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Evaluating the Use of Simulated Food Wastes for Biofuel Production

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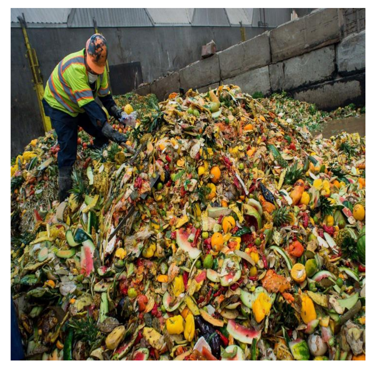
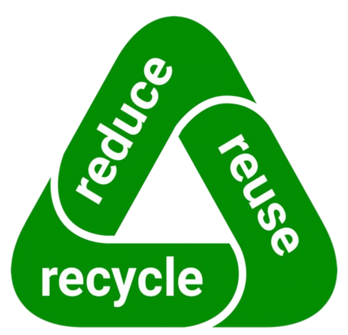
BACKGROUND & OBJECTIVES



The Problem

- 1.3 billion tons of food are wasted yearly
  - Massive environmental burden
  - Economic loss of nearly $940 billion
- Most global efforts have focused on reducing food waste at consumer level
  - Largely untapped research in reusing food waste
- We can convert food waste into biofuel, a renewable resource, using biochemical engineering for energy
  - Reduced dependence on fossil fuels
  - Circular economy: waste is converted into energy



Purpose & Objectives

We will contribute to the growing field of sustainable energy by demonstrating how fruit juices can simulate food waste and be repurposed into clean, renewable fuel. Specifically, we will:

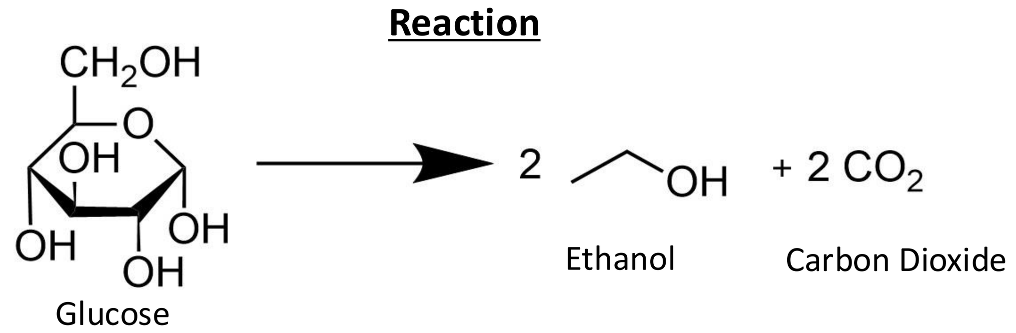
- Determine the time taken to reach equilibrium cell growth and ethanol concentration in each juice
- Find which yeast environment consumes the highest percentage of initial glucose at steady state
- Identify which juice would be optimal as simulated food waste to produce ethanol over long times using a batch reaction

Accomplishments

- Found that steady state cell concentration is reached at around 50 hours
- Identified that yeast in apple juice consumed the highest percentage of initial glucose
- Determined that yeast in grape juice yielded the highest ethanol productivity per initial glucose concentration with batch time of 2 days

THEORY & METHODS

Reaction



Materials

- 4 fruit juices: apple, grape, pineapple, grape-cranberry
- 2 bioreactor tanks: 5-gallon capacity
- *S. Cerevisiae* culture

Procedure

1. Inoculation of yeast for 20 minutes → 2. Batch fermentation with 2 juices at a time → 3. Density and absorbance measurements → 4. Clean and iterate using a new set of juices

