product quality and market positioning, as highlighted by the widespread adoption of DOC/DOCG quality certifications. However, the analysis seems to reveal a diffuse declared commitment to environmental stewardship accompanied by a predominant emphasis on social aspects in relation to the actual practices implemented.

ORAL

Function, barriers, and the environmental benefits of reuse bottle system for wine

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Keywords: reuse bottles, carbon footprint

ABSTRACT

With 0.3 to 0.7 kg CO2eq per 0.75 L wine, the glass bottle is the main contributor to the carbon footprint of a bottle of wine. Reuse of wine bottles is discussed as a promising strategy to significantly reduce the carbon footprint of wine. The objective of this study was to investigate the function, barriers, and the potential environmental benefits of reuse wine bottle system. The study focused the German market, which is generally quite advanced in reusing bottles, especially in the water and beer segments. In the first step of the study, 695 private wineries, 68 cooperative wineries, and 19 wine cellars were surveyed and categorized into clusters with multiple correspondence analysis (MCA). Additionally, breweries and mineral water producers, who participate in reuse bottle pools, were interviewed. Most wine producers (62 %) indicated a favorable attitude toward the reuse of bottles. The type of business (winery, cooperative, wine cellar) has a negligible impact. Structural circumstances of the businesses, as well as the perceived advantages and disadvantages of a reuse bottle system provide a more accurate description of the readiness towards reuse bottles. The second part of the study addresses technical trials determining the glass integrity and stability after multiple use of 0.75 L wine bottles. The bottle diameter, protruding areas, and the glass coating as well as bottle handling during filling, logistics, and cleaning were found to have an influence on the integrity and stability of the bottles. Some label adhesives with dispersion glue, labels with high print density and foil-coated areas on the label were also identified as obstacles in the alkaline-based cleaning processes of bottles. In the last part of the study a life cycle assessment (LCA) was conducted to calculate potential CO2 savings of a wine bottle reuse system in comparison to using new bottles. When considering re-logistics within a 500 km radius, sorting and cleaning processes of used bottles, the CO2 savings of a reuse system can account for 50-80 % already after five use cycles.

ORAL

Sustainability in the winery sector: A European study

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Keywords: sustainability, barriers, certification, wine, ESG

ABSTRACT

This paper investigates sustainability in European wineries. The growing body of literature on the subject of sustainability underlines the increasing attention on the environmental and social impacts of intensive and irresponsible wine production. The consumer demand for biological and sustainable wine, as well as the increasing number of sustainable programs and certifications, have driven the need for greater transparency for managing sustainable wine production. This study has utilised a qualitative field method which involved more than 40 in-depth interviews over a 5-year data collection period with wine businesses across Europe. In addition, internal documents and protocols on sustainability certification have been embedded in the hermeneutic unit. This article presents the main sustainability practices in European wineries, considering environmental, social, and governance dimensions. Results show a very large range of practices that have been developed in different business areas, such as a vineyard, canteen, and supply chain. Topics, including biodiversity, local partnership, water consumption, working conditions of seasonal workers, supplier selection, and fertiliser use, are just a few of the themes that have been identified.

ORAL

Microbial consortia as a tool for sustainable vineyard management: a study on their acceptance among Veneto region's grape-growers

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Keywords: sustainable viticulture, technology acceptance model, theory of planned behavior, microbial consortia

ABSTRACT

Sustainability is a key focus in viticulture, where managing abiotic and biotic stress presents a major challenge. To address these issues and enhance plant resilience, adopting sustainable crop protection techniques, such as microbial consortia, is essential (Alikadic et al.,2019). Microbial consortia, symbiotic communities of microorganisms, offer an agroecological crop protection strategy that enhances crop health and resilience, ensuring stable yields, reducing plant protection costs, and minimizing environmental impacts in viticulture (Sandrini et al., 2022). Legislative frameworks like the EU Green Deal, Common Agricultural Policy, EU Directive 128/2009/EC and Italian Legislative Decree n°150/2012 support this innovation to reduce pesticide use and provide economic savings for farmers. The adoption of this technology depends on farmers' acceptance. Socioeconomic barriers are key obstacles (Cullen et al., 2013). However, the role of socio-psychological factors is underexplored, requiring further research on why and how farmers adopt sustainable practices (Zeweld et al., 2017). This study aims to identify cognitive, social, and psychological factors influencing farmers' adoption of microbial consortia in the Veneto region, correlating these with their economic resources. A model, like the one in Mohr and Kuhl (2021), combining the Theory of Planned Behavior (Ajzen, 1991), the Technology Acceptance Model (Davis, 1989), and five additional factors, has been developed (Fig.1).

Specifically, a questionnaire, refined through a pilot test with 30 producers, will be distributed to 300 winegrowers in the Prosecco DOC area to assess the future adoption of the technology. Based on the literature review and pilot test results, we expect low adoption intentions for this innovation due to obstacles like economic resources, dispositional factors, social norms, and cognitive factors. Attitude (ATT) is the primary driver of adoption, with a strong positive effect on farmers' decisions. Social norms have a minimal impact, mainly influencing attitudes rather than intentions, while perceived behavioral control (BC) plays a significant role. However, perceived cost may negatively affect BC and ATT, ultimately limiting adoption. Perceived usefulness is the strongest predictor of adoption, while perceived ease of use has less impact. Perceived risk, particularly concerning diseases like Esca, may encourage adoption by promoting preventive measures. In conclusion, perceived usefulness and attitude are key drivers of adoption, with social pressures playing a minor role. High cost perceptions could limit adoption, but clearer communication on the benefits of microbial consortia can enhance farmers' understanding and increase adoption rates.

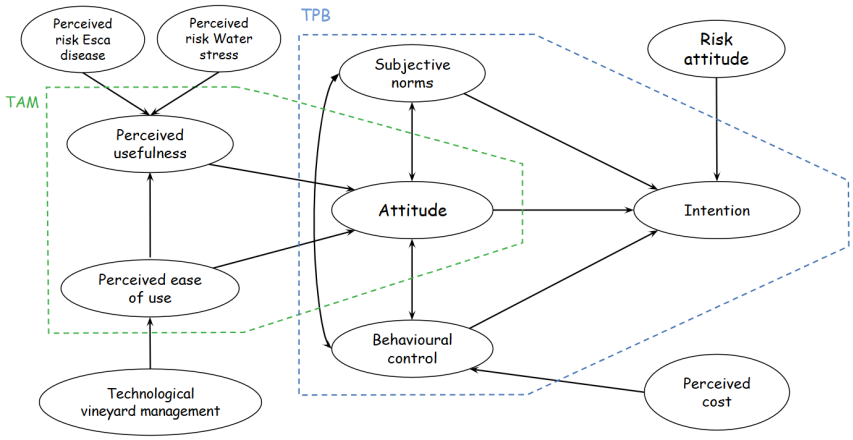

Figure 1. Theoretical model to analyze farmers' intention to adopt microbial consortia.

