RESEARCH PERFORMANCE PROGRESS REPORT

Research Team

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Project Overview

Smoke-derived volatile phenols (VPs) are absorbed by the skin of wine grape berries, where they reside in modified form until fermentation and consumption, where they impart off flavors associated with smoke taint. Our research team has developed a proof of principle pipeline for the discovery of novel grape-associated bacteria that can degrade these phenolic compounds. Using this pipeline, we have captured several distinct bacteria capable of selectively removing guaiacol, 4-methyl guaiacol, or phenol. To understand which genes specifically provide this ability within these bacteria, we performed transcriptomics and identified two key enzymes that could potentially be engineered into the wine making process to degrade the offensive compounds prior to wine consumption. Our ongoing objectives are to:

1) Extend this process to identify bacteria capable of selectively removing other critical phenolic components responsible for smoke taint, including thiophenols, syringols and glycoside conjugates of the offending phenolics.
2) Test the efficacy of individual enzymes for their ability to degrade guaiacol and 4 methyl guaiacol within wine must and during fermentation.
3) Engineer commercially available yeast strains with the newly identified genetic modules necessary for guaiacol and 4-methyl guaiacol degradation for use during fermentation.

Research Activities

All work described prior to the three ongoing objectives has been completed. Five bacteria with selective ability to degrade either guaiacol, 4-methyl guaiacol, or phenol have been cultured, and the key enzymes necessary for catabolizing guaiacol to catechol have been identified.

Key Accomplishments

Currently in Revision for publication and anticipated publication in September 2025.

- Discovered five strains of Actinobacteria capable of degrading offensive phenolic compounds in a tunable and selective manner.
- Identified two key, rare enzymes necessary for guaiacol degradation missing from most bacteria and demonstrated that these enzymes can selectively consume individual phenolic compounds from media while leaving related phenolic compounds undamaged.
- Captured key temporal dynamics of the gene expression related to these enzymes that point to rapid induction of the synthesis of these enzymes following exposure to guaiacol.
- These results provide a roadmap for developing a novel remediation process that can fine tune phenolic profiles in wine, providing centralized protection in the winery rather than the vineyard.

Future Goals and Aims

Next steps will include extending this discovery pipeline to identify bacteria capable of selectively removing all other critical phenolic components that lead to smoke taint in wine grapes, testing the efficacy of these enzymes at removal within wine and wine must, and developing *in vitro* and *in vivo* technologies from the associated genetic pathways to remove these components from wine.