Equations

$$\%ABV = 131.25 \cdot (Original\ Gravity - Final\ Gravity)$$

$$C_{Ethanol}\ \frac{g}{L} = \frac{\%ABV}{100} \cdot 789\ \frac{g}{L}$$

RESULTS & DISCUSSION

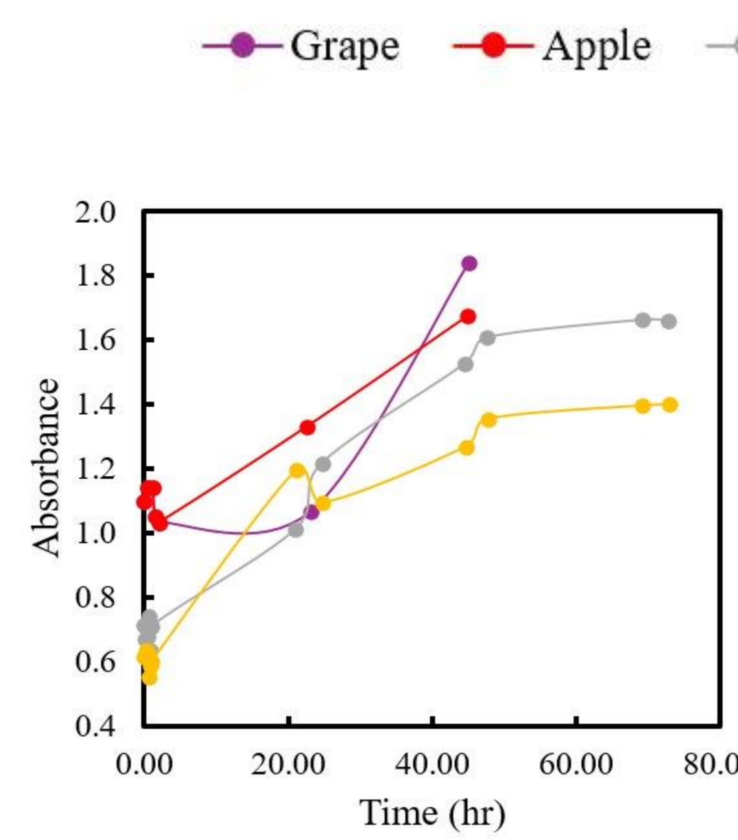


Figure 1. Absorbance vs. time (hr) for bioreactor samples of fermented fruit juices

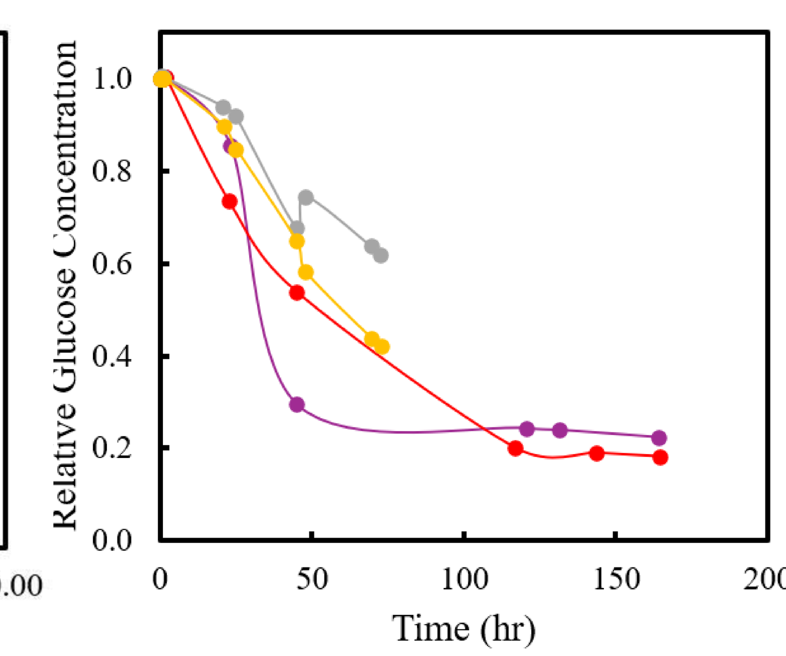


Figure 2. Relative glucose concentration vs. time (hr) for bioreactor samples of fermented fruit juices

Absorbance Data Shows Steady State Cell Concentration is Reached at Approximately 50 Hours

- In **Fig.** 1, at time of 50 hours the ethanol concentration is substantial enough to inhibit cell growth.
- Because of this, we see a plateau from time 50 – 80 hours for grape-cranberry and pineapple.
- The blank samples used to measure apple and grape trials were contaminated and steady state absorbance data was not found, but we will assume the same claim is true for grape and apple.

