Recent Developments in Bleaching, Deodorisation and Physical Refining of Oils and Fats

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VEGETABLE OILS WORLD PRODUCTION

124 Mio Tons in 2006

PO+ SBO = 55%
### INCREASED DEMAND FOR FOOD USE

<table>
<thead>
<tr>
<th>Year</th>
<th>Expected growth rate</th>
<th>Oils and Fats production</th>
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<tbody>
<tr>
<td></td>
<td>Consumption kg/capita</td>
<td>Population Billion</td>
</tr>
<tr>
<td>1980</td>
<td>12.8</td>
<td>4.4</td>
</tr>
<tr>
<td>1990</td>
<td>15.3</td>
<td>5.3</td>
</tr>
<tr>
<td>2000</td>
<td>18.3</td>
<td>6.1</td>
</tr>
<tr>
<td>2010</td>
<td>20.9</td>
<td>6.6</td>
</tr>
<tr>
<td>2020</td>
<td>23.8</td>
<td>7.4</td>
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</table>

- ~ 3-4 Mio TPY extra for edible consumption
- ~ 4-5 Mio TPY extra production
NON-EDIBLE USE OF VEGETABLE OILS

<table>
<thead>
<tr>
<th>Year</th>
<th>Total (Million tons)</th>
<th>Food (Million tons)</th>
<th>Nonfood (Million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993/94</td>
<td>61.5</td>
<td>55</td>
<td>6.5</td>
</tr>
<tr>
<td>1999/00</td>
<td>82.7</td>
<td>74.7</td>
<td>8</td>
</tr>
<tr>
<td>2006/07</td>
<td>121.9</td>
<td>99.2</td>
<td>22.7</td>
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</table>

- Palm: 10 – Rape: 5 (BD)

BIODIESEL ?!!
STRONG PRICE INCREASE FOR CRUDE OILS (FROM 2005)

- Increase demand for food use (China, India)
- Booming biodiesel market (Europe, USA)

Major vegetable oils price evolution

Crude fossil oil
> 100 US$/barrel

0 US$/barrel
QUALITATIVE SOLUTION: Food vs Technical Oils

‘Primary’ Oils for Human Consumption

* High Quality Commodity Oils (Soy, Rape, Sun, Palm, …)
* Specialty oils with high nutritional value (Olive, Fish, Flaxseed, …)

‘Secondary’ Oils for Technical Applications (e.g. Biodiesel)

* Low Quality animal fats (tallow, lard, chicken, pig…)
* Side streams (FAD, acid oils, …) and used oils (Used Frying Oils)
* Oils from special industrial crops (Jatropha oil, Algae oil)
TRENDS IN EDIBLE OIL PROCESSING

Increased need for more efficient processes (commodity oils)

* More cost efficient processes (lower investment & operating costs)
* Valorisation and/or reduction of by-products
* Flexible plants able to process wide range of different oils
* Larger capacities (economics of scale)

Increased demand for higher quality food oils

* Low or no trans FA (formed during refining and hydrogenation)
* Balanced FA composition (optimal ratio of saturated/mono-/polyunsaturated FA)
* High concentration of natural anti-oxidants (tocopherols) and phytosterols
* No contaminants (pesticides, PAH, dioxins, PCB,....)
INCREASED ATTENTION FOR NUTRITIONAL QUALITY OF FOOD OILS AND FATS
OFI Middle East 2008
Technical and Commercial Conference
Hilton Hotel
Abu Dhabi, UAE, April 15-16, 2008

Seed → Cleaning / Drying → Mechanical Extraction
Seed → Cracking → Flaking → Solvent Extraction
Seed → Dehulling → Preparation

Crude Oil → Meal
Crude Oil → Extraction

Speciality Fats → Hydrogenation
Frying oil → Neutralising
Margarine → Dehydration
Soap → Degumming
Lubricants → Bleaching
Biodiesel → Winterising