ORAL

Valorization of grape marc in a biorefinery loop for producing short- and medium-chain fatty acids, hydrogen, and methane, with polyphenol recovery

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ABSTRACT

Global grape production amounts to approximately 70 million tons per year, with Europe contributing 61% of the world's wine output, primarily from Italy, France, and Spain. This research focused on utilizing red grape marc (RGM), a byproduct of winemaking, in a laboratory-scale biorefinery to generate fatty acids, hydrogen, and methane. The study analyzed the influence of hydraulic retention time (HRT) and organic loading rate (OLR) on production efficiency. Short HRTs (2–6 days) inhibited yields, resulting in minimal fatty acid and biogas production. The highest yields of short-chain fatty acids, caproic acid, and hydrogen were achieved at 10 days HRT and 5 gCOD/L·d OLR, with respective outputs of 30%, 5% w/w, and 25 LH_2/kgVS. The presence of trace amounts of heptanoic and octanoic acids suggested the initial stages of chain elongation. A downstream purification process involving centrifugation and ultrafiltration produced a fatty acid stream with over 90% purity, suitable for future applications in Single Cell Oils. Methane generation was most effective at 20 days HRT and 2.5 gCOD/L·d OLR, yielding 160–170 LCH_4/kgVS. Additionally, the study examined the role of polyphenols, revealing that their removal led to a 30% decline in methane production, likely due to the simultaneous extraction of fermentable sugars crucial for methane formation.

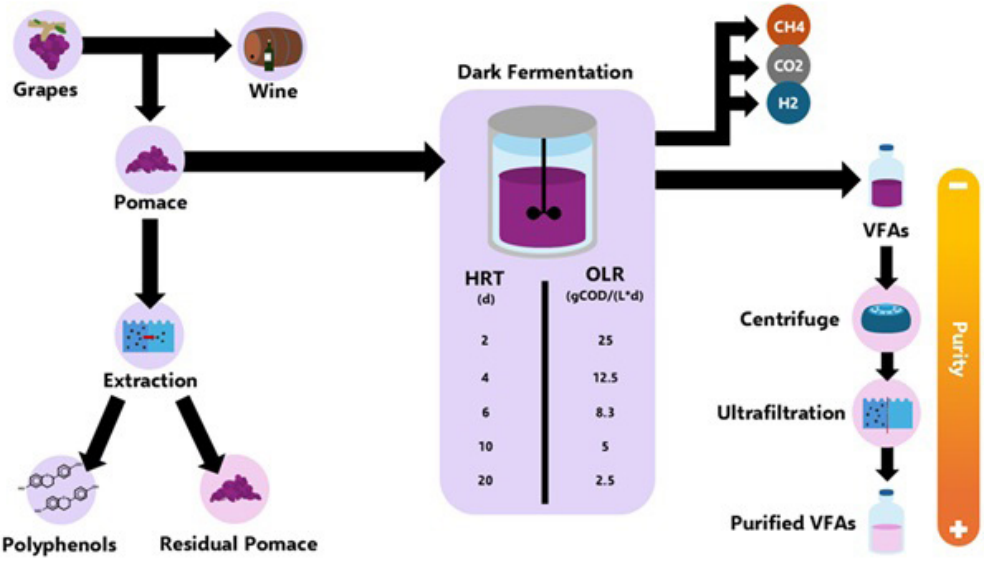

Figure 1.

ORAL

Valorization of winemaking by-products through circular economy approaches

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Keywords: grapes, wine, circular economy

ABSTRACT

Winemaking generates significant amounts of by-products, such as grape pomace and wine lees, which are primarily used for distillation and composting. However, these by-products are rich in valuable compounds like oils, proteins, polysaccharides, and polyphenols that remain largely underutilized. This study aims to minimize the environmental footprint of the wine industry by adopting a circular economy approach, focusing on the extraction and reuse of active compounds in various winemaking stages, ranging from biocontrol in vineyards to oxidative stabilization of wine.

An environmentally friendly and selective extraction method, supercritical fluid extraction (SC-CO_2), was employed to recover high-value molecules. Using SC-CO2 alone, oil extraction from grape pomace and seeds yielded 7% and 12% w/w, respectively, with 69% unsaturated fatty acids. These fatty acids were preserved due to the extraction temperature (40°C). Additionally, polyphenols were coextracted, serving as antioxidants that contribute to the stabilisation of the extracted oil. SC-CO_2 with water as a co-solvent also enabled the isolation of water-soluble compounds, including low-methoxy pectin (400 kDa), 9% proteins, and polyphenols. The total yield of water-soluble polyphenols reached approximately 200 mg/100 g gallic acid equivalent (GAE), including catechin and epicatechin [1]. Moreover, this green extraction method preserved the native structure of the extracted protein as demonstrated by calorimetry measurements.

To enhance the selectivity of compound recovery, functionalized mesoporous silica-based materials (MMS-f) with tailored functional groups such as hydroxyl (OH), thiol (SH), or amine (NH_2) were tested. These materials proved highly effective and versatile for adsorbing specific compounds, such as small peptides (e.g., glutathione) and proteins (e.g., beta-lactoglobulin as a model of globular proteins) [2, 3]. Their primary function is to isolate and concentrate the targeted molecules, releasing them in a minimal volume of water through desorption. This concentrated solution can then be dried to preserve the active molecules, thereby optimizing the drying process. This work aligns with several Sustainable Development Goals, particularly SDG 12, SDG 7 and SDG 13.