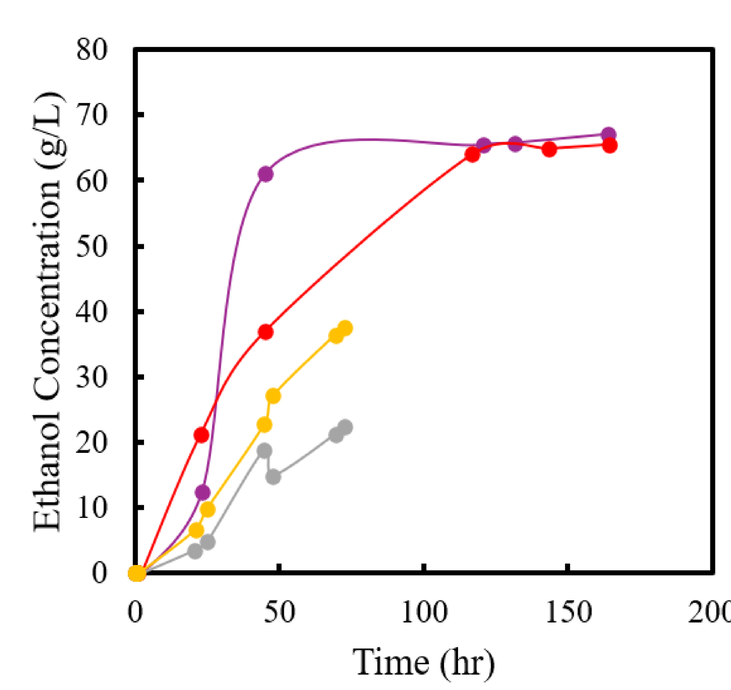


Figure 3. Ethanol concentration (g/L) vs. time (hr) for bioreactor samples of fermented fruit juices

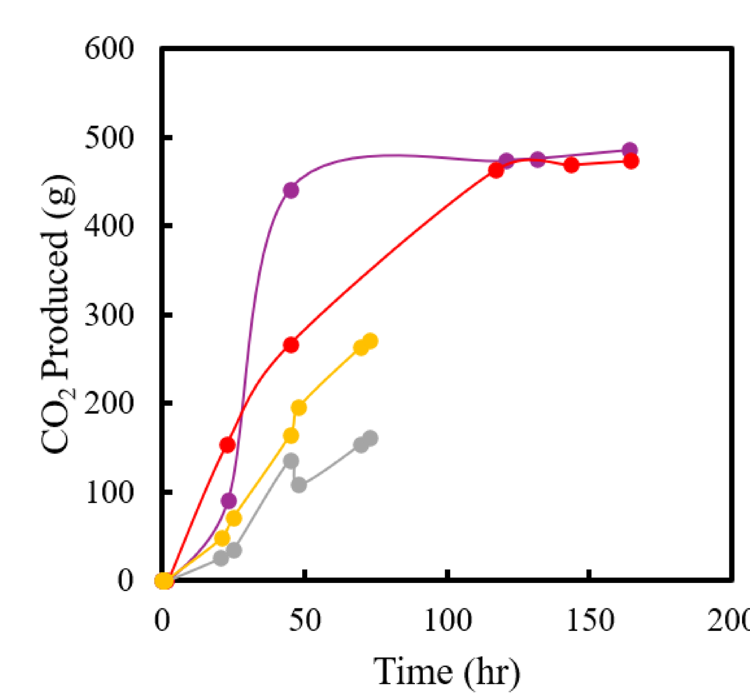


Figure 4. Carbon dioxide produced (g) vs. time (hr) for bioreactor samples of fermented fruit juices