Modification: Fractionation → Interesterification → Hydrogenation

Refined Oil → Refined Oil

Oleochemical Processes
Direct refining cost

Cross-over point shifts to lower FFA

Physical refining becomes more attractive

Soybean

Chemical

Physical

Palm

%FFA

Desmet Ballestra Presentation
ADSORPTION

PROCESSES
DEVELOPMENTS IN EDIBLE OIL REFINING - I

** ADSORPTION PROCESSES **

1. Bleaching (adsorption of pigments, metals, polar components,..)
2. Silica treatment (adsorption of soaps and gums, replacing water wash stage)
3. Activated carbon treatment (removal of contaminants like PAH and dioxins)

** DEVELOPMENTS IN ADSORPTION **

1. Reduce adsorbent consumption (especially bleaching earth)
2. Improve overall efficiency
3. Reduce amount of solid waste and disposal costs

→ Combiclean Process
BLEACHING

Unit Operation in Refining with Highest Operating Cost

Main Objective: Reducing Bleaching Earth Consumption

* Cost 1: Cost of bleaching earth (depending on origin and degree of activation)
* Cost 2: Oil losses in spent bleaching earth (30-40% oil in spent BE)
* Cost 3: Disposal of spent bleaching earth: can be a cost factor as well

Processes to reduce Bleaching Earth Consumption

* Bleaching with pre-filtration over spent BE → 10-20% BE saving
* Bleaching with silica pre-treatment
* Counter-current bleaching → 30-40% BE saving
Continuous bleaching with pre-filtration

From degumming neutralisation

Degummed oil

Steam

Pre-filtration

Spent bleach earth

Bleaching earth

Vacuum unit

Cleaning

Final filtration

Polish filters

Bleached oil

To deodorisation

First Adsorption of
Metals, soaps,
Color pigments

Spent bleach earth

Sparge steam

Leaf filters

Process with 3 filters:
1. Prefiltration (used BE)
2. Effective filtration
3. Stand-by/cleaning
Counter-current bleaching process

From degumming neutralisation

Degummed oil

Prebleaching with used BE

Prebleacher

Candle filter

Recycling spent earth

Vacuum unit

Bleached oil

To deodorisation

Polish filters

Sparging steam

Sparge

Final bleacher

Bleach earth

Leaf filters

Spent bleach earth

Citric acid

From degumming neutralisation

Degummed oil

Prebleaching with used BE

Candle filter

Recycling spent earth

Vacuum unit

Bleached oil

To deodorisation

Polish filters

Sparging steam

Sparge

Final bleacher

Bleach earth

Leaf filters

Spent bleach earth

Citric acid

Oils & Fats

Desmet Ballestra Presentation
Prebleaching
More efficient use of BE

Adsorption of P and soaps

COMBICLEAN process

Vacuum unit

Active carbon

Descummed oil

Silica

Pre filtration

Bleaching earth

final filtration

cleaning

bleacher

Sparge steam

Spent bleach earth

Leaf filters

Spent carbon

Polish filters

To deodourisation

To deodourisation

Final bleaching
Removal of contaminants

Desmet Ballestra Presentation
1. INTEGRATED ADSORPTION PROCESS
- Modular and extendable with required/desired process stages

2. SEPARATE ADDITION OF EACH ADSORBENT
- Increases overall efficiency of each adsorbent (lower costs)

3. SPLITTING OF SOLID WASTE STREAMS
- Easier valorisation/disposal
- ‘Pure’ Spent BE with no contaminants can be added to meal
- Spent AC with contaminants has to be treated as ‘toxic’ waste
DEODORIZATION –
STEAM REFINING
DEVELOPMENTS IN EDIBLE OIL DEODORIZATION

OBJECTIVES OF DEODORIZATION

(1) Stripping of volatile components (FFA, volatile contaminants, .....)
(2) Deodorisation (thermal degradation and stripping of odor & taste components)
(3) Heat Bleaching (thermal degradation of coloring pigments)

