Food Safety and Quality

Gerrit van Duijn
Presentation overview

• Food safety in the traditional supply chain

• Supply chains overview
  - Seed oil supply chain
  - Palm oil supply chain
  - Oil refining

• Food safety control of crude oils

• Refining process validation for contaminant reduction
Traditional supply chain
Traditional supply chain - as flowsheet

- Harvesting
- Crushing
- Pressing
- Refined oil transport
- Refining
- Seed reception
Exercise

List food safety risks of the traditional supply chain.
Traditional Palm oil mill
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Seed oil supply chain

- Oil seed farmers
  - Seed control

- Oil seed storage
  - Seed control

- Oil extraction
  - Crude oil control

- Oil Processing
  - Product control

- Consumer goods manufacturers

Meal

Acid Oil
Seed reception, sampling and storage
Seed oil extraction

**Oil seed receiving**
- Truck scale
- Oil seed vessel
- Batch scale

**Seed preparation**
- Quality control
  - Impurities
  - Oil content
  - Moisture
- Electro magnet
- Day bin
- De-hulling for sunflower

**Pressing**
- Press
  - 15 - 20 % oil
- Desolventizer/toaster
- Extractor
- Hexane
- Steam
- Distillation
- Condensation

**Solvent extraction**
- Desolventizer/toaster
- Extractor
- Distillation
- Condensation

**Meal storage**
- Meal storage

**Solvent extraction**
- Optional dryer
- Extracted oil
- Crude oil
- Degumming
- Crude lecithin

**Oil treatment/storage**
- Oil filter
- Pressed oil
- Degummed oil

**Warehouse or silo's**
- Optional dryer
- Cooker
  - 80 – 100 °C
Palm oil supply chain

Plantations

Small holders

Fruit bunch grading

Crude oil control

Previous cargoes

Crude oil control

Product control

Kernels

Oil extraction

Acid Oil

Oil Processing

Consumer goods manufacturers
Fruit bunch grading
Palm oil extraction

- Receiving station
- Fresh Fruit Bunches
- Steriliser
- Press
- Bunch separation
- Settling Tank
- Centrifuge
- Palm Oil Storage
- Sludge
- To refinery and/or export
- Fiber/Nut Separator
- Nut Cracker
- Shell
- Kernel Dryer
- Kernel Storage
- To Palmkernel extraction
Current refining process - introduced in 1900

From decanting to refining due to:

- Use of coconut oil for margarine
- Decolouring of cottonseed oil
- Changing taste
- Removal of catalyst poisons before hydrogenation.
- Removal of solvents from extracted oils
Basic principles of refining

- Reaction with acid followed by water extraction and gravity separation. ➔ **DEGUMMING**
- Reaction with base followed by gravity separation. ➔ **NEUTRALISATION**
- Agglomeration of fine particles followed by filtration.
- Adsorption on clay or active carbon followed by filtration. ➔ **BLEACHING**
- Evaporation of volatile components by steam distillation. ➔ **DEODORISATION**
Neutralisation, deodorisation, bleaching, and deodorisation are key processes in refining crude oil. These processes help remove impurities such as Cell residues, Water, Hexane, Metals, Dirt, Free Fatty Acids, Colour, Oxides, PAH, Flavours, Pesticides, and volatiles. Chemical and physical methods are used in these processes, with chemical methods involving lye, soap, earth, spent earth, steam, and exhaust gases, and physical methods involving acid/water, spent earth, steam, and acid oil exhaust gases.
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Quality control of incoming fats
- 1910
Case: Which hazards should we analyze crude oils for?

- Sulphuric acid
- Poly Aromatic Hydrocarbons
- Lubricant oil
- Glass particles
- Pesticides
- Iron
- Dioxin
- Natural toxins
- Micro organisms
- Diesel
- Hexane
- Xylene
Hazards we should analyze crude oils for.

YES:
- Poly Aromatic Hydrocarbons
- Pesticides
- Hexane
- Diesel
- Lubricant oil
- Natural toxins

NO:
- Dioxin
- Sulphuric Acid
- Micro organisms
- Glass particles
- Iron
- Xylene (except maiden voyages)
## Minor components in crude oils – effect on quality

<table>
<thead>
<tr>
<th>Minor component</th>
<th>Origin</th>
<th>Quality effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free Fatty Acids</td>
<td>Hydrolysis</td>
<td>Off-taste, smoke during frying</td>
</tr>
<tr>
<td>Peroxides</td>
<td>Oxidation</td>
<td>Off-taste</td>
</tr>
<tr>
<td>Phosphatides</td>
<td>From cell membranes</td>
<td>Burns at high temperature</td>
</tr>
<tr>
<td>Moisture</td>
<td>From oil crop, transport &amp; storage</td>
<td>Components in free water</td>
</tr>
<tr>
<td>Dirt</td>
<td>Oil crop and harvest residues</td>
<td>Appearance</td>
</tr>
<tr>
<td>Taste &amp; odour</td>
<td>From oil crop</td>
<td>Not matching with product taste</td>
</tr>
<tr>
<td>Metals</td>
<td>Soil, milling storage &amp; transport</td>
<td>Catalyst for oxidation</td>
</tr>
</tbody>
</table>
## Contaminants in crude oils – effect on health

