MITIGATION: IMPACT OF AGRICULTURAL PRACTICES

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Overview

• Introduction
• Agriculture
• Processing
• Formation pathways
• Conclusion
• #1 in palm oil and pink guave
• 2.4 M MT palm oil
• Total planted 531,299 ha
• 8 refineries in 3 continents
• Globally > 800 customers
• Annual sales: > 1 Billion EUR
Sime Darby: a Century of Responsibility

William Sime and Henry Darby started first commercial plantation at Tennamaraman Estate, Selangor, Malaysia

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1917</td>
<td>First commercial plantation</td>
</tr>
<tr>
<td>1965</td>
<td>First R&amp;D project on biological pest management</td>
</tr>
<tr>
<td>1985</td>
<td>Zero burning technology introduced</td>
</tr>
<tr>
<td>1989</td>
<td>New composting technology for empty fruit bunches</td>
</tr>
<tr>
<td>1992</td>
<td>Global UN 500 award for zero burning technology</td>
</tr>
<tr>
<td>2003</td>
<td>Founding member of RSPO</td>
</tr>
<tr>
<td>2007</td>
<td>SPOT project: first shipment of traceable Palm Oil to Unilever</td>
</tr>
<tr>
<td>2011</td>
<td>&gt;50% of all plantations RSPO certified</td>
</tr>
</tbody>
</table>
New R&D Innovation Centre Europe

- Customer meeting place
- Food laboratories
- Pilot plants
- Quality and Nutrition centre

Netherlands
What is palm oil?

“It has the scent of violets, the taste of olive oil and a color which tinges food like saffron but is more attractive”

Ca’da Mosto, 15th century explorer, on discovering palm oil
## Basic Facts on Oil Palm

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin</td>
<td>West Africa</td>
</tr>
<tr>
<td>Height increment</td>
<td>60-70 cm per year</td>
</tr>
<tr>
<td>Frond length</td>
<td>6-8 m</td>
</tr>
<tr>
<td>Ripe fruit</td>
<td>Yellowish red</td>
</tr>
<tr>
<td>Nursery period</td>
<td>12-15 months</td>
</tr>
<tr>
<td>Age of harvesting</td>
<td>30 months after planting</td>
</tr>
<tr>
<td>Planting density</td>
<td>124-148 trees/ha</td>
</tr>
<tr>
<td># of bunches</td>
<td>12-18 bunches per year</td>
</tr>
<tr>
<td>Fruit per bunch</td>
<td>1,000-3,000 fruitlets</td>
</tr>
<tr>
<td>Bunch weight</td>
<td>20-30 kg</td>
</tr>
<tr>
<td>Fruitlet weight</td>
<td>10 g</td>
</tr>
<tr>
<td>Kernel per fruit</td>
<td>5-8%</td>
</tr>
<tr>
<td>Oil to bunch ratio</td>
<td>20-25%</td>
</tr>
<tr>
<td>Oil production</td>
<td>4-5 tonnes/ha/year</td>
</tr>
</tbody>
</table>
Oil Palm

Palm oil
- Olein
- Stearin

Palm Kernel oil
# Yield comparison

<table>
<thead>
<tr>
<th>Oil crop</th>
<th>Oil value as % of total crop value</th>
<th>Typical crop yield MT/ha/yr</th>
<th>Oil yield MT/ha/yr</th>
<th>Planting to harvest (months)</th>
<th>Recovery process</th>
<th>Side product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>40</td>
<td>3</td>
<td>0.5 – 1</td>
<td>&lt; 6</td>
<td>hexane extraction</td>
<td>High quality animal feed meal*</td>
</tr>
<tr>
<td>Sunflower</td>
<td>80</td>
<td>2.5</td>
<td>0.5 – 1</td>
<td>&lt; 6</td>
<td>pressing and extraction</td>
<td>Low quality animal feed meal</td>
</tr>
<tr>
<td>Rapeseed (Canola)</td>
<td>80</td>
<td>3.5</td>
<td>0.5 - 1</td>
<td>&lt; 6</td>
<td>pressing and extraction</td>
<td>Low quality animal feed meal</td>
</tr>
<tr>
<td>Palm oil</td>
<td>90</td>
<td>20</td>
<td>4 - 5</td>
<td>30 - 40</td>
<td>pressing</td>
<td>Palm kernels</td>
</tr>
<tr>
<td>Palm kernel</td>
<td>10</td>
<td>0.4</td>
<td></td>
<td></td>
<td>pressing</td>
<td>Low quality animal feed meal</td>
</tr>
</tbody>
</table>

*the high quality animal feed meal is the main product
Oil Palm:
# 1 crop in oil yield per hectare

Source: Oil World, 2008
High Oil Output on Less Land

Palm Oil: takes up 13 million hectares or 6% of the area but 38% of world vegetable oil output

Total area: ± 240 M Ha  % volume vegetable oils

Soybean: 27.6%  Palm oil: 38.2%  Rapeseed: 16.5%  Sunflower: 8.8%  Coconut: 3.0%  Groundnut: 3.4%  Cotton: 2.5%

Source: Oil World, 2009
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Agriculture

- Harvesting of the fruit bunches:
Agriculture

• Harvesting of the fruit bunches:
Harvesting

- Traditional harvesting
  - Ripe fruits are harvested
  - Fruit bunches are transported to mills
  - At oil mill fruits are processed
Simplified oil milling process