ORAL

Supporting wine production from vineyard to glass through secure IoT devices and blockchain

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Keywords: blockchain, safe IoT devices, cold chain, traceability, immutability

ABSTRACT

Temperature fluctuations can significantly affect the chemical composition of wine and in turn its taste and aromas. Therefore, there is the need to trace the journey of wine through the cold chain supply from vineyard to glass. Especially when product handling is managed by subcontractors or third parties (e.g., logistic services) an appropriate technological support is necessary to develop advanced packaging solutions able to monitor and certify transport conditions in a secure and tamper proof way.

Recently, monitoring and traceability systems have evolved by incorporating novel solutions such as cloud storage, to allow remote consultation and continuous data availability. However, these solutions lack a sufficient level of security, especially in heterogeneous and thrustless environments. This is the case of the wine industry, where several different organizations should collaborate from the vineyard to the final distribution without an adequate level of mutual trust.

In this perspective, we propose an innovative solution that aims to improve wine cold chain management, through cutting-edge technological solutions capable of ensuring the safety and integrity of temperature-sensitive products throughout the entire production and distribution process. It is based on two main ingredients: the use of IoT devices with high security standards (tamper-poof hardware and software) and the use of blockchain technology, a public and non-modifiable register that allows secure and immutable storage of information.

Compared to existing solutions [5,6], the proposed one exhibits radically different and superior safety features, which are essential in the case of precious wine products or wines subject to specific classifications, like DOP or IGP. In particular, the used devices autonomously produce measurements of temperature, humidity or other physical quantities and publish their values directly on the blockchain, making them unchangeable and non-repudiable. Any deviation from optimal conditions can be timely identified and communicated without the possibility of falsification. The used devices are very flexible and configurable, allowing the measurement and safe saving of various physical quantities, not only temperature and humidity, but potentially also vibrations, electromagnetic radiation, light radiation and many others depending on the needs of the customers. Finally, security is significantly improved both at the sensor level (tamper-proof software/hardware) and in data storage. The sensors are authenticated and verified against tampering, because any attempt to modify a sensor would render it unusable. Storage takes place on blockchain, public and non-modifiable, without intermediaries (such as centralized servers or the cloud) who could tamper with them. Overall, the proposed solution can increase consumer confidence in product quality and safety, as well as the trust among participants, with an immediate identification of roles and responsibilities.

POSTER

Winery by-products as potential bioresources for green valorization and sustainable biotechnological applications

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Keywords: winery by-products, resource recovery, green valorization, sustainable applications, circular bioeconomy

ABSTRACT

The wine and distillery industries are among the most prominent sectors in EU agriculture, where 75% of grape production is dedicated to winemaking. The winemaking process generates substantial by-products—more than 30%, including both solid and liquid waste. To address the growing need for effective waste management, green and innovative valorization strategies are essential for transforming these by-products into value-added compounds for sustainable bio-based applications.

This study explores grape marc, along with pre- and post-distillation wine lees, as untapped sources of valuable compounds. The chemical composition of these by-products was analyzed, and the optimization of compound extraction using emerging technologies was investigated. The results indicated that these by-products have dry matter content ranging from 4 to 92 g/100g, low pH (3.4–4.6), and high total acidity (0.33–1.14 g/L). The most abundant source of organic acid in grape marc (GM) is tartaric acid, while pre-distillation (PRE) and post-distillation (POST) wine lees are rich in succinic acid.

Polysaccharide content varied from 83.4 to 16,869.4 mg/L, with GM being particularly abundant in high and medium molecular weight polysaccharides. In contrast, PRE and POST wine lees were more abundant in low molecular weight oligosaccharides. Proteins, measured by the BCA assay, ranged from 6.02 to 55.3 g/L, with PRE exhibiting the highest protein content, followed by POST and GM.

The total polyphenolic content ranged from 3.35 to 88.0 mg gallic acid equivalent per gram. GM was particularly rich in quercetin, while PRE and POST were more abundant in epicatechin and catechin. Additionally, the analysis of PRE and POST in both solid and liquid fractions revealed distinct polyphenolic content, underscoring the varied potential of each by-product.

These winery residues provide valuable source of polysaccharides, proteins, phenolic compounds, and other organic compounds, positioning them as potential bioresources for green valorization. The findings underscore the potential of winery by-products in driving sustainable applications, providing a viable pathway for recovering valuable compounds and advancing a circular, resource-efficient bioeconomy that supports sustainable development.

ACKNOWLEDGEMENTS

This research was funded by the European Commission, Horizon Europe research and innovation Programme, Marie Skłodowska-Curie Postdoctoral Fellowship, Grant agreement No. 101105437, Project BionovFOOD (Green processing and valorization of organic by-products of distilleries, as novel approaches for climate-smart protein applications for alternative food and circular bio-economy).

POSTER

Increasing the capacity of change and adaptation of agri-food chain: the Agri-food CHIP project

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Keywords: sustainagility, sustainability, agri-food chain, oil mill, winery by-products

ABSTRACT

The increasing vulnerability of food systems is a pressing challenge amplified by global interconnectedness. Political instability, natural disasters, economic crises, invasive species, health emergencies, and geopolitical turmoil severely affect socio-economic structures and food security in unpredictable ways. Resilience, defined as adaptive capacity, is key to addressing these challenges. Agroecologists have introduced the concept of "sustainagility," emphasizing a system's ability to maintain adaptability and meet evolving needs. Sustainagility centers on enhancing change readiness to navigate future uncertainties.

The Agri-food CHIP (Agri-food CHains Integration Project) project, funded by the Ministry of University and Research under the PRIN 2022 call, focuses on Salento, the southernmost region of Apulia in Italy, characterized by marginal areas and traditional food chains like the olive oil industry. This sector has faced in the last years significant socio-economic consequences due to the bacterium *Xylella fastidiosa*, which has caused widespread olive tree decline, compounded by the impacts of the COVID-19 pandemic and geopolitical disruptions. However, other local food chains harbor latent resources with untapped economic potential, including the wine chain, that could provide grape seed oil, bioactive compounds, and wine additives.

This project proposes a model of resilience and sustainagility for Salento by leveraging existing assets and fostering diverse solutions. Key strategies include: (i) integrating food supply chains via circular economy principles; (ii) transforming olive oil mills into multi-process extraction hubs; and (iii) employing digital technologies to interconnect food networks with stakeholders, aligning with Industry 4.0 and Industry 5.0 paradigms.

Innovative and sustainable extraction processes will be developed using advanced biotechnologies and mild technologies—such as ultrasounds, microwaves, and pulsed electric fields—enabling eco-friendly, water-based extraction methods. Resultant products will be assessed for quality parameters (virgin grape seed oil) or enological applications (e.g., grape seed panels, fresh grape skins).

