Bio-ethanol production

from sugar- and starch, cellulose containing feedstock

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Feedstock: types

- Sugar
- Starch
- Cellulose

(starch granules)
Feedstock types

Cellulose fibrils in plant cell wall (TEM)

polymers of beta glucose

Glucose monomer
Feedstock: examples

- Sugar cane
- Corn
- Cassava
- Sugar palm
- Sugar beet
- Sweet Sorghum
- Sweet potato
- Bananas
- Coffee residues
- Wood
Production potentials

1 kg of sucrose $\rightarrow$ 0.52 liters of ethanol ($\approx 12.6$ MJ)

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Yield</th>
<th>Ethanol yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar palm</td>
<td>20 ton sucrose /ha/year</td>
<td>$\approx 10000$ liters/ha/year</td>
</tr>
<tr>
<td>Cassava</td>
<td>25 - 60 ton/ha per year</td>
<td>$\approx 3750$ - $6000$ liters/ha/year</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>40 - 75 ton raw sugar cane/ha/yr</td>
<td>$\approx 2800$ - $5250$ liters/ha/year</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td></td>
<td>$\approx 2500$ – $4000$ liters / ha/ year</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>60 ton/ha/year</td>
<td>$\approx 5700$ liters/ha/year</td>
</tr>
<tr>
<td>Corn</td>
<td>5 ton/ha/year</td>
<td>$\approx 2050$ liters/ha/year</td>
</tr>
<tr>
<td>Wheat</td>
<td>4 ton/ha/year</td>
<td>$\approx 1560$ liters/ha/year</td>
</tr>
</tbody>
</table>
Cassava

- 25 ton/ha per year
- 150 liter etanol/ton
- 3.750 lts etanol/ha por year

Evaluation of efficiency of bioethanol production from different cassava varieties
Sweet sorghum

Sugar beet

2500-5700 liter/ha/year
**Sweet potato ethanol**

- 45 ton/ha per year
- 150 liter ethanol/ton
- 6750 lts etanol/ha per year

**other root crops**

* Xanthosoma y Violaceum
Banana

- No need for mechanisation
- 50 kg/plant
- 67 ton/ha per year
- 3,350-7,000 liter ethanol/ha per year
Ethanol production

- (Hydrolisis)
- Fermentation
- Distillation
- Drying
Hydrolisis

• The cellulose molecules are composed of long chains of sugar molecules. In the hydrolysis process, these chains are broken down to free the sugar, before it is fermented for alcohol production.

• There are two major cellulose hydrolysis (cellulolysis) processes: a chemical reaction using acids, or an enzymatic reaction.
Fermentation

- The chemical equation below summarizes the fermentation of glucose, whose chemical formula is $C_6H_{12}O_6$.

- One glucose molecule is converted into two ethanol molecules and two carbon dioxide molecules:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$
Fermentation

Conventional Ethanol Production Process

- Barley
- Rye
- Milo
- Corn
- Wheat
- Tapioca

**Grinding**

**Slurry Tank**

**Jet Cooker**

- Water
- >100 °C
- 5-8 min.

**Thermo-stable Alpha Amylase**

**Liquefaction**

**Glucoamylase**

**Saccharification**

**60 °C**

**8-10 hrs. (optional)**

**Secondary Liquefaction**

- 95 °C
- ~ 90 min.

**Yeast**

**Fermentation**

**Alcohol Recovery**

**Distillation & Dehydration**

**Storage Tank**

**DDGS**

*pH adjustment steps are not shown*
Fermentation: Colombia
Distillation & Ethanol drying

Distillation of 1000 liter of 10 v/v [%] produces about 100 liter of ethanol in the following forms*:

<table>
<thead>
<tr>
<th>Liters production</th>
<th>Vol [%]</th>
<th>Liters pure EtOH</th>
</tr>
</thead>
<tbody>
<tr>
<td>75,5</td>
<td>50</td>
<td>37,7</td>
</tr>
<tr>
<td>37,7</td>
<td>70</td>
<td>26,4</td>
</tr>
<tr>
<td>37,7</td>
<td>95</td>
<td>35,8</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

(*based on field data John Loke)
Uses for ethanol

Hydrous ethanol
- Engine fuel (flextek → > 60 vol %)
- Cooking stoves
- Gelfuels

Anhydrous ethanol
- Blends with gasoline (e.g. E85)
- Blends with diesel
- Direct use in cars
- Stoves
Flextek

-东风汽车公司*

65 % ethanol &
35% water

*Dongfeng Motor Corporation (China)*
Small scale bioethanol production

Rural communities

↓

Consortium of bio-ethanol producers

↓

Total land for energy crops
Up to 100 ha.

↓

Micro plants: 1,000 – 2,000 liters/day (50%-99,5%)

↓

Central plant for anhydrous ethanol (99,5%)
Composición del fruto del café
Coffee Cherry

- Exocarpio (pulpa 42%) - pulp
- Mesocarpio (mucilago 16%) - mucilage
- Endocarpio (pergamino 4%) - parchment
- Agua 20% (water)
- Espermodermo (película plateada) - silver skin
- Endospermo (semilla 18%) - seed

COOPEDOTA
Innovative technology to enable rural entrepreneurs to access markets for bio-energy
Thank you for your attention.

Questions?