TOWARDS TO ANAEROBIC CO-DIGESTION OF OFMSW BASED ON THE ANALYSIS OF CHEESE WHEY AND MEAT WASTE ON TWO TYPES OF SLUDGE

Authors
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Outline

1. Background
2. Method
3. Results
4. Conclusions
## 1. Background

### Supply and Demand of energy(*)

<table>
<thead>
<tr>
<th>Fuels</th>
<th>Supply (PJ)</th>
<th>Demand (PJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>México</td>
<td>8,624</td>
<td>5,128</td>
</tr>
</tbody>
</table>

The Mexican Law for the Use of Renewable Energy and the Financing of Energy Transition (LAERFTE, 2008) establishes that, by 2024, participation of non-fossil sources in electricity generation will be 35% in Mexico.

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(*) Prospectivas del Sector Energético, Secretaría de Energía. 2016
1. Background

Current situation.

- **Mexico City**
  - 117,500 t/d (2015)
  - 128,000 t/d (2020)

- **OFMSW**: 75%
- Treatment through **anaerobic digestion**, energy production.
- The characteristics of the substrate condition the production of biogas

Fatty acids long chain (Lauric, myristic, palmitic)

Monomers (Sugars, amino acids)

Complex Polymers

Lipids
Proteins
Carbohydrates

Hydrolytic Bacteria

Acidogenesis

Fermentative Bacteria

Hydrolysis

Volatile Fatty Acids

Valerate
Caproate

H₂ + CO₂

Acetogenesis

Homoacetogenic bacteria
Oxidative Bacteria of Acetate

Acetate

Sulfate-reducing bacteria
Nitrate-reducing bacteria
Alcohols (Methanol, ethanol)

Syntrophic Hydrogen Production Bacteria

Nitrate (NO₃⁻)

Acetolactic Methanogenic

H₂S

Propionate

Acetate

Butyrate

Oxidative Bacteria of Acetate

Methanogenesis

Acetate

H₂S

N₂

NH₃

Hydrogenotrophic Methanogenic

CH₄

Nitrate- and sulfates

Sulfate-reducing bacteria
Denitrifying bacteria

First stage

Second stage
1. Background

Substrates for Anaerobic Digestion

Tendency to flexibilize the production of biogas according to the energy demand

- Agriculture waste
- Animal by-products
- Industrial and commercial waste
- Energy crops
- Municipal waste

1. Background

Food waste by type in Mexico

1. Background

In Mexico, 47% is discharged to sewer system
The CW produced has a pH of 5 to 5.8.

1. Background

Waste from the meat industry

National Consumption by origin

- Bovino: 89% National, 11% International
- Pollo: 83% National, 17% International
- Porcino: 69% National, 31% International
- Guajolote: 12% National, 88% International

In Mexico 403,257 tones of beef are wasted. A 34.8% of national food waste

20% is discharged to rivers; 15% to landfills; And 3%, incinerated.

Reference: Prepared based on Consejo Mexicano de la Carne con datos del SIAP. AMEG. 2015
3. Aim

Assess anaerobic co-digestion of OFMSW based on the analysis of cheese whey (CW) and meat waste (MW) on two types of sludge to increase biogas production.
5. Method

- Origin of substrates and seed sludge
- Characteristics of the substrate
- Batch experiments
- Cumulative biogas production
5. Method

Origin of substrates and seed sludge

OFMSW
Cuautitlán Izcalli (65 kg)
Granular (20 L)

MW
Santa Cruz Market (10 kg)
Sludge

CW
Santa Rosa Farm (10 L)
Suspended (20 L)
5. Method

Characterization based on Standard Methods

Reduced particle size
5. Method

**Batch experiments**

![Substrate and Inoculum](image)

- Substrate: 50%
- Inoculum: 50%

**Analysis and experimental follow-up**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Initials/finals</th>
<th>Daily</th>
<th>Weekly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids (ST, SF, SV)</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biogas (CO₂ and CH₄)</td>
<td>●●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>●</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Operational conditions**
- Reactor Capacity: 500 mL
- Working volume: 400 mL
- Temperature: 35 °C