Density Data Shows that Reaction Products and Reactants Reached Equilibrium at Different Times

- In **Fig. 2** Relative Glucose Concentration (RGC) is shown and can be defined as the amount of glucose remaining divided by the initial glucose in the reactor
- The reaction with the most efficient ethanol production would have a RGC close to zero
- The Apple juice run was most effective in consuming high percentages of glucose (80%)
- In **Fig. 3 & 4**, we see the Ethanol concentration and the amount of CO_2 produced over time, showing that the grape and apple reach the same ethanol concentration of approximately 65 g/L
- However, grape achieves this in nearly half the time it takes for apple

Batch Reactor Design Indicates that Grape Juice is the Optimal Environment for Bioethanol Production

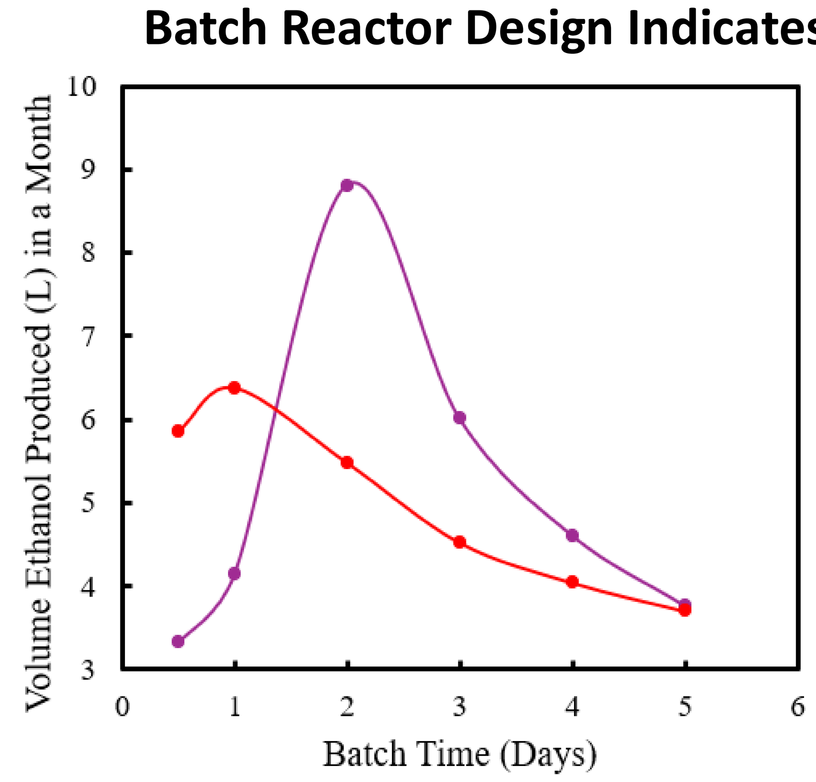


Figure 5. Volume of ethanol produced in one month given differing reactor batch times. Dead time is assumed to be negligible compared to the overall reaction time

