Introduction

The world today is in no shortage of wasted food. Out of the 4.4 x 10^10 metric tons of food that is produced by the world in total each year, a full third of it is wasted or lost (FAO, 2013).

- Wasted food, via microbes, generates organic acids that can be used to synthesize plastics, fibers, adhesives, and solvents (Devinette et al., 2000; Wisch 2000). (Kotl et al., 2017).
- Most prior research has been on primary sludge as the exclusive substrate (Easterjohn et al., 1998), or on food waste with extremely low loading rates. (Kim et al., 2014). In addition, the goal of past research has been on methane production, rather than acid production.

The motivation behind this research is to maximize acid production at high loading rates of food waste while disallowing methane production.

The decline in lactic acid concentrations may be a result of the following factors in order of greatest to least preference:

- pH was held constant at 5.5.
- It cannot be extracted cost-effectively from the substrate.
- Pretreatments for the food waste should be considered; such measures may aid in increasing total yields, or decreasing retention time.
- Much of this research may be repurposed to the digestion and stabilization of other substrates: human waste is an excellent candidate for this type of research.

Methods

Sample Preparation
- Food waste was taken from local dining halls and homogenized. Preliminary tests were run on the undiluted VS concentration in the food waste solids content, nutritional composition, etc. The food waste was then inoculated with primary sludge to ensure a healthy bacteria culture.
- Substrate was then placed into a bioreactor (pictured below), where desired variables were controlled for.

Data Collection
- Five different batches of food waste were prepared: Batches 1 & 2 were used to design general parameters.
- Batches 3-5 were then used to optimize loading rates.
- Batches 4 & 5 (the focus of this poster) refined and confirmed previous results.

- Samples were then taken from the bioreactors at predetermined intervals to judge progression in acid production.
- The concentrations of acids generated by the bacteria were measured using high performance liquid chromatography (HPLC).
- Data on macromolecule composition and volatile solids concentration were also collected to help characterize the substrate.

- The microbial consumption of the following macronutrients present in the substrate in 24 hours:
  - Carbohydrates, with an 85% net consumption rate.
  - Lipids, with a 70% net consumption rate.
- Waste rich in carbohydrates and lipids is more easily indicated that waste food shipped to landfills costs the United States $113 billion dollars, or 870 million lbs., of lactic acid thrown away each day in the form of food waste.
- Digesters created especially for food waste can be scaled down tremendously in size and capital: large-scale two stage anaerobic digesters have retention times of up to 14 days (Scherer et al., 1999) and thus require huge amounts of space to accommodate all of the substrate it sinters.

Further Considerations
- Research on separating out valuable product from the food waste must be done. The product is useless if it cannot be extracted cost-effectively from the substrate.
- Pretreatments for the food waste should be considered; such measures may aid in increasing total yields, or decreasing retention time.
- Much of this research may be repurposed to the digestion and stabilization of other substrates: human waste is an excellent candidate for this type of research.

References & Acknowledgments

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2. Agricultural & Biological Engineering
3. Environmental Sciences and Engineering
4. Environmental & Biological Engineering

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Optimization of Lactic Acid Production from Food Waste via Anaerobic Respiration

Results

Optimal Loading Rates

<table>
<thead>
<tr>
<th>Batches</th>
<th>Lactic Acid Yield per Gram Volatile Solids</th>
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</thead>
<tbody>
<tr>
<td>Batches 1 &amp; 2</td>
<td>0.62</td>
</tr>
<tr>
<td>Batches 3 &amp; 4</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Optimal pH and Temperature Thresholds

<table>
<thead>
<tr>
<th>pH</th>
<th>Temperature</th>
<th>Lactic Acid Yield per Gram Volatile Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>≥41 °C</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Macronutrient Analysis

- Carbohydrates, with an 85% net consumption rate.
- Lipids, with a 70% net consumption rate.

Conclusions

- Food lost to transportation, neglect, or disease can be fermented to generate useful byproducts in the form of lactic acid, which has been shown to reach concentrations of 40 g / L of food waste in just 16 hours; optimal conditions for fermentation are at a pH of 5.5, a temperature of 41 °C, and a retention time of 16 hours, and a loading rate of 150 g volatile solids / L.
- Microbial life in the food waste exhibits a level of resilience to varying temperature and pH. Small variations in performance across varying parameters suggest tolerance for changing conditions.
- Technology for harnessing this food waste resource should be investigated: the current market price for lactic acid is 37 $ / lb. (Ewing 2013). Optimal pH and loading rates were tested in the wasted food in the world (in one year) were to be fermented for 16 hours, and the lactic acid from food fermentation could be captured completely, there would be approximately 368 billion dollars’ worth of product available for human consumption. That’s a little more than 2 billion dollars, or 87 million lbs., of lactic acid thrown away each day in the form of food waste.
- Digesters created especially for food waste can be scaled down tremendously in size and capital: current large-scale two stage anaerobic digesters have retention times of up to 14 days (Scherer et al., 1999) and thus require huge amounts of space to accommodate all of the substrate it sinters.

References