Finally, a carbon-conscious track-and-trace framework will document all processes, differentiating the approach from conventional blockchain solutions. The project incorporates smart-contract features and a customer-centric voice application for enhanced accessibility via smart speakers. This comprehensive approach aims to drive sustainable innovation and adaptability in the agri-food sector of Salento.

POSTER

Towards a sustainable winery: revalorization of green CO_2 for methane production

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Keywords: decarbonization, methane, green carbon dioxide, wine

ABSTRACT

The FUELPHORIA project explores innovative pathways for sustainable energy production, with DEMO 2 focused on transforming winery-derived CO_2 into methane (CH_4) using renewable hydrogen (H_2). Hosted at Viñas del Vero (VdV) winery in Spain, this demonstration integrates circular economy principles to mitigate emissions and produce renewable fuels.

The wine fermentation process at VdV generates approximately 520 tons of CO_2 annually, previously emitted to the atmosphere. A newly installed CO_2 capture and purification unit, capable of processing gas from 12 fermentation tanks and capturing up to 120 tons of CO_2 per season, purifies the gas to over 99% CO_2 purity for subsequent use. This CO_2 is fed into an advanced methanation reactor, where it reacts with green H_2 generated on-site via a photovoltaic-powered electrolyzer. The electrolyzer produces 500 liters per hour of H_2 with 99.94% purity and an output pressure of 30 bar. The methanation reactor, will have the capacity to convert the CO_2 and H_2 into high-purity CH_4 (exceeding 99%), with a production capacity of 2 kg/day.

The Key project objectives include: a) Designing and deploying scalable CO_2 capture and methanation systems compatible with winery operations, b) Developing nickel-based catalysts with enhanced stability and performance to maximize CH_4 yield and reduce side reactions, c) Demonstrating technology scalability through modular system designs, ensuring alignment with seasonal CO_2 availability., c) Experimental campaigns validated the catalyst's long-term stability and conversion efficiency, achieving a Technology Readiness Level progression from 5 to 7 and d) The demonstration addresses logistical challenges unique to winery environments, such as seasonal CO_2 production, through flexible system integration.

By producing methane as a substitute for natural gas, DEMO 2 contributes to emission reductions, showcases the potential of renewable fuels, and exemplifies how industry-specific waste streams can be revalorized for sustainable energy production. This initiative demonstrates the feasibility of achieving carbon neutrality in the wine industry and serves as a replicable model for similar industrial symbiosis opportunities.

The present work will present the recent advances and developments installed during the DEMO construction VdV.

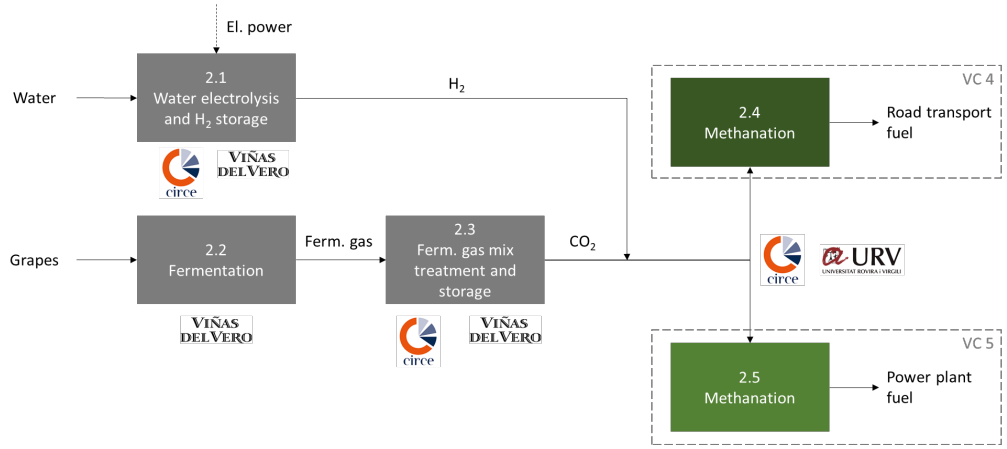

Figure 1. FUELPHORIA´S DEMO 2 process diagram.

ACKNOWLEDGEMENTS

Authors want to thank the EU. This research was co-funded by the European Union's Horizon Europe Innovation Action HORIZON-CL5-2022-D3-02 (Sustainable, secure and competitive energy supply), under the "Accelerating the sustainable production of advanced biofuels and RFNBOs - from feedstock to end-use" (FUELPHORIA) project (Grant Agreement No. 101118286). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor CINEA can be held responsible for them.

POSTER

Mannoproteins extraction from wine lees using natural deep eutectic solvents

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Keywords: mannoproteins, yeast polysaccharides, green extraction, wine lees, natural deep eutectic solvents, foam stability

ABSTRACT

Wine lees can be a good source of yeast mannoproteins for both food and wine applications [1,2]a sludge-like material mainly consisting of yeast cells, are rich in mannoproteins. However, no reports on the extraction of mannoproteins from wine lees to be used as winemaking additives are available. This study aimed at developing efficient methods for yeast glycocompounds extraction from wine lees, and to assess their impacts when added back to wine. White wine lees were extracted using physical (autoclave and ultrasonication. However, mannoprotein extraction from wine lees has not yet been scaled up to an industrial scale, mainly because of the limited cost-effectiveness ratio of the methods employed at the laboratory scale [2]upon fermentation, settle at the bottom of wine tanks. Lees from commercial red and white winemaking were processed to yield mannoprotein-rich extracts. An established autoclave-based extraction protocol, as well as a simplified version of it, were applied. The composition of the obtained wine lees extracts was determined. Extracts were tested as emulsifying and foaming agents in model food systems and benchmarked against analogues extracts derived from laboratory-grown yeast cultures of the same two strains used for red and white wines production. All extracts showed good functionalities as emulsifying and foaming agents. However, some differences were noted in both composition and functionality, and these were related to the purification process used, yeast strain, and to the extract's origin (red lees, white lees, lab-grown yeasts.

