Biofuels from Waste and Non Edible Feedstocks

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Eco Asia Conference October 28-29, 2008, Hong Kong
Biofuels, 1

The break-through

August 2005

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Biofuels, 2

The turning point

December 2007

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Biofuels, 3

The end of a myth?

April 2008
Biofuels, 4

The future?

The little shrub that could — maybe


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1987: 1st pilot plant worldwide for Biodiesel: Silberberg, Styria, Austria

1st Biodiesel Plant in a European Capital, BDV Vienna, 2006

IFC: Over 25 Years Experience in Biodiesel

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Biodiesel Plant Hong Kong, 100.000 t/a by BDI, Austria
Feedstocks: Trap grease, UCO, PFAD
Put into operation: 2009
Biodiesel: Fatty Acid (M)ethyl Esters from natural origin

Triacylglycerides
Vegetable oils, animal fat, microbial oils

Hydrolysis, veg. oil raffination, soap stock

Fatty Acids

Esterification

Transesterification

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Biodiesel Production 2007

Source: EBB, NBB, EurObserver

USA: 1,000,000 t
Rest of world: 2,500,000 t
EU27: 5,713,000 t
Germany: 2,890,000 t
France: 872,000 t
Italy: 363,000 t
Others: 1,588,000 t
(Austria: 267,000 t)

World transport fuel demand 2050: 4.050 mill. tons

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# Vegetable Oil Production

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World total</td>
<td>130.3</td>
<td>138.4</td>
<td>145.8</td>
<td>152.9</td>
<td>22.6</td>
</tr>
<tr>
<td>Soybean</td>
<td>30.9</td>
<td>32.9</td>
<td>34.8</td>
<td>36.6</td>
<td>5.7</td>
</tr>
<tr>
<td>Palm</td>
<td>29.9</td>
<td>33.3</td>
<td>35.2</td>
<td>37.6</td>
<td>7.7</td>
</tr>
<tr>
<td>Rape/Canola</td>
<td>14.4</td>
<td>15.7</td>
<td>17.7</td>
<td>18.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Sunflower</td>
<td>9.6</td>
<td>9.4</td>
<td>10.5</td>
<td>10.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>4.2</td>
<td>5.0</td>
<td>4.9</td>
<td>5.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Peanut</td>
<td>4.8</td>
<td>4.5</td>
<td>4.6</td>
<td>4.5</td>
<td>-0.3</td>
</tr>
<tr>
<td>Corn</td>
<td>2.0</td>
<td>2.1</td>
<td>2.2</td>
<td>2.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Olive</td>
<td>3.2</td>
<td>3.0</td>
<td>2.7</td>
<td>3.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>Palm-kernel</td>
<td>3.5</td>
<td>3.9</td>
<td>4.1</td>
<td>4.3</td>
<td>0.8</td>
</tr>
<tr>
<td>Coconut</td>
<td>3.1</td>
<td>3.2</td>
<td>3.3</td>
<td>3.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Butter</td>
<td>6.4</td>
<td>6.6</td>
<td>6.8</td>
<td>7.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Lard</td>
<td>7.3</td>
<td>7.5</td>
<td>7.7</td>
<td>7.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Tallow</td>
<td>8.1</td>
<td>8.3</td>
<td>8.4</td>
<td>8.5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Other commodities not included in this table are **fish oil (~1.0 MT)**, **sesame (~0.8 MT)**, **linseed (~0.7 MT)**, and **castor (~0.5 MT)**. MT; million metric tons.

Source: INFORM adapted from *Oil World Annual 2006*

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European Directive on the Promotion of the Use of Energy from Renewable Sources
January 2008

Binding Target for Renewable Energy 2020: 20 %
Binding Target for Biofuels 2020: 10 %

• Valid for all 27 member states

• Production being sustainable (> 35 % GHG saving)

• Second-generation biofuels becoming commercially available

• Fuel Quality Directive: allow for adequate levels of blending

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Feedstocks for Biodiesel Production

First Generation:
Vegetable food oils: rape seed, palm, soybean, sunflower

Second Generation:
„New“ seed oils
Cuphea, camelina, crambe, cotton seed, GMO
Non-edible seed oils
Jatropha curcas, castor oil, karanja….
Waste oils and fats
Used frying oil, tallow, soap stock, trap grease

Third Generation:
Single cell oils: algae
1983:

First Experiments With Used Frying Oil

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Potential of Used Frying Oil in EU-27

Per Capita Disappearance of Fats and Oils

Netherlands 88 kg/a
Belgium 62 kg/a
Germany 42 kg/a
Austria 30 kg/a
EU-15 43 kg/a
USA 45 kg/a
Brazil 22 kg/a

Maximum Collectable Amount of Recycled Frying Oil

approx. 5 kg/p.a.
population: 493 mill.
2.5 mill. t/a
approx 1 % of transport fuel demand
All 150 City Buses in Graz are running with 100 % Biodiesel from Used Frying Oil