**Biogas quantification**
- Volume: increase in pressure
- Composition: gas chromatography
- Variable response: methane volume
## 6. Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>OFMSW</th>
<th>CW</th>
<th>MW</th>
<th>Granular sludge</th>
<th>Suspended sludge</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>5.05 ± 0.14</td>
<td>3.67 ± 0.14</td>
<td>7.15 ± 0.14</td>
<td>6.71 ± 0.12</td>
<td>6.5 ± 0.13</td>
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<tr>
<td>Humidity (%)</td>
<td></td>
<td>86 ± 0.14</td>
<td>94 ± 0.14</td>
<td>50 ± 0.14</td>
<td>92 ± 0.15</td>
<td>90 ± 0.16</td>
</tr>
<tr>
<td>COD (gO₂/kg)</td>
<td></td>
<td>50 ± 1.3</td>
<td>72 ± 1.3</td>
<td>73 ± 1.3</td>
<td>47 ± 0.3</td>
<td>72 ± 0.7</td>
</tr>
<tr>
<td>TS (g/kg)</td>
<td></td>
<td>130 ± 5.6</td>
<td>64 ± 5.6</td>
<td>531 ± 5.6</td>
<td>61 ± 1.3</td>
<td>96 ± 1.3</td>
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<tr>
<td>VS (g/kg)</td>
<td></td>
<td>125 ± 17</td>
<td>54 ± 17</td>
<td>522 ± 17</td>
<td>61 ± 0.9</td>
<td>96 ± 1.3</td>
</tr>
<tr>
<td>NH₄-N (g/kg)</td>
<td></td>
<td>0.2 ± 0.01</td>
<td>0.3 ± 0.01</td>
<td>0.5 ± 0.01</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Nitrogen* (g/g)</td>
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<td>2 ± 0.14</td>
<td>2 ± 0.14</td>
<td>9 ± 0.14</td>
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<td>-</td>
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<tr>
<td>Carbon* (g/g)</td>
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<td>44 ± 1.3</td>
<td>36 ± 1.3</td>
<td>68 ± 1.3</td>
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<td>-</td>
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<tr>
<td>Hydrogen* (g/g)</td>
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<td>5 ± 5.6</td>
<td>6 ± 5.6</td>
<td>9 ± 5.6</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Carbohydrates</td>
<td>g/kg</td>
<td>118 ± 17</td>
<td>18 ± 17</td>
<td>4.1 ± 17</td>
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<td>-</td>
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<tr>
<td>Lipids</td>
<td>g/kg</td>
<td>39 ± 0.14</td>
<td>1.6 ± 0.14</td>
<td>72 ± 0.14</td>
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<tr>
<td>Proteins</td>
<td>g/kg</td>
<td>34 ± 0.14</td>
<td>11 ± 0.14</td>
<td>155 ± 0.14</td>
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<tr>
<td>Lignin</td>
<td>g/kg</td>
<td>30 ± 1.3</td>
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<td>-</td>
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<tr>
<td>Cellulose</td>
<td>g/kg</td>
<td>47 ± 5.6</td>
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<td>-</td>
<td>-</td>
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<tr>
<td>Hemicellulose</td>
<td>g/kg</td>
<td>12 ± 17</td>
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</table>
6. Results

<table>
<thead>
<tr>
<th>Seed sludge</th>
<th>Initial conditions</th>
<th>Reactor</th>
<th>21 days anaerobic monodigestion*</th>
<th>90 days anaerobic codigestion*</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>VFA (g L(^{-1}))</td>
<td>Biogas production (NL kgVS(^{-1}))</td>
</tr>
<tr>
<td>Granular</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>OFMSW+CW</td>
<td>R1</td>
<td>3.4</td>
<td>113</td>
<td></td>
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<tr>
<td>OFMSW+MW</td>
<td>R2</td>
<td>7.9</td>
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<td>OFMSW</td>
<td>R3</td>
<td>1.0</td>
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<tr>
<td>Suspended</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OFMSW+CW</td>
<td>R4</td>
<td>9.7</td>
<td>81</td>
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<tr>
<td>OFMSW+MW</td>
<td>R5</td>
<td>10.9</td>
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<tr>
<td>OFMSW</td>
<td>R6</td>
<td>1.3</td>
<td>6.8</td>
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</table>
## 6. Results

<table>
<thead>
<tr>
<th>Reactor</th>
<th>RT</th>
<th>pH</th>
<th>TS (g/ kg)</th>
<th>TS removed (%)</th>
<th>VS (g/ kg)</th>
<th>VS removed (%)</th>
<th>COD (gO2/kg)</th>
<th>COD removed (%)</th>
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<tbody>
<tr>
<td>R1</td>
<td>Initial</td>
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<td>102</td>
<td>47.5</td>
<td>84</td>
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<td>21</td>
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<td>38</td>
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<td>R3</td>
<td>Initial</td>
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<td>29.5</td>
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<td>R4</td>
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<td>18</td>
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<td>19</td>
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<td>R5</td>
<td>Initial</td>
<td>8.3</td>
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<td>68.6</td>
<td>80</td>
<td>76.2</td>
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<td>48.2</td>
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<td>Final</td>
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<td>27</td>
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<td>19</td>
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<tr>
<td>R6</td>
<td>Initial</td>
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<td>104</td>
<td>81.7</td>
<td>96</td>
<td>90.6</td>
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<td></td>
<td>Final</td>
<td>6.7</td>
<td>19</td>
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<td>9</td>
<td></td>
<td>11</td>
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</tr>
</tbody>
</table>
6. Results

Figure 2. Daily variation of biogas production under BPM test at 35°C, granular sludge.

Figure 3. Process performance on suspended sludge and daily quantity of biogas production.
7. Conclusions

- The highest concentration of VFA at the end of the first stage (45-day) was R1, and thereafter due to the accumulation decreased the biogas production.
- At the end of co-digestion, (90-day) high biogas yield of 383 NL kgVS⁻¹ was observed at R2; co-digestion of mixtures of meat waste with OFMSW allows higher production of biogas.
- The highest production of biogas was from reactors operated with granular sludge.
- The conclusions of this study apply to lab-scale batch operations, therefore, a further improvement of the seeded sludge is deemed required to increase the rate of either CW or MW in codigestion with OFMSW.
Thank you
ANATOMY OF A GROUP MEETING PRESENTATION

- Pulled all-nighter, finished slides 5 minutes before meeting started.
- Trying to come up with insightful question that will impress advisor.
- First year, only person actually paying attention. Has no clue what's going on.
- Relieved she doesn't have to explain why she hasn't done anything this week.
- Starving, thought there'd be food at meeting.
- Has written two proposals in his head since meeting started.