In order to improve solubilization of the cell wall components of wine lees taken before and after distillation, this study explores the potential of Natural Deep Eutectic Solvents (NADES) combined with autoclave treatment. Three food-grade NADES formulations [3,4]the best NADES combination (citric acid-betaine including citric acid/betaine (pH 1.42), tartaric acid/betaine (pH 1.13), urea/choline chloride (pH 9.65) were used. Firstly, the stability of the NADES was confirmed by comparing their physicochemical properties before and after the autoclave treatment, as indicated by FTIR analysis. However, urea/choline chloride showed changes in pH and water content, likely due to evaporation.

Then, 5 g of wine lees were suspended in 40 mL of the different NADES and subjected to the autoclave treatment (121°C, 20 min). Extracts were analyzed for their composition and tested as surfactants in model conditions at different pHs (3.4, 5.4, 7.0), comparing the results to those achieved by extracting the lees with the solvent employed in previous research (McIlvaine buffer at pH 3.4, MIB) [1,2,5]upon fermentation, settle at the bottom of wine tanks. Lees from commercial red and white winemaking were processed to yield mannoprotein-rich extracts. An established autoclave-based extraction protocol, as well as a simplified version of it, were applied. The composition of the obtained wine lees extracts was determined. Extracts were tested as emulsifying and foaming agents in model food systems and benchmarked against analogues extracts derived from laboratory-grown yeast cultures of the same two strains used for red and white wines production. All extracts showed good functionalities as emulsifying and foaming agents. However, some differences were noted in both composition and functionality, and these were related to the purification process used, yeast strain, and to the extract's origin (red lees, white lees, lab-grown yeasts. The type of solvent strongly influenced the yield and composition of the extracts. Treatment with Citric acid/betaine resulted in the highest polysaccharide content (33.16 g/100g of lees) and cell wall destabilization (as assessed by microscopy), whereas urea/choline chloride maximized protein (6.63 g/100g of lees) and high molecular weight (> 250 kDa) mannoproteins extraction. When tested as emulsifiers in model systems, extracts exhibited distinct behaviors. At all pHs tested, the sample obtained using urea/choline chloride was the best, showing emulsifying activity (volume of the emulsion/total volume x 100) of 56–62% after 7 days. These emulsions also showed the highest viscosity (>900 Pa·s) and viscoelastic moduli. In terms of foaming properties, although MIB extracts performed significantly better, NADES-based extracts also produced foams with high stability (foam volume of 5.8 cm² lasting after 4 hours), particularly at pH 3.4, indicating the potential use of these extracts as foam enhancers in wines.

Results from this study, the first to combine NADES and autoclave treatment for the extraction of mannoproteins from wine lees, indicate that NADES can enhance the efficiency of mannoprotein extraction, paving the way for a scalable and sustainable valorization of wine lees, an underexploited by-product of the winemaking industry.


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SESSION

ORAL

Extraction of stilbenes from grape cane waste and their possible applications

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Keywords: grape canes, pruning, waste, resveratrol, antifungal

ABSTRACT

Vine pruning residues constitute a significant fraction of vitivinicultural waste; in fact, depending on the variety and training system, they can reach 1-5 tons/ha/year. Currently, these wastes are underutilized, as they are left in the vineyard or composted. After cutting, however, if they are stored at room temperature, a strong synthesis of stilbenes is activated in the canes, in particular of resveratrol, which reaches its maximum concentration 2-3 months after harvest (reaching concentrations of up to 2.5 mg/g of dry weight). Grinding the shoots and extracting them with a hydroalcoholic solution (70% ethanol) which is then evaporated under vacuum, allows us to obtain a crude extract very rich in resveratrol. The extract also contains high quantities of Ɛ-viniferin, a dimer of resveratrol. Stilbenes belong to the class of phytoalexins, which are plant defense molecules, and in fact both resveratrol and viniferin show antifungal properties. A study performed on *Vitis vinifera* both in vitro and in vivo has demonstrated the possibility of using the grape cane extract, without the need for further purification, as a natural antifungal product. In particular, it has been shown that the application of the extract (titrated at 100µg/ml of resveratrol) has both a preventive and curative effect against *Botrytis cinerea*, but other studies have highlighted a certain potential also against *Plasmopara viticola*. With these premises, approximately 25 kg of shoots could provide the quantity of extract sufficient to treat one hectare of vineyard. In addition, the grape cane extract, if compared with the root extract of *Polygonum cuspidatum*, a plant known in traditional Chinese medicine and which is currently the main source from which resveratrol is obtained (4 mg/g dry weight), is simpler, with a reduced number of different compounds, so a possible purification step is also simpler to obtain pure molecules that could also be used in the food or cosmetic sectors. Further studies will be needed to test alternative and more sustainable extraction solvents.

ORAL

A new step toward the comprehensive valorisation of grape marc through subcritical water extraction of polysaccharides

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Keywords: biorefinery, grape marc, subcritical water, polysaccharides

ABSTRACT

Winemaking generates a significant amount of waste. Grape marc, the main solid residue, constitutes 20-25% of the pressed grapes and approximately 8-9 million tons are produced globally each year. The huge amounts, combined with the seasonal nature of the winemaking process, pose significant disposal, management, and environmental challenges. In this context, grape marc is already repurposed for various applications, including ethanol distillation, extraction of enocyanins, grape seed oil, and tartaric acid, as well as for energy generation, and animal feed. In recent years, the concept of biorefinery—focused on the sequential utilization of biomass to obtain multiple high-value products—has gained significant interest. This approach involves and combines different chemical, physical and biological techniques to maximize the biomass valorisation and economic profits. However, the integration and maintenance of multiple types of equipment make the economic feasibility challenging. An innovative alternative could be the application of a biorefinery strategy based solely on the sequential extraction of different classes of high-value bioactive compounds by a unique, versatile and green technology. The extraction technology using pressurized fluids, particularly supercritical and subcritical fluids, may represent the best solution in this context.

The aim of the present work is to investigate another step towards a biorefinery strategy to complete the grape marc valorisation by extracting polysaccharides using subcritical water (SCW). Subcritical water refers to liquid water at a temperature above its boiling point and below its critical point (Tc= 374°C, Pc= 221 bar). The increased temperature and pressure conditions enhance extraction mechanisms in solid matrices. SCW can be exploited not only as a solvent, but also as an outstanding and sustainable reaction medium, making it an environmentally friendly method for biomass conversion. Several experimental trials at different temperatures (120, 160, and 200°C), adding different carboxylic acids (tartaric, malic and citric acid) at different percentages (0, 5 and 10%) were performed.