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Origin</th>
<th>Health effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy metals</td>
<td>Soil, milling storage &amp; transport</td>
<td>Toxic</td>
</tr>
<tr>
<td>Poly Aromatic Hydrocarbons</td>
<td>Drying of oil crop</td>
<td>Carcinogenic, genotoxic</td>
</tr>
<tr>
<td>Pesticides above MRL</td>
<td>Crop protection chemicals</td>
<td>Toxic (ADI $\approx 100 \times$ MRL)</td>
</tr>
<tr>
<td>Dioxins</td>
<td>Environmental pollution</td>
<td>Highly toxic</td>
</tr>
<tr>
<td>Mycotoxins</td>
<td>Mould or fungus</td>
<td>Toxic</td>
</tr>
<tr>
<td>Mineral oil</td>
<td>Process, storage, transport</td>
<td>Toxicity depends on chain length</td>
</tr>
<tr>
<td>Residues previous cargoes</td>
<td>Overseas transport</td>
<td>Depends on component</td>
</tr>
</tbody>
</table>
Supply Chain risk assessment: PAH contact during drying with exhaust gasses

Sunflower seeds

Coconuts
Benzo(a)pyrene in Crude Oils

- Coconut: 79% samples > 1 ppb
- Sunflower: 12% samples > 1 ppb
- Rapeseed: 9% samples > 1 ppb
- Soybean: 7% samples > 1 ppb
- Palm oil: 0% samples > 1 ppb

Legal EU limit in refined oil:

MVO - de ketenorganisatie voor oliën en vetten
Pesticides

- Crop protection during growth
- Protection of oil seeds during storage and transport
- Transfer in storage silos
Pesticide definitions

ARfD = Acute Reference Dose
ADI  = Acceptable Daily Intake
MRL = Maximum Residue Limit
LOD = Level of Determination
DL  = Detection Limit of used analytical method
GAP = Good Agricultural Practice
Mineral oil (alkanes)

- \(<C6\): Gas
- \(C6\): Hexane
- \(C5 – C8\): Gasoline
- \(C10 – C24\): Diesel
- \(\geq C16\): Fuel and lubricant oil
- \(\geq C35\): Asphalt

Allowed use:
- Hexane in crude extracted oil
- Paraffin oil to prevent dust explosions in USA
- Solvent for pesticides
Risk for mineral oil contamination
# Crude Oil Risk Matrix

<table>
<thead>
<tr>
<th>EU Limit</th>
<th>Pesticides</th>
<th>PAH</th>
<th>Mineral Oil in Edible Oil Imported in EU</th>
<th>Previous Cargoes in Sea Going Vessels</th>
<th>Dioxins and PCB's</th>
<th>Aflatoxins</th>
<th>ZEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean oil</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Sunflower oil</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Rapeseed oil</td>
<td></td>
<td></td>
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<tr>
<td>Corn oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm oil</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palm kernel oil</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coconut oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groundnut oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linseed oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cottonseed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grape seed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olive</td>
<td></td>
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</tr>
</tbody>
</table>

**Occurrence**
- **High risk**: Regularly (> once a year)
- **Medium risk**: Occasionally (every 1-5 years)
- **Low risk**: Seldom (< once every 5 years)
- **Regulated**: Not applicable

**Monitoring frequency**:
- **High risk**: Every batch
- **Medium risk**: Minimum once per quarter
- **Low risk**: Maximum once per quarter
- **Regulated**: Every batch (FEDIOL CoP)

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**MVO - de ketenorganisatie voor oliën en vetten**
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• Refining process validation for contaminant reduction
Refining process validation for contaminant reduction

- The refinery, processing the oil, is informed and the contaminated lot must be blocked.
- The standard refining process is validated for contaminant removal to below acceptable limit by:
  - processing a minimum batch with the standard refining recipe
  - analyzing the contaminant level in the refined oil.
- Result < limit: the crude oil is de-blocked and the full lot can be processed.
- Result > limit: repeat validation with modified process conditions or declassify to non food.
- Repeat validation if contaminant level is higher in a next delivery.
<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Hydrocarbons &lt; C20</th>
<th>Hydrocarbons &gt; C20</th>
<th>PAH (BaP)</th>
<th>Pesticides</th>
<th>Aflatoxin B1</th>
<th>Zearalenone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil reception</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degumming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutralization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93%</td>
<td></td>
</tr>
<tr>
<td>Bleaching</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>77%</td>
<td></td>
</tr>
<tr>
<td>Deodorization</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

= Chemical refining
= Physical refining
= Chemical and Physical
### Enrichment in deodorizer distillate

**Example Dioxin:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bleached oil</strong></td>
<td>1000 kg</td>
</tr>
<tr>
<td>FFA</td>
<td>2 %</td>
</tr>
<tr>
<td>Dioxin level</td>
<td>0.1 ng TEQ/kg = 100 ng TEQ</td>
</tr>
<tr>
<td><strong>Deodorized oil</strong></td>
<td>977 kg</td>
</tr>
<tr>
<td>FFA</td>
<td>0.1 %</td>
</tr>
<tr>
<td>Dioxin</td>
<td>not detectable</td>
</tr>
<tr>
<td><strong>Deodorizer distillate</strong></td>
<td>23 kg</td>
</tr>
<tr>
<td>FFA</td>
<td>19 kg</td>
</tr>
<tr>
<td>Dioxin</td>
<td>100 ng TEQ = 4.3 ng TEQ/kg</td>
</tr>
</tbody>
</table>

Limit for food and feed = 0.75 ng TEQ/kg
## USE OF OIL/FAT AND BY-PRODUCTS

<table>
<thead>
<tr>
<th>Process and product</th>
<th>Contaminant</th>
<th>Dioxin</th>
<th>PAH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Coconut</td>
</tr>
<tr>
<td>Crude or degummed oil/fat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank bottom from storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physically refined oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deodorizer distillate PR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemically refined oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soapstock and acid oil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deodorizer distillate CR</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Green: = food and feed
- Blue: = feed, monitoring every 3 month
- Yellow: = feed, 100 % monitoring
- Red: = not allowed in food and feed
The refiner’s challenge

Product quality

refining process

Conditions

Contaminant removal

Minimal side reaction products

And reduced environmental impact!