Design and mathematical optimization of multi-strain ecosystems in winery

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For food processing, fermentation by microorganisms allows food preservation and production of several fermented products, among the most consumed are bread, cheese, beer and wine. In all these anthropic environments, microbes form communities where individual microorganisms interact in various ways such as competition, predation, commensalism or mutualism that may have a tremendous effect on the final product quality. Exploiting these interactions by ecological engineering (by choosing the good partners in the good proportions) appears to be a promising strategy for improving fermented food. However, it demands a profound understanding of the interaction's mechanisms and an exponential number of experiments to assess all possible microbes combination. To meet these challenges in winery, we choose to guide our ecological designs by a mathematical model simulating the microbial and metabolic dynamics of the oenological fermentation. We perform a deep phenotyping of fermentation driven by different yeast-yeast combination that gives us the necessary information to build a mathematical model (of ordinaries differential equations) that simulate the dynamic of mixed cultures from isolated cultures data. With this model, we test different inoculation protocols (which strain/species, in what proportion and at which time) and evaluate their performance for maximizing different functional traits.

Oenology, fermentation, yeast-yeast interactions, population dynamics, non-saccharomyces species, ecological engineering, microbiology, wine.