The extraction yield of polysaccharides was significantly affected by SCW conditions. A comparison with the conventional extraction process revealed the higher efficiency of SCW. Under optimal conditions (120 °C and 10% tartaric acid), SCW achieved an extraction yield of 13.2 ± 0.3%, which was four times higher than the conventional method (3.2 ± 0.2%), with a 30-fold decrease in extraction time. The hydrolysis mechanisms also occured during the SCW process, leading to the depolymerization of polysaccharides, the formation of monosaccharides, and the generation of degradation products such as 5-hydroxymethylfurfural. However, these degradation products are classified as biobased platform chemicals with considerable market demand.

ORAL

Sustainable strategies for the management and valorization of wine lees

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Keywords: wine lees, mannoproteins, green extraction, natural deep eutectic solvents (NADES), vinasse, circular economy, polysaccharides, food ingredients, response surface methodology

ABSTRACT

Wine lees represent an abundant yet largely undervalorised by-product of the winemaking industry. In particular, lees rich in spent yeast biomass, collected after racking or distillation, hold considerable potential for the extraction of bioactive macromolecules such as mannoproteins and polysaccharides with relevant food and technological applications. However, several limitations hinder their industrial valorization, including low extraction yields, high processing costs, and the lack of processes that are compatible with current distillation practices. This presentation outlines two complementary strategies aimed at overcoming these obstacles by focusing on sustainable approaches for the extraction and valorization of post-fermentation and post-distillation wine lees. The first strategy explores, for the first time, the combined use of natural deep eutectic solvents (NADES) and autoclave treatment (121°C, 20 min) to enhance yeast cell wall solubilization. Three food-grade NADES were tested for their physicochemical stability and extraction performance. Results showed high extraction yields for both polysaccharides (up to 33.2 g/100g) and proteins (up to 6.6 g/100g), with promising functional properties such as emulsifying activity (56–62%), high viscosity (>70 Pa·s), and good foaming ability at wine pH (3.4). The solvents remained stable under thermal treatment, supporting their use in green extraction processes. The second strategy focuses on optimizing thermal extraction conditions for a scalable process using post-distillation lees, with the goal of designing a pilot plant that can be integrated into existing distilleries. To this end, Response Surface Methodology was applied to assess the combined effects of temperature (104–112°C), time (20–60 min), and solids concentration (10–50%) through 15 treatment combinations using a pressure extraction system. Results indicated optimal protein extraction at 110°C, 30 min, and 20% solids, while varying conditions favored different polysaccharide fractions. The physical characterization of the extracts (viscosity, density, specific heat) informed the selection of suitable equipment, including vertical disk separators, industrial cookers, and rotary pumps. Overall, these studies present two complementary and sustainable strategies to convert wine lees into valuable functional ingredients, offering a concrete step towards the adoption of circular economy practices in the wine sector.

ORAL

The collection of micro-climatic information through a mobile robot

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Keywords: micro-climate mapping, mobile sensors, agricultural robots, recurrent neural network, reinforcement learning, trajectory planning

ABSTRACT

Temperature fluctuations and, in general, climatic conditions can significantly affect the chemical composition of grapes and, in turn, the taste and aromas of wine. At the same time, having a complete climatic mapping of the vineyard is a challenging topic. Traditional solutions are based on using sensors displaced in strategic points of interest. However, in many cases, disseminating a large number of fixed sensors capable of monitoring environmental parameters in a capillary manner is impractical in terms of costs and space constraints. For this reason, some alternative solutions have been envisioned by combining a limited number of sensors and artificial intelligence solutions for building precise predictive models. Our recent investigation explored the possibility of exploiting an agricultural robot performing repetitive tasks, such as weeding, to collect capillary information during its journey. The low cost of equipping existing agricultural robots with dedicated sensors and the technological advances in artificial intelligence constitute the enabling factors to be explored and exploited in this application area. In this research, we aimed to make the path of the agricultural robot "expert" to best combine its operational activities with data acquisition and energy recharge. In particular, the Reinforcement Learning technique was used to learn from the past and identify the best trajectory and stopping pattern the robot should follow in a specific contextual situation. At the same time, convolutional and recurrent networks are applied to discover the correlations, respectively spatial and temporal, in the values of the monitored environmental parameters and further guide the robot's decisions. In summary, the use of mobile sensors accompanied by advanced artificial intelligence techniques can be a valid tool to create a "digital twin" of the vineyard to monitor and estimate the trend of specific climatic quantities, such as temperature and humidity, but also, in the future, the phenological stage of each plant and the development of pathogens. The combination of all these tools can lead to a next generation of decision support systems for viticulture, which help not only to prevent plant diseases, predict and optimize their growth, but also optimize the usage of resources, like energy, water, and pesticides, to increase the quality of the product while reducing the waste of precious resources.

ORAL

Carbon sequestration in vineyard soils: biomass utilization in a climate change scenario–the SUSTAIN project

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Keywords: soil, carbon sequestration, climate change, vineyards, digestate

ABSTRACT

The SUSTAIN project aims at assessing the soil organic carbon (SOC) stock and vulnerability in vineyard soils under a climate change scenario. The accumulation and stabilization mechanisms of SOC and its relative distribution between pools with different turnover rates are investigated, together with shifts in microbial community composition.

Three experimental vineyards located in the Veneto region (North of Italy), and characterized by different pedoclimatic conditions, are investigated. In each of them, a randomized block design, consisting of 3 blocks composed of 8 plots each, and two factors, i.e., land management practice (i.e., digestate application, cover crop, bare soil) and climate manipulation (i.e., ambient temperature *vs.* warming), is set up. Open top chambers (OTC) are used to obtain a temperature increase of ~2 °C (SSP2-4.5). Three grape varieties (i.e., Corvina at Negrar, Glera at Lonigo, and Garganega at Albaredo d'Adige) all having the same age (i.e., 12 months old) are tested.

Soil samples will be collected at four times (i.e., after 0, 6, 12 and 18 months from the OTC placement) and at 3 depths (i.e., 0-15, 15-30, 30-45 cm), and characterized from the physical, chemical and microbiological point of view. SOC storage and potential vulnerability to climate change will be investigated by separating SOC into functionally defined fractions, namely particulate (POM) and mineral-associated organic matter (MAOM). In fact, being more protected from microbial degradation by soil minerals, MAOM is generally expected to be less prone to disturbance compared to POM.

