Innovative management of maceration processes and stabilization techniques for the production of monovarietal wines

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This PhD project aims to find variety-specific tools aimed at improving the phenolic traits of monovarietal wines, with a particular focus on how phenolics are accumulated in the berry during ripening, extracted during maceration, and evolve over time. Several winemaking techniques will be tested to understand how they can affect the extraction and stabilization of phenolic compounds and to design novel approaches to use them to obtain variety-specific results.

Gestione innovativa dei processi di macerazione e delle tecniche di stabilizzazione per la produzione di vini monovarietali

Questo progetto di dottorato mira a trovare strumenti specifici per varietà al fine di migliorare i tratti fenolici dei vini monovarietali, con particolare attenzione alla cinetica con cui i composti fenolici si accumulano nell'acino durante la maturazione, vengono estratti durante la macerazione e si evolvono nel tempo. Verranno testate diverse tecniche di vinificazione per capire come possono influenzare l'estrazione e la stabilizzazione dei composti fenolici e per progettare nuovi approcci per utilizzarle al fine di ottenere risultati specifici per varietà.

## **1. State-of-the-Art**

Italian grape varieties are famous for their wide diversity in terms of berry constituents. The variability among cultivars is important because it represents the differences that characterize the corresponding monovarietal wines (Giacosa et al., 2021). Therefore, monovarietal winemaking should be intended as a production process aimed at enhancing the characteristics of each variety. The quality of grapes is based on the content of primary and secondary metabolites that accumulate during ripening. In particular, the sugar and acid content and the total amount of extractable phenolic substances are important variety-dependent parameters, further influenced by the harvest date. Indeed, the accumulation kinetic of phenolic compounds in the berry differs according to the variety, the climatic conditions of the vintage, and the growing area (Cagnasso et al. 2011). Therefore, the evaluation of the accumulation kinetics of phenolic compounds in berry skins and seeds are crucial to plan the harvest date and to ensure the right extractable phenolic pool from grapes. The color characteristics and mouthfeel properties of red wines firstly depend on the extraction of phenolic compounds that takes place during grape skin maceration. To improve the extraction of phenolic compounds, several techniques are used. The use of enzymes has been proposed to increase the extraction of phenolic substances during the maceration. Their use facilitates the disruption of skin cell walls leading to an enhanced phenolic extraction. Enzyme preparations are marketed to increase phenolic extraction in a specific extent; however, the final result may be affected by the mix of primary and side enzyme activities featured in commercial mixture (Romero et al., 2008). Moreover, in literature contrasting results have been found according to the variety and the type of enzyme activity tested. Río Segade et al. (2015) obtained variable outcomes in terms of anthocyanin extraction by testing the same enzyme formulation on varieties with distinct anthocyanin profiles. On the other hand, various enzyme activities tested on the same variety led to a different phenolic extraction from grape skins, with consequently different implications on the wine chromatic characteristics (Bautista-Ortín et al., 2005). Tannins play an important role in color stabilization and in the determination of wine mouthfeel properties. Given that different maceration conditions (i.e., length, temperature) can affect the phenolic extraction, several techniques have been proposed in the literature to modulate the extraction of tannins from the seeds and skins during maceration, but different results have been obtained depending on the variety (Busse-Valverde et al., 2010). Few studies have been conducted on how to modulate the maceration conditions to achieve variety-specific results. Monomeric anthocyanins extracted from grape skins during the maceration can undergo various phenomena, such as reabsorption by cell wall materials, oxidation and interaction with other phenolic or non-phenolic compounds. These latter reactions result in the formation of more stable pigments. Copigments, anthocyanin-tannin and anthocyanin-anthocyanin adducts, and pyranoanthocyanins represent key compounds in the determination of wine colour and their formation is affected not only by the initial amount of phenolics in grapes, but also by the winemaking and storage conditions. In particular, the oxygen exposure drives the evolution of phenolic traits of wines after the alcoholic fermentation, as oxygen can react with di– and tri–hydroxyphenols to produce quinones and hydrogen peroxide, which can oxidize further substances. The effect of oxygen on the wine evolution has been deeply studied, nevertheless, high variability in the results was reported according to the wine composition (Petrozziello et al., 2018).

## **2. PhD Thesis Objectives and Milestones**

Within the overall objective mentioned above this PhD thesis project can be subdivided into the following activities according to the Gantt diagram given in Table 1:

A1) **Deepening the understanding of varietal berry composition** by studying the kinetics of phenolic compound accumulation on selected varieties (A1.1) to find new solutions and tools (development of accumulation models, A1.2) to determine the optimal harvest date;

A2) **Evaluation of different maceration conditions** such as length, temperature, and cap management to identify how they can affect the phenolic extraction (A2.1) and how they can be modulated in varietal winemaking (A2.2);

A3) **Application of novel technological aids** to improve wine phenolic traits**,** with a particular focus on enhanced enzyme treatments applied during the maceration to increase the phenolic extraction (A3.1) and subsequent identification of possible specific applications for Piedmontese varieties (A3.2);

A4) **Study of the evolution of wine phenolic characteristics through aging** by exploring phenolic stabilization under different winemaking conditions (A4.1) and evaluating the chromatic characteristics of varietal wines after different oxygen exposure levels (A4.2);

A5) **Elaboration of tailor-made techniques for varietal enology**;

A6) **Writing and Editing** of the PhD thesis, scientific papers and oral and/or poster communications.

***Table 1***Gantt diagram for this PhD thesis project.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Activity Months | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** |
| A1) | ***In-depth study of berry composition*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Evaluation of phenolic ripeness |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Models for phenolic accumulation |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A2) | ***Effect of maceration conditions*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Influence of maceration techniques |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Variety-specific application |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A3) | ***Technological aids*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Evaluation of enzymes performance |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Application in varietal enology |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A4) | ***Phenolics in wine evolution*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 1) Phenolic stabilization |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 2) Effect of oxygen exposure |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A5) | ***Creation of variety-specific strategies*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| A6) | ***Thesis and Papers Preparation*** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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