# phd School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

***(XXXIX cycle, 2023-26)***

## Project draft

**1.Field of interest**

AGR/16 - Microbiologia Agraria

AGR/09 - Meccanica Agraria

**2.Project title**

Management for energy savings during winemaking process, and especially during the steps of alcoholic and malolactic fermentations.

**3.Tutor** (membro del Collegio dei Docenti)

Ileana Vigentini

**- Eventually: co-tutor/s**

Roberto Beghi

**4.Relevance of the topic and state of the art:**

The establishment of sustainable approaches in viticulture and winemaking processes has become a strategic plan to face climate change under several aspects, including economics, environmental and society dimensions [1]. The relationship between sustainability and climate crisis has been leading winemakers to more conscious measurements of several climatic impacting factors in cellar, such as energy consumption during the wine production. Regarding the fermentation process, energy-saving solutions have been recently considered. In particular, the exploitation of yeasts and malolactic bacteria selected to maintain a balance between fermentation yield and wine quality by increasing the standard working temperature of 2-4°C, could represent an innovative and economically advantageous eco-friendly strategy [2]. About 90% of electricity used by wineries is consumed by the refrigeration system, which in itself includes: fermentation control, cold stabilization and cold storage [2,3]. Specifically, few studies addressed the quantification of required heat dissipation during alcoholic fermentation (AF) of sparkling base wines, showing that coupling innovative thermal protocols with rationally chosen yeast strains [4,5,6] could lead to an energy saving of ~70% (increasing temperature of 3-4°C during the fermentation process) [1,2]. Therefore, the influence of temperature on the different yeasts for exploiting such a procedure without compromising aroma production are required. Concerning energy savings and malolactic fermentation (MLF) no studies are available in literature. It is widely accepted that co-inoculation strategies [7] can significantly reduce the necessity to heat tanks [4,5], a step that is necessary to start the MLF when a sequential or spontaneous MLF is desired. To face the global warming impact, more research will be needed to accurately quantify energy savings related to co-inoculation.

## 5.Layout of the project (draft)

The research aims at evaluating and selecting microbial strains able to limit the variation of aroma profiles and sensory properties of the final wine at various temperature programs under an energy-saving mission. The specific research **objectives** will be:
- To deepen the potential energy savings achievable in white winemaking by combining innovative thermal protocols for **AF** with the use of specific yeasts selected;
- To explore and measure the potential energy savings achievable in red winemaking by using innovative protocols of co-inoculation for **MLF**;
- To investigate the potential energy savings achievable in sparkling wine production by using innovative thermal protocols for **secondary fermentation** with the use of specific yeasts.

### 5.1. Materials & Methods:

The research activity will involve the University of Milan (DSBCO and DiSAA), CREA (Conegliano, IT) and Lallemand Inc (Toulouse, FR). Industrial vinification trials will be carried out to test best yeast/bacteria strains and quantify the energy savings associated with the innovative protocols accordingly designed to their metabolism (higher temperatures for AF, co-inoculation for MLF, specific thermal conditions for prise de mousse) compared with standard winemaking procedures.

**WP1 - Selection of Yeast Cultures for alcoholic fermentation.**

Task 1.1 Screening of yeast cultures. Growth performance of *Saccharomyces cerevisiae* or non-*Saccharomyces* yeasts will be monitored at 2 or 3 different temperature programs.

Task 1.2 Evaluation of fermentation performance during white and red winemaking. Yeast candidates selected in Task 1.1 will be analysed for their fermentative vigor and power, sugar consumption, acetic acid and glycerol production and aroma profile under different thermal protocols. Attractive strains will be tested for energy quantification and energy savings calculations in winery trials.

**WP2 - Selection of Yeast and Bacterial Cultures for malolactic fermentation.**

Task 2.1 Evaluation of the interactions of the yeasts selected on the WP1 with the malolactic bacteria. *Oenococcus oeni* and *Lactobacillus planetarium* starter cultures will be analysed in co-inoculation vs sequential inoculation tests with yeasts in laboratory tests. Microbiological and standard chemical analyses will be applied to assess the fermentation performance for red and white winemaking.