The results obtained at the end of this project (in 2026) will help implementing agro-environmental management practices supported by the new common agricultural policy (CAP), including carbon farming payment schemes based not only on the quantity of SOC stocked, but also on its turnover or susceptibility to global warming. Moreover, such a study will provide insights on vineyard vulnerability and possible changes in wine quality in a climate change scenario.

ACKNOWLEDGEMENTS

This study was carried out within the SUSTAIN project "SeqUeSTro del cArbonio in vIgNeto: utilizzo di biomasse in uno scenario di cambiamento climatico" funded by the Ministero dell'agricoltura, della sovranità alimentare e delle foreste (Area 2 - Cambiamento climatico, biodiversità, funzionalità suoli e altri servizi ecologici e sociali dell'agricoltura; D.M n. 419782 del 14/08/2023 - Procedura di selezione per la concessione di contributi finalizzati alla realizzazione di progetti di ricerca pubblica nel settore vitivinicolo).

ORAL

High-throughput direct monitoring of microbial resources for oenology by direct injection mass spectrometry

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Keywords: alcoholic fermentation, yeast, wine

ABSTRACT

Microorganisms have been widely used in oenology since prehistoric times. Their metabolism significantly impacts many wine properties and is particularly essential for the production of flavor compounds, thereby affecting perceived wine quality. Volatile organic compound (VOC) concentration depends not only on growth of single microorganism strain but also on their interaction with each other and the food matrix. For this reason, a rapid and non-invasive screening of the microbial volatilome is of utmost relevance for the evaluation, selection, and optimization of microbial strains in oenology. Our research group has developed and successfully applied a setup based on Proton-transfer-reaction time-of-flight mass spectrometry (PTR-ToF-MS) coupled to a multipurpose GC sampler for high-throughput and non-invasive monitoring of biotechnological processes. PTR-ToF-MS belongs to direct injection mass spectrometry, and as such, it offers online, real-time evaluation of VOCs with high sensitivity. This contribution describes two case studies of the volatilome of microorganisms relevant to oenology. The first case study involved six different S. cerevisiae strains (four meiotic segregants of a natural strain and two laboratory strains) inoculated onto a solid YPD medium and monitored for 11 days every 4 hours. In this case, more than 300 peaks were extracted from the average spectra associated with each time point, 70 of which were tentatively identified. Univariate and multivariate analyses were performed on the data matrix (3640 measurements x 70 peaks), highlighting the volatilome evolution and strain-specific features. This serves as a paradigmatic example of the method's potential in terms of its high-throughput capability, sensitivity, reproducibility, and stability. The second case study explored different single and multiple inoculations of diverse oenological yeasts in both commercial grape juice and fresh must. The experiment highlighted variability in the overall volatile profile associated with (i) the different yeast species, (ii) the different yeast combinations, and (iii) the different fermenting matrices. The results of these two case studies demonstrate the potential of PTR-ToF-MS for monitoring experimental variables associated with alcoholic fermentation in wine, thereby opening new opportunities for managing this crucial phase and improving the quality of the final products and optimizing the processes.

ORAL

Microbial resources for improving the sustainability in oenology

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Keywords: bioprotection, antioxidant, lactic acid bacteria, sulphur dioxide

ABSTRACT

Sulphur dioxide has long been considered an irreplaceable additive due to its numerous significant positive effects during winemaking and beyond. However, the association between sulphur dioxide and health-related issues and the consequent awareness of consumers for products without synthetic additives has led to explore new ways to ensure the quality of wine. Moreover, the general increase of the wine pH related to climate change inevitably reduces the effectiveness of sulphur dioxide. The search for alternatives is becoming even more challenging as consumers' preferences are increasingly leaning towards green consumerism, clean labelling and environmental sustainability. One of the proposed alternatives is bioprotection that consists in the inoculation in must or wine of selected microorganisms having specific activities, with the aim of replacing sulphur dioxide. Many studies have been focused on the antimicrobial activity of microorganisms, however, the available research regarding their antioxidant activity is certainly more limited. The aim of this study was to investigate the antioxidant effects of *Metschnikowia pulcherrima* and *Lacticaseibacillus casei* during the production of Pinot Grigio, with the former inoculated during pre-fermentative maceration and the latter at the end of alcoholic fermentation. In the control, 2 g/hL of sulphur dioxide were added during the pre-fermentative steps. The antioxidant effect of *M. pulcherrima* has been associated to its ability to consume oxygen very efficiently, reducing its availability for the oxidation processes. Regarding *Lcb. casei* N87, the strain used in this study has the capability to switch from fermentation to aerobic respiration metabolism when provided with heme and menaquinone. The effect of the growth of this strain under respiratory conditions has been advantageously studied in the production of Cheddar-type cheese, wheat sourdough fermentation and fermented sausages (Reale et al., 2016a,b; Camprini et al., 2023). At the end of fermentation, the amount of polyphenols was found to be similar in the two experimental conditions. However, during storage the samples inoculated with the bioprotective cultures presented a higher concentration of polyphenols, demonstrating the effectiveness of these strains in the protection of these potentially oxidizable compounds. This study shows that the use of bioprotective cultures coupled with respiration-based technology may be effectively exploited to protect must and wine from oxidation, allowing the reduction of the use of sulphur dioxide. However, further studies will be needed to investigate the effects of bioprotective cultures on other wine parameters and grape varieties associated with different winemaking processes.