1. Fresh Fruit Bunches
   - Sterilization
     - Stripping
       - Fruits
         - Digestion/Pressing
           - Press Cake
             - Empty Fruit Bunches
           - Dilute Oil
             - Clarification/Purification
               - Oil
                 - Oil drying
                   - Palm Oil
                   - Palm Mill Effluent
                     - Sludge
                       - Condensate
                         - Effluent treatment
                           - Crude Palm Oil
                             - Palm Kernel
                               - Shell
                                 - Nut cracking
                                   - Kernel
                                     - Kernel drying
                                       - Winnowing
                                         - Shell
                                           - Nut cracking
                                             - Kernel
                                               - Palm Kernel
                                                 - Fibre and shell as boiler fuel
Deodorisation process

- **Process aid**: Acid + lye, Bleaching earth acid, Steam
- **Waste**: Soap, Spent earth, Acid oil, Waste water, Exhaust gas
- **Crude oil**
  - Neutralisation 95°C
  - Bleaching 70 - 90°C
  - Deodorisation 180 - 270°C
- **Removed with waste**
  - Free fatty acids
  - Dirt
  - Phospholipids
  - Hexane
  - Water
  - Metals
  - Chlorophyll
  - Soap
  - Heavy PAH
  - Oxidised components
  - Free fatty acids
  - Oxidised components
  - Carotenes
  - Taste and odour
  - Pesticides
  - Light PAH
  - Part of "goodies"

Refined oil
3-MCPD ester formation*
Breakthrough in understanding mechanisms of formation

- Generated from triglycerides and NOT from DAG
- Organochlorine molecule identified in palm fruit released by enzymes after fruits are damaged

![Chemical structure of 3-MCPD ester]

- This molecule generates HCl during deodorisation
- HCl reacts with triglyceride to 3-MCPD-ester
- Hypothesis: organochlorine molecules results from inorganic chlorine from fertilizers used

* Nagy et al. (Food Additives and Contaminants 2011)
Standard supply chain of palm oil

The basic process route of standard quality palm oil
Special Quality Palm Products

- Sime Darby developed a new harvesting technology:
  - Strict harvesting procedure
  - Careful selection of fresh fruit bunches
  - Shortest time from harvesting to oil milling
  - No loose fruits added
  - Also 5-10% lower yields

- Special quality green palm oil
- FFA levels lower
- Low in diglyceride content
Special Quality Palm Products

- New Sime Darby refining process:

```
Plantations only → Oil mill → Fractionation → Mild refining → Red palm olein
          ^            |                 |              |
          |            v                 v              
          Crude stearin → Crude olein → 20 MT containers
          ^                          |          |
          
       Special quality palm fractions
```
Special Quality Palm Products

• Traditional refining process:
  – Good quality colorless oil
  – Bland taste
  – But...also removal of the ‘goodies’ present in vegetable oils

• ‘Goodies’:
  – Vitamins
  – Natural anti-oxidants = tocopherols
  – Colorants = carotenoids
Special Quality Palm Products

• Mildly refined red palm olein
  – Natural colorant for frying oils and margarines
  – Antioxidants (tocopherols)

• Normally refined special quality palm fractions
  – Low diglyceride content
  – Colorless appearance
  – Bland taste
  – Low 3-MCPD ester content
Effect of deodorisation temperature

Graph showing the effect of temperature on the reduction and transformation of various compounds:
- FFA
- Tocopherols
- Pesticides
- Light PAH
- Trans
Special Quality Palm Products

**Fruit bunches + loose fruits**
- Plantations + small holders
- Oil mill ➔ Crude PO ➔ Refining ➔ Fractionation ➔ PO olein

**Fruit bunches only**
- Plantations only
- Oil mill ➔ Crude PO ➔ Refining ➔ Fractionation ➔ cPO olein, cPO stearin

**POlein1**
- PO olein
- PO stearin

**POlein2**
- PO olein
# 3-MCPD ester results for palm oil products

<table>
<thead>
<tr>
<th>Sample</th>
<th>FFA</th>
<th>DG</th>
<th>3-MCPD esters (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard quality palm oil</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Crude palm oil</td>
<td>C1</td>
<td>3.2</td>
<td>4.4</td>
</tr>
<tr>
<td>Avg. Refined palm oil</td>
<td>P1</td>
<td>&lt; 0.08</td>
<td>4.7</td>
</tr>
<tr>
<td>Avg. Refined palm olein</td>
<td>POlein1</td>
<td>&lt; 0.08</td>
<td>6.5</td>
</tr>
<tr>
<td><strong>Special Quality palm oil (new Sime Darby harvesting technology)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Crude palm olein</td>
<td>C2</td>
<td>&lt; 1.2</td>
<td>3.6</td>
</tr>
<tr>
<td>Avg. Refined palm olein</td>
<td>POlein2</td>
<td>0.03</td>
<td>0.2-0.6</td>
</tr>
</tbody>
</table>
Effect deodorisation on ester levels
Sime Darby oil processing pilot plant
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3-MCPD ester mitigation strategy

- Prevent formation of the precursor by quickly processing fruits after harvesting, less enzyme activity (FFA-level might be used as marker)

- Hypothesis: organochlorine molecules results from inorganic chlorine (e.g. FeCl$_2$; FeCl$_3$, MgCl$_2$, CaCl$_2$) from fertilizers used

- Mitigation strategy:
  - Use (unripe) fruits
  - Process fruits <24 h after harvesting to minimize formation
  - Minimize inorganic chlorine in fertilizers
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Conclusion

• New Sime Darby harvesting technology
• New Special Quality palm oil
  – Excellent quality
    • 3-MCPD-ester levels: 8-10 times lower
  – Higher costs
    • Complex supply chain as it needs to be separated
    • Yields are lower
• Product availability
  – Now available in Asia
  – Europe: available in future depending on market needs
• Glycidyl-ester problem
  – Sime Darby scientist working on new refining technology
  – Proof-of-principle demonstrated in pilot plant
  – Commercialisation: asap
Thank you for your attention!

For further information:

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