A Kinetic Model for Single-Yeast Sour Beer Fermentation

During the fermentation process in which glucose and or other sugars are metabolized by yeast to form ethanol, certain strains of yeast, called ‘sour yeasts’, will first metabolize sugar to produce lactic acid, after which, the mechanism switches to produce only ethanol. We sought to adapt an existing mathematical model of a fermentation to describe this lactic acid fermentation.

After understanding and implementing several papers, we decided that the math model contained in [1], was ideal to adapt to describe a lactic acid fermentation. The key aspect of the model is a switch function, which we replicated to demonstrate the change in metabolism when a sour yeast ceases to produce lactic acid during a fermentation. This model is also limited to glucose as the sugar source. Utilizing the existing rate equations and stoichiometric coefficients within the model, we were able to construct a rate expression for lactic acid and integrate it into the model proposed [1].

These rate equations should model a lactic acid production coinciding with cell mass growth causing an early pH decrease to about 3.2. We accomplished this through the switch function model approach [1] controlling lactic acid production with a single parameter which we established by comparing our model to data [1]. Our final pH was achieved at around 5 hours.

We hope that our model could be used in the industrial production of sour alcohol. Improvements include describing more realistic worts, such as maltose and maltotriose, as well as modeling a greater range of beverage production settings, as described in [2]. Fermentation modeling can be implemented to improve the ease of production and decrease the waste involved in experimentation.

[1] *González-Hernández, Y.; Michiels, E.; Perré, P. A Comprehensive Mechanistic Yeast Model Able to Switch Metabolism According to Growth Conditions. Fermentation 2022, 8, 710. https://doi.org/10.3390/fermentation8120710*
[2] *J. Gee DA, Ramirez WF. Optimal temperature control for batch beer fermentation. Biotechnol Bioeng. 1988 Feb 20;31(3):224-34. doi: 10.1002/bit.260310308. PMID: 18584597.*