Task 2.2 Microvinification experiments (100 hL) with attractive yeast-bacteria couples will be carried out in red winemaking in co-inoculation vs sequential MLF with energy quantification and energy savings calculations (of co-inoculation).

**WP3 - Fermentation with the selected yeast and malolactic bacteria in winery.**

Task 3.1 Evaluation of persistence and dominance of the strains and energy saving during the fermentation step. The potential maximum energy saving obtainable from selected couple-mix microorganisms will be validated at industrial scale. Model yeast strains containing the synthetic malolactic metabolic route could be used for comparison at laboratory scale.

Task 3.2 Validation of the refermentation performance of best yeasts (WP1) in sparkling wine production with energy quantification and energy savings calculations will be investigated.

**WP4 - Data analysis, scientific paper(s) and thesis writing.**

An extensive literature search will be needed for the set-up of the experiments and data analysis. A review-literature paper is expected at the beginning of the project.

**5.2. Schedule and major steps (3 years):**

| | 1st Year | | | 2nd Year | | | 3rd Year | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1-4 | 5-8 | 9-12 | 1-4 | 5-8 | 9-12 | 1-4 | 5-8 | 9-12 |
| WP1 | | | | | | | | | |
| Task 1.1 | | | | | | | | | |
| Task 1.2 | | | | | | | | | |
| WP2 | | | | | | | | | |
| Task 2.1 | | | | | | | | | |
| Task 2.2 | | | | | | | | | |
| WP3 | | | | | | | | | |
| Task 3.1 | | | | | | | | | |
| Task 3.2 | | | | | | | | | |
| WP4 | | | | | | | | | |

**6. Available funds**

- International project: "Natural microbial interactions in grapevine and wine ecosystems as a tool to foster wine innovation (Eco2Wine)", Horizon Europe, MARIE SKŁODOWSKA-CURIE Doctoral Networks 2022 (HORIZON-MSCA-2022-DN-01)", Grant Agreement Number 101119480, 5.000,00€/year
- International project: "Yeasts for the Sustainability in Viticulture and Oenology (YeSVitE)". Settimo Programma Quadro, Azioni Marie-Curie, PEOPLE-2013 IRSES, Grant Agreement Number 612441. 2.500,00€/3 years

**7. Literature:**


[1] Escalona, C.J.M. and Comuzzo, P. (2022) Improving Sustainable Viticulture and Winemaking Practices, Academic Press, Pages 1-24, ISBN 9780323851503

[2] Galitsky, C., Worrell, E., Radspieler, A., Healy, P., Zechiel, S. (2005) BEST Winery Guidebook: Benchmarking and Energy and Water Savings Tool for the Wine Industry

[3] Malvoni, M., Congedo, P.M., Laforgia, D. (2017) Analysis of energy consumption: a case study of an Italian winery. Energy Procedia 126, 227–233

[4] Giovenzana V., Beghi R., Vagnoli P., Iacono, F., Guidetti R., Nardi T. (2016) Evaluation of Energy Saving Using a New Yeast Combined with Temperature Management in Sparkling Base Wine Fermentation. American Journal of Enology and Viticulture. 67. 10.5344/ajev.2016.15115

[5] Schwinn, M. et al. (2019) Impact of fermentation temperature on required heat dissipation, growth and viability of yeast, on sensory characteristics and on the formation of volatiles in Riesling. Australian Journal of Grape and Wine Research 25, 173–184

[6] Giovenzana V., Beghi R., Guidetti R., Nardi T., Luison M. (2023) Evaluation of energy savings in white winemaking: impact of temperature management combined with specific yeasts choice on required heat dissipation during industrial-scale fermentation. Journal of Agricultural Engineering. https:/doi.org/10.4081/jae.2023.1523

[7] Capozzi, V., Berbegal, C., Tufariello, M., Spano, G., Grieco F (2019) Impact of co-inoculation of *Saccharomyces cerevisiae*, *Hanseniaspora uvarum* and *Oenococcus oeni* autochthonous strains in controlled multi starter grape must fermentations. LWT Food Sci Technol 109:241–249