ORAL

Classification and prediction of tannin botanical origin through voltammetry and machine learning approach

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Keywords: linear sweep voltammetry, enological tannins, machine learning wine

ABSTRACT

The classification of enological tannins has gained importance following the OIV's requirement to include their botanical origin on product labels (OIV-OENO624-2022). A rapid classification method would be particularly valuable for producers and retailers, enabling them to quickly determine the origin of tannins. This study explores a novel approach using linear sweep voltammetry (LSV) coupled with machine learning algorithms to classify enological tannins. While traditional methods such as LC-MS, UV-Vis, and FTIR provide detailed chemical information, they are often time-consuming, costly, and require skilled personnel. In contrast, voltammetry offers a rapid, cost-effective alternative, albeit with challenges in interpreting the resulting voltammograms due to signal overlaps from various electrochemical processes. Interpreting these results may require advanced data processing, such as signal deconvolution (Ugliano, 2016) and machine learning algorithms to extract insights from voltammetric patterns (Choi et al., 2022). However, the efficiency of machine learning algorithms is closely linked to a large availability of data. To address these limitations, a Generative Adversarial Network (GAN) was employed to generate synthetic voltammograms, combined with experimental data to expand the training dataset. This augmented dataset was used to train machine learning models, including Random Forest, Extreme Gradient Boosting, and Support Vector Machine (SVM), with the latter achieving the best classification results. The SVM model demonstrated high accuracy (94%) and excellent discrimination between tannin classes, as indicated by an AUC-ROC of 0.9971. The study also integrated feature importance and Recursive Feature Elimination (RFE) analyses to identify key voltammetric features contributing to the classification. Features around 0.3V, 0.57–0.65 V, and 1.11–1.17 V were found to be critical for distinguishing between tannin types. While the proposed method highlights the potential of combining voltammetry and machine learning for rapid tannin classification, further studies on model solutions are required to generalize the approach to different wine matrices. This workflow provides a promising tool for the wine industry, offering a rapid, cost-effective method to classify tannins and optimize their enological applications.

ORAL

SO_2 consumption in white wine oxidation: approaches to low input vinifications based on rapid electrochemical analyses and predictive enology

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Keywords: White wine shelf life, precision enology, SO_2 consumption, predictive modeling

ABSTRACT

Oxidative stability is a critical factor in maintaining wine quality during its shelf-life. SO_2 is commonly added to wine due to its strong antioxidant activity, although there is a general push to reduce SO_2 use in vinification. Reducing the reliance on SO_2 while maintaining oxidative stability is a pressing challenge for winemakers, emphasizing the need for predictive tools to optimize wine oxidation management.

In this study, the relationship between O_2 and SO_2 consumption of 71 Lugana white wines was studied Samples underwent controlled oxidative stress (oxygen consumed ~ 5ppm) to monitor oxygen and SO_2 consumption, while control anoxic samples were stored in the same temperature controlled room at 20°C. Samples were characterized for SO2 content before and after oxygen consumption, ammonia, primary amino nitrogen (PAN), polyphenols, ascorbic acid, and catechins. Cyclic voltammetry was employed to obtain information on the redox-active compounds present in the wines.

Oxygen consumption rate followed first-order kinetics, with half-lives ranging from 2.1 to 18.1 days. SO_2 consumption ranged from 1.4 to 18 mg/L in the oxygenated samples and from 0.6 mg/L to 14.9 mg/L in the anoxic samples. Final free SO2 concentrations showed a strong correlation with their initial values in both oxygenated and anoxic samples. On average, oxygenated samples consumed 4.6 mg/L more free SO2 compared to anoxic samples, with a pseudo-stoichiometric coefficient of 0.92 mg of free SO_2 consumed per mg of O_2. Notably, variability among individual samples was substantial, with ratios ranging from 0.62 to 1.95 mg free SO_2/mg O2.

The amount of free SO2 consumed in oxygenated samples was significantly inversely correlated with the half-life, suggesting that, under equal oxygen availability, wines with faster oxygen consumption tend to consume less free SO_2. Electrochemical profiles also revealed significant variability among the redox-active compounds of the different wines, particularly in the voltametric regions located around 420mV 820mV.

In consideration of the large variability in SO2 consumption levels of the different wines and the multivariate nature of SO2 consumption chemistry, different modelling approaches were explored to identify opportunities for the development of predictive tools for SO2 stability.

The results of these investigations will be presented, with a focus on a model that predicts the final concentration of SO2 in wine. This model, developed using data from voltammograms and other analytical parameters readily accessible to winemakers, demonstrated good performance on the training set (RMSE = 2.94 mg/L) and was confirmed on the test set (RMSE = 2.55 mg/L).

By combining rapid electrochemical analysis and predictive modelling, more rational use of SO2 appears possible, contributing to more efficient and sustainable wine management practices.


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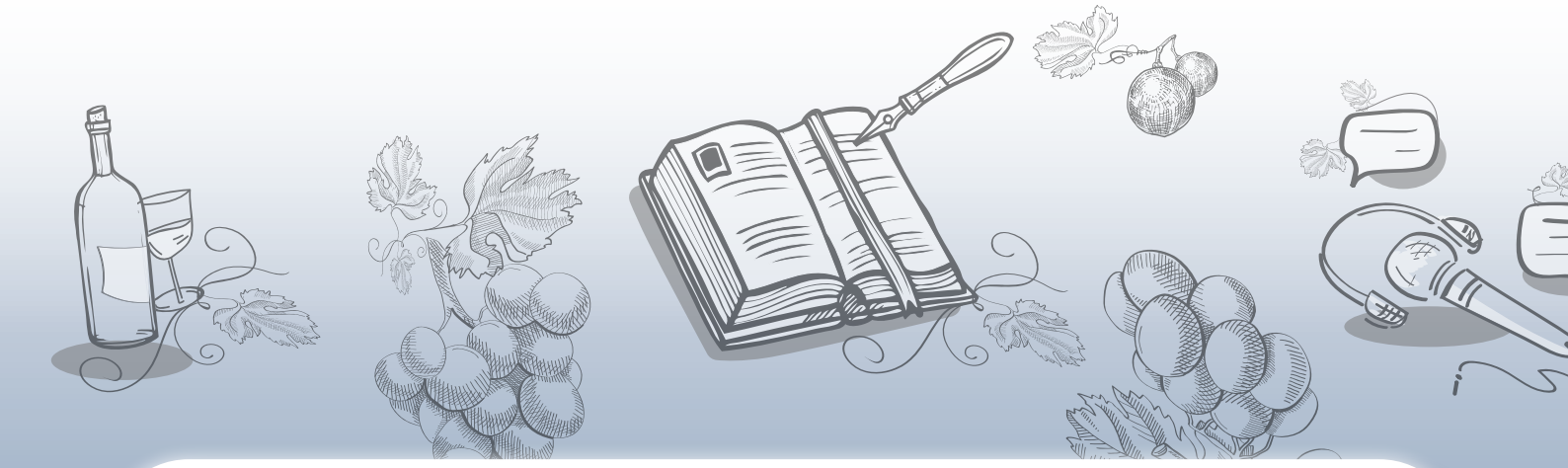

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