DEVELOPMENTS IN DEODORIZATION TECHNOLOGY

(1) Improved deodorizer design (all-in-one, stand alone concept,....)
(2) Reducing heat load (dual temperature deodorizing, lower pressure,....)
(3) Controlled stripping of valuable components and contaminants (packed column)
Distillation

**Operating Parameters**

- **Temperature**
  - **Fatty acid removal**
    - wanted
  - **Tocopherol removal**
    - unwanted
  - **Odor - Flavor removal**
    - wanted

- **Time**
  - **Stripping steam**

- **Pressure**
  - **Polymerisation**
    - unwanted

Deo/**doriser design**

**Thermal action**

- **Low pressure by chilled water / Ice condensing**
  - **Continuous / Semicontinuous**
  - **Crossflow (tray) / Countercurrent (pack)**
  - **Shallow bed / Deep bed**
  - **Economizing / Cooling / Heating under vacuum**
Dual Temperature deodorizer: Principle

- **Lower temperature - longer time (stage 1)**
  for mild deodorizing and moderate stripping
  thermolytic/hydrolytic breakdown reactions

- **Higher temperature - shorter time (stage 2)**
  for final stripping and heat bleaching
  for controlled stripping of valuable minor components
Packed column stripper

Structured packing
100-300 m²/m³

Vapor phase (steam)

Liquid phase (oil)

To FAD scrubber + vacuum unit

$\Delta P : 0.1 - 0.5 \text{ mbar/m}$

$\Delta T : \text{min. } 1.3^\circ\text{C} / \text{%FFA}$

$H : 3-5 \text{ m}$

$D : f (\text{vapor load})$

Counter-current contact oil/steam

Short residence time at high temperature

Liquid phase (stripped oil)

To deodorizer
Features

- Efficient stripping because of counter-current contact oil/steam
- Pressure drop over column can make stripping more difficult
- Short residence time at high temperature

  Low \textit{trans} formation, but no complete deodorization

Applications

- Stripping of tocopherols/sterols from vegetable oils
- Stripping of contaminants (pesticides)
- Partial deodorization of cocoa butter
LOW PRESSURE DEODORIZATION

- Deodorizing Pressure range : 2-5 mbar

- Low pressure required
  * For stripping of volatile components (FFA, contaminants, …)
  * Protection against oxidation

- Trend for lower pressure during deodorization
  * Allows same stripping at lower temp. and/or with less steam
  * Lower pressure (1.5-2 mbar) with Dry Ice Condensing
  * Cost factor (higher electricity consumption, but nearly no motive steam)
**Dry Ice Condensation: Principle**

Ice Surface Condenser (-26°C)

Ammonia

Noncondensables

Steam ejector

Surface Condenser (30°C)

Motive Steam

Rest of condensed water

Vapor from FA scrubber

1 mbar

Iced vapor (> 95%)
Condensation of steam (into ice) on surface condensers

Low pressure can be reached (< 2 mbar)

Strongly reduced odor emission

10x less waste water

Nearly no motive steam but higher electricity consumption
QUALISTOCK DEODORISER: Single vessel - stand alone concept

Stand alone concept:
No building necessary

All critical deodorizing steps integrated in a single vessel
Qualistock deodoriser

Simplified erection

- less building
- minimum space
- faster installation
- easy maintainance & access
Conclusions

Objective of new developments in edible oil processing:

1. Increase Overall Process Efficiency
   - Lower investment costs (more efficient, easier to install equipment)
   - Lower operating costs (more efficient processes);
   - Reduction/valorisation of by-products (spent BE, FAD,…)

2. Enhance Nutritional Quality of Food Oils
   - Mild deodorizing conditions (less \textit{trans} FA, less polymeric TAG)
   - Removal of contaminants (AC treatment, stripping,…)
   - Lower pressure during deodorization
Thank you for your attention

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