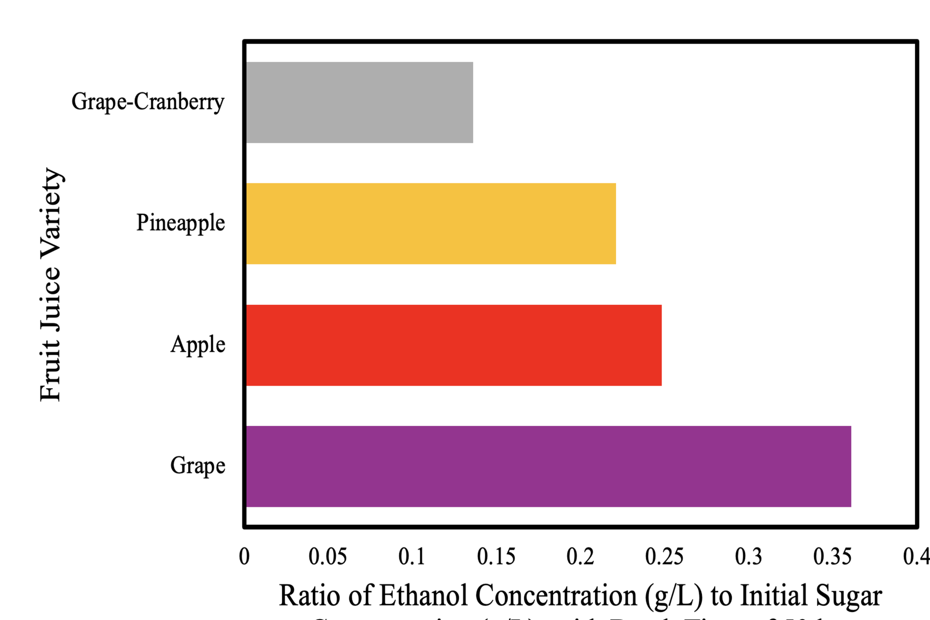


Figure 6. Ratio of final ethanol concentration (g/L) to initial sugar concentration (g/L) for each fruit juice variety, with a batch time of 50 hours

- In **Fig. 5,** theoretical apple and grape juice productivities are compared, showing that the optimal batch time varies by juice, and that the optimal condition is to cultivate yeast in grape juice with a batch time of two days
- We also can compare the productivity of this batch time to the other two juices in **Fig. 6**, and we see that grape juice is still superior
- **Main Accomplishment:** A batch time of 2 days with grape waste will have the highest productivity of ethanol per month

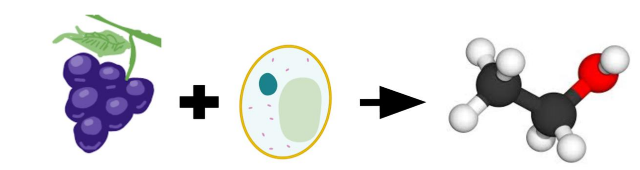
CONCLUSIONS

Purpose and Scope

We determined which food waste has the highest ethanol productivity rate for the energy and sustainability industries: Grape juice

Objectives and Conclusions

- Steady state cell concentration is reached at around 50 hours
- Yeast in apple juice consumed the highest percentage (80%) of glucose
- Apple and grape yeasts reached the same ethanol percentage of about 8.5% ABV, but grape reached this in a fraction of the time
- Yeast in grape juice yielded the highest ethanol productivity per initial glucose concentration with batch time of 2 days, producing 8.8 L/month of ethanol



RECOMMENDATIONS

- Rerun apple and grape trials with refrigerated blank samples for spectrophotometer calibration
- Time Limitation: Conduct multiple trials and average the results
- Time Limitation: Run pineapple and grape-cranberry juice for longer durations
- Time and Money Limitation: Use a closer representation of real food waste, such as powders, and standardize measurements of samples containing the waste

REFERENCES

- Gonçalves, J. (2025). A revisit of plant food waste along food supply chains. *Journal of Cleaner Production*, **423**, 140452. https://doi.org/10.1016/j.jclepro.2023
- Santeramo, F. G. (2021). Exploring the link among food loss, waste and food security: What the research should focus on? *Agriculture & Food Security*, **10**, 26. https://doi.org/10.1186/s40066-021-00302-z
- Lavoie, J. (2023, January 4). How to use a hydrometer to measure alcohol by volume. *Beer Craftr*. https://www.beercraftr.com/how-to-use-hydrometer-to-measure-abv/