Recent Developments in Edible Oil Deodorization

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Desmet Ballestra Group
Desmet Ballestra:

Foundation: 1946 (Desmet)
Turn-over: 400 M€
Offices: 17 owned
Staff: 1100 people (over 200 in Italy)
References: 5,900 plants in 148 countries
Desmet Ballestra world leader in:
De Smet Ballestra
Oil and fats technologies

Crushing
Seed preparation
Pre-pressing
Mechanical extraction
Solvent extraction

Oil & Fats refinery
Degumming/neutralizing
Bleaching
Deodorizing/physical refining
(continuous and semicontinuous)

Fats modification
Fractionation
Hydrogenation
Interesterification
chemical
enzymatic

Images of industrial equipment relevant to oil and fats technologies.
Deodorization is a crucial refining stage with an important effect on the refined oil quality

Desired or Targeted Effects
- Bland taste & smell
- Low FFA & no hydrolysis
- High oxidative stability
- Light & stable color
- Removal of contaminants

Unwanted Effects
- Formation of trans FA
- Polymerisation (dimers)
- Degradation of natural anti-oxidants

NUTRITIONAL QUALITY
Distillation

Operating Parameters

Temperature

Time

Stripping steam

Pressure

Thermal action

Low pressure by chilled water / Ice condensing

Continuous / Semicontinuous

Crossflow (tray) / Countercurrent (pack)

Shallow bed / Deep bed

Economizing / Cooling / Heating under vacuum

Deodoriser

Deodoriser design
TEMPERATURE

- Temperature range: 160°C – 270°C

- Depending on type of oil and refining option
  * Heat sensitive oils (cocoa butter, fish oil): 160°C-190°C
  * For FFA stripping and/or heat bleaching: 240°C-260°C

- Trend to reduce ‘heat load’ during deodorization
  * Less thermal degradation (trans FA, polymers,…)
  * Preservation of natural character (retention of anti-oxydants)
  * Compensated with lower pressure if FFA stripping required
**TIME**

- Time range: 5 min – few hours

- Depending on type of oil and refining option
  
  * Deodorization of soft oils : 20 - 90 min.
  
  * FFA stripping (with packed column) : 5 - 10 min.

  * Full deodorization of fish oil : 2 - 4 hrs
PRESSURE

- Pressure range: 1-5 mbar (mostly 2-3 mbar)

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

- Trend to reduce pressure during deodorization
  * Allows same stripping at lower temp. and/or with less steam
  * Lower pressure (1.5-2 mbar) with Chilled barometric water system or Ice Condensing system
  * Cost factor (lower pressure against higher steam consumption)
STRIPPING AGENT

- Nitrogen
  * inert and non-condensable gas
  * lower losses (no hydrolysis) and higher distillate quality
  * more powerful vacuum system required
  * profitability is very uncertain

- Steam
  * most ‘evident’ choice and most used
  * 5 - 30 kg sparge steam/ton oil, depending on the refining mode and type of oil
## EFFECT OF PROCESS VARIABLES

<table>
<thead>
<tr>
<th></th>
<th>Temperature</th>
<th>Time</th>
<th>Pressure</th>
<th>Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Taste</strong></td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>FFA</strong></td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>+</td>
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<tr>
<td><strong>Tocopherols</strong></td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>+</td>
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<tr>
<td><strong>Contaminants$^1$</strong></td>
<td>++</td>
<td>-</td>
<td>++</td>
<td>+</td>
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$^1$pesticides, PAH, dioxins
Trends and developments in edible oil deodorization

- Higher capacities
  - >1500 tpd no exception

- Higher energy efficiency
  - Optimised heat recovery

- High stripping efficiency
  - Tray design/Packed columns

- Low neutral oil losses
  - Tray & scrubber design

- Lower heat load
  - Packed column/dual temp

- Lower pressure
  - Ice condensing/Chilled water

- Higher distillate value
  - Dual condensation
Heat recovery in continuous deodorizer (Qualistock)

Bleached oil is pumped through coils and preheated with deodorized oil.

Oil/Oil heat exchange
Heat recovery in continuous deodorizer (Qualistock)

Deodorized oil leaving tray to cooling section

Cold bleached oil - in

Preheated oil - out

Deodorized oil entering tray from upper section
Improved heat recovery in continuous deodorizing:

Light fuel consumption
Around 3 to 3.5 kg/ton

Natural gas consumption:
Around 3.7 to 4.3 Nm3
Heat recovery in semi-continuous deodorizers

- L.P. Steam Generation & Thermosyphon: Heat Recovery 75%
- Double Thermosyphon: Heat Recovery 67%
- Single Thermosyphon: Heat Recovery 45%
Improved heat recovery in semi-continuous deodorizing:

- Light fuel consumption: Around 4 to 4.5 kg/ton
- Natural gas consumption: Around 5.0 to 5.5 Nm3
High stripping efficiency

High stripping efficiency in a deep bed deodorizer with special designed steam lift pumps
Trans formation during deodorization of soybean oil

% TFA

Time (minutes)

270°C
260°C
250°C
230°C

TFA max. 1.0%

200°C 210°C 220°C 230°C 240°C 250°C 260°C 270°C
Conventional vacuum systems

- Combination of steam jet ejectors (boosters), vapor condensers and mechanical (liquid-ring) vacuum pump

- High motive steam consumption (60-85% of total steam)

<table>
<thead>
<tr>
<th>Pressure</th>
<th>kg motive steam per kg stripping steam</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30°C (1)</td>
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<tr>
<td>Booster</td>
<td>Deodorizer</td>
</tr>
<tr>
<td>2.5 mbar</td>
<td>3 mbar</td>
</tr>
<tr>
<td>1.5 mbar</td>
<td>2 mbar</td>
</tr>
</tbody>
</table>

Note: (1) Barometric condenser water inlet temperature: 24°C; outlet temperature: 30°C
(2) Barometric condenser water inlet temperature: 5°C; outlet temperature: 10°C;
CHILLED BAROMETRIC VACUUM SYSTEM

- Reduced steam consumption
- Vacuum of 1 to 1.5 mbar in the deodorizer is possible
ICE CONDENSING VACUUM SYSTEM

Condensation of steam (into ice) on surface condensers

Low pressure can be reached (< 2 mbar)

Strongly reduced odor emission
Dry Ice Condensation: Principle

Ice Surface Condenser (-26°C)

Ammonia

1 mbar

Vapor from FA scrubber

Non-condensables

Surface Condenser (30°C)

Steam ejector

Motive Steam

Condensed Vapor (ice) (> 95%)

Barometric condenser water
Energy consumption in continuous deodorizer

- **Ejectors No HR**
- **Ejectors 80% HR**
- **Chilled 80% HR**
- **Ice 80% HR**

**kw**

- **Ejector steam + Electricity**
- **Injector steam**
- **Heating**
DOUBLE FATTY ACIDS CONDENSATION SYSTEM

- Increases acidity of the fatty acid distillate
- Recovers valuable by-products (tocopherol concentrates)
CONCLUSIONS

Deodorizers become more and more heat efficient.

Improved vacuum systems (chilled water, ice condensing) allow better product quality (low trans, better retention of natural anti-oxydants….)

Deodorizers can be tailor made, designed for specific applications and raw materials, to improve the overall efficiency of the deodorizing process.
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THANK YOU FOR YOUR ATTENTION !!!

Science behind technology !