World Climate Star 2002
Osmose Award 2006
Animal Byproducts as Feedstock

Animals

Food Production

Food, Tallow + Byproducts

Food, Oleochemistry

Disposal

Rendering

Meat and Bone Meal + Fat

SRM – Specified Risk Material

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Prion protein responsible for BSE disease:

Destruction during Biodiesel process?
The Scientific Panel on Biological Hazards concludes that the Biodiesel process as described (BDI) is considered as safe for treatment and use of ABP of category 1.
Potential for Biodiesel-Production in EU-27

Maximum Potential on Rendered Fat: 2,000,000 t/a

Demand for Transport Fuel EU-27: 300,000,000 t/a

Substitution: 0.7 %

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**Jatropha curcas L.**
The Biodiesel Crop in the Future???
Jatropha curcas Hype

jatros (griech.) = physician
trophe (griech.) = food

Useful links:
www.jatropha.de
www.jatropha.world.org

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Symposium on Biofuel and Industrial Products from *Jatropha curcas* and other Tropical Oil Seed Plants

Managua / Nicaragua
23 - 27 February 1997
Jatropha curcas L. Source: www.jatropha.de

Jatropha fence, Mali, India

Rajasthan, India

Single trees, 35 y, Mali

Seeds, Ghana

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Possible Areas for Jatropha Cultivation

Figure 2. Global indication of the most suitable climate conditions for the growth of Jatropha (J. curcas L.) (30° N, 35° S) and Oil palm (Elaeis guineensis Jacq.) (4° N, 8° S).
Why *Jatropha c.* for Biofuel Production?

- Oil quality is similar to major food oils
- Could be used as PPO or transformed into biodiesel
- No change in oil raffination and biodiesel production is necessary
- High oil content in the seeds: 55 % (dehulled)
- High productivity: approx. 1,600 l of oil per ha
- Content of toxic compounds in the seeds: curcine in protein, phorbol esters in oil
- No competition with food production
Possible Risks of Jatropha

• High yields need agricultural production (water, fertilizer, pest control)

• Toxic seeds have to be processed in specified plants (labelling ?)

• Harvesting is laborious, long harvesting period

• Detoxification of oil cake would improve the economy

• Research on non-toxic varieties, plant breeding, GM
Toxic Principles of *Jatropha Curcas* L.

**Phorbol esters:**
- mainly in the oil; esters of tigliane diterpenes
- tumor promotion, cell proliferation, activation of blood platelets, lymphocyte mitogenesis, inflammation

**Curcin:**
- mainly in the oil cake; Ribosome-inactivating protein

**Non-toxic varieties found in Mexico**
Identification of 6 New Phorbol Esters


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Castor (*Ricinus communis* L.)

World production: 0.6 mill. t/a

- **Occurrence**
  - Central Africa
  - India
  - Central and South America

- **Seeds**
  - 40-50% Oil
  - 14-22% Proteins

- **Use**
  - Glue, Cosmetics, Lubricants, Dyes
Castor: Unusual Compounds

a) Ricin
Lectine
LD_{50}: 0,02 mg/kg

b) Ricinolic acid

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Pongamia Pinnata L.
Karanja, Indian Beech Tree

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Hevea Brasiliensis, Rubber Tree
Hevea Brasiliensis, Rubber Seed

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# Fatty Acid Distribution of Non Edible Oils

<table>
<thead>
<tr>
<th></th>
<th>C-16:0</th>
<th>C-18:0</th>
<th>C-18:1</th>
<th>C-18:2</th>
<th>C-18:3</th>
<th>Others</th>
<th>Iodine Nr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rape seed</td>
<td>3-5</td>
<td>1-2</td>
<td>55-65</td>
<td>20-26</td>
<td>8-10</td>
<td></td>
<td>96-117</td>
</tr>
<tr>
<td>Jatropha curcas</td>
<td>12-17</td>
<td>5-10</td>
<td>37-63</td>
<td>19-41</td>
<td></td>
<td>1-2</td>
<td>93-107</td>
</tr>
<tr>
<td>Pongamia pinnata</td>
<td>3-8</td>
<td>2-9</td>
<td>44-71</td>
<td>10-18</td>
<td></td>
<td>15-20</td>
<td>80-96</td>
</tr>
<tr>
<td>Rubber seed</td>
<td>7-8</td>
<td>9-10</td>
<td>28-30</td>
<td>33-35</td>
<td>20-21</td>
<td></td>
<td>121-145</td>
</tr>
<tr>
<td>Sal</td>
<td>5-9</td>
<td>34-48</td>
<td>34-45</td>
<td>2-3</td>
<td></td>
<td>6-12</td>
<td>33-45</td>
</tr>
<tr>
<td>Castor</td>
<td>1-2</td>
<td>1-2</td>
<td>3-4</td>
<td>5-6</td>
<td>0.5-1</td>
<td>87-88</td>
<td>82-90</td>
</tr>
<tr>
<td>Tobacco seed</td>
<td>11</td>
<td>3.5</td>
<td>14.5</td>
<td>69.5</td>
<td></td>
<td></td>
<td>136-146</td>
</tr>
</tbody>
</table>

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*October 28, 2008, Hong Kong*
## Potential Non-edible Seed Oils in India

<table>
<thead>
<tr>
<th>Oil seed</th>
<th>Seed/kernl (00MT)</th>
<th>Oil yield (%)</th>
<th>Oil potential (000MT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sal</td>
<td>5504.0</td>
<td>12.5</td>
<td>68.8</td>
</tr>
<tr>
<td>Mohwa</td>
<td>490.0</td>
<td>35.0</td>
<td>17.10</td>
</tr>
<tr>
<td>Neem</td>
<td>418.0</td>
<td>20.0</td>
<td>8.36</td>
</tr>
<tr>
<td>Mangokernel</td>
<td>600.0</td>
<td>8.0</td>
<td>4.80</td>
</tr>
<tr>
<td>Karanja</td>
<td>111.0</td>
<td>27.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Kusum</td>
<td>90.0</td>
<td>33.0</td>
<td>2.97</td>
</tr>
<tr>
<td>Khakan</td>
<td>46.0</td>
<td>33.0</td>
<td>1.52</td>
</tr>
<tr>
<td>Pinnai/Undi</td>
<td>18.6</td>
<td>60.0</td>
<td>1.12</td>
</tr>
<tr>
<td>Pisa</td>
<td>12.0</td>
<td>48.0</td>
<td>0.58</td>
</tr>
<tr>
<td>Rubberseed</td>
<td>30.0</td>
<td>18.5</td>
<td>0.56</td>
</tr>
<tr>
<td>Dhupa</td>
<td>30.0</td>
<td>17.0</td>
<td>0.51</td>
</tr>
<tr>
<td>Kokum</td>
<td>12.5</td>
<td>40.0</td>
<td>0.50</td>
</tr>
<tr>
<td>Maroti/Kavathi</td>
<td>12.0</td>
<td>33.0</td>
<td>0.40</td>
</tr>
<tr>
<td>Nahor</td>
<td>5.7</td>
<td>40.0</td>
<td>0.23</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7379</strong></td>
<td><strong>-</strong></td>
<td><strong>110.50</strong></td>
</tr>
</tbody>
</table>

Source: Maheshwari, Naik, 2007
Microalgae for Biodiesel Production

M. Mittelbach, Melbourne, 2007

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## Oil Yields: kg/ha

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>145</td>
</tr>
<tr>
<td>Cotton</td>
<td>273</td>
</tr>
<tr>
<td>Soybean</td>
<td>375</td>
</tr>
<tr>
<td>Mustard</td>
<td>481</td>
</tr>
<tr>
<td>Camelina</td>
<td>490</td>
</tr>
<tr>
<td>Safflower</td>
<td>655</td>
</tr>
<tr>
<td>Rice</td>
<td>696</td>
</tr>
<tr>
<td>Sunflower</td>
<td>800</td>
</tr>
<tr>
<td>Peanuts</td>
<td>890</td>
</tr>
<tr>
<td>Poppy seed</td>
<td>978</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>1000</td>
</tr>
<tr>
<td>Castor</td>
<td>1188</td>
</tr>
<tr>
<td>Jojoba</td>
<td>1528</td>
</tr>
<tr>
<td>Jatropha</td>
<td>1590</td>
</tr>
<tr>
<td>Macadam</td>
<td>1887</td>
</tr>
<tr>
<td>Avocado</td>
<td>2217</td>
</tr>
<tr>
<td>Coconut</td>
<td>2260</td>
</tr>
<tr>
<td>Oilpalm</td>
<td>- 5000</td>
</tr>
<tr>
<td>Algae</td>
<td>20,000 – 100,000</td>
</tr>
</tbody>
</table>
Economy of Algal Biodiesel


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Conclusions, 1:

• Current food & fuel discussion triggers the search for alternative feedstocks for biofuels production

• Biomass from waste or non-edible feedstocks is a perfect alternative for biofuel production

• Besides ethanol biodiesel is the most established biofuel worldwide

• There is a potential of about 2 % substitution of transport fuel with BD from used frying oil and animal fat

• Non edible seeds like Jatropha today are booming, but risks have to be considered carefully

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Conclusions, 2:

• There is a huge variety of other non-edible seed oils, but the overall potential is limited

• Areas for marine biomass are unlimited, production costs today are far too high

• Biomass from non edible sources will be an ideal supplement, but no substitution for biofuels from agricultural crops

Goal: Food and Fuel
Thank You for Your Kind Attention!

Questions?