Oil Deodorising: New Technologies and Solutions to Improve Final Edible Oil Quality

Chia Ing Chuk
Asst. Technical Manager
Desmet Ballestra Malaysia
Deodorising: Crucial Part of The Refining Process

- CPO
- Degumming
- Bleaching
- Deodorising
- RBDPO

Crude Palm Oil

Hydrating gums (converting non-hydratable gums to hydratable gums)...

Adsorbing impurities, breaking down pigments...

Removing FFA, eliminating taste and odour, improving stability, heat bleaching...

Refined, Bleached, Deodorised Palm Oil
# Deodorising: RBDPO Specifications

<table>
<thead>
<tr>
<th>Refined, Bleached, Deodorised Palm Oil (RBDPO)</th>
<th>PORAM Spec</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFA (% palmitic acid):</td>
<td>0.1% max</td>
<td>0.05% max</td>
</tr>
<tr>
<td>M&amp;I:</td>
<td>0.1% max</td>
<td>0.05% max</td>
</tr>
<tr>
<td>Colour (5.25” Lovibond cell):</td>
<td>3 red max</td>
<td>2.5 red max</td>
</tr>
<tr>
<td>M.Pt (AOCS Cc 3-25):</td>
<td>33-39°C</td>
<td>Not specified</td>
</tr>
<tr>
<td>IV (Wijs):</td>
<td>50-55</td>
<td>51.5-52.5</td>
</tr>
<tr>
<td>PV:</td>
<td>Not specified</td>
<td>Nil</td>
</tr>
<tr>
<td>Taste:</td>
<td>Not specified</td>
<td>Bland</td>
</tr>
<tr>
<td>P:</td>
<td>Not specified</td>
<td>3 ppm max</td>
</tr>
</tbody>
</table>

![Image of refined, bleached, deodorised palm oil](image_url)
Deodorising: The Conventional Route

1. Heat Recovery
2. Final Heating
3. FFA Stripping
4. Retention Time
Deodorising: Driving Force for Development

Drivers for new developments in Edible Oil Processing

- PLANT EFFICIENCY
- REFINING PROCESS
- OIL QUALITY
- PROCESS SUSTAINABILITY
**Desmet Ballestra Qualistock™+ Deodoriser**

**Heat Recovery**
- High heat recovery efficiency up to 80-90%.

**Final Heating**
- Pigtail coils. Free vertical expansion of coil bundles, less risk of failure.
- Reduced neutral oil carryover.

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- Oil heating and cooling under vacuum conditions, reduced oxidation potentials.
- Space saving, reduced installation and structural cost as compared to external heat exchanger.
**Fatty Acids Stripping**
- FFA stripping by packed column to increase contact surface of oil and steam, reduced sparging steam usage as compared to FFA stripping only by deodorising tray.
- Directly under packed scrubber, under lowest vacuum pressure.
- Reuse sparging steam injected in lower trays for stripping.

**Deodorising Trays**
- Special chimney design to reduce neutral oil carryover and eliminate the need to segregate splash oil.
- Sparging by mammoth pump, providing high oil circulation rate to increase steam and oil contact.
Desmet Ballestra Qualistock™+ Deodoriser

Deodorised Oil Buffer Tray

- Sparging steam to prevent FFA vapour from condensing back into product oil.
- Possibility of antioxidant dosage under vacuum conditions.
Edible Oil Refining: Unwanted Components and Contaminants

- Foreign
  - Pesticides
  - PAHC’s
  - PCB
  - Dioxines
  - Aflatoxines
  - ...

- Oil related
  - Gums
  - FFA
  - Color bodies
  - Oxidation products
  - Metals
  - ...

- Process related
  - TFA
  - Polymers
  - Acrolein
  - Dialkylketones
  - 3-MCPDE/GE
  - ...

With improving analytical detection methods more “unwanted” components are and will be found in the oil (e.g. 3-MCPDE/GE)
Edible Oil Refining: 3-MCPD and GE

Levels of MCPDE and GE in food oils (2012-2015)

- Palm
- Palm kernel
- Coconut
- Walnut
- Sunflower
- Soy bean
- Rapeseed
- Peanut
- Olive
- Corn

![Bar chart showing concentrations of 2-MCPD, 3-MCPD, and GE in different oils.]

Mean Concentration (ppm) in 2015

<table>
<thead>
<tr>
<th>Oil</th>
<th>3-MCPD</th>
<th>GE</th>
</tr>
</thead>
<tbody>
<tr>
<td>soybean</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>rapeseed</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>palm</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Highest levels of 3-MCPD esters and GE are found in **palm oil**
Edible Oil Refining: 3-MCPD and GE

Ammendment to EC regulation 1881/2006 for GE

"Section 4: 3-monochloropropanediol (3-MCPD) and glycidyl fatty acid esters"

<table>
<thead>
<tr>
<th>Foodstuffs (1)</th>
<th>Maximum level (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1 3-monochloropropanediol (3-MCPD)</td>
<td></td>
</tr>
<tr>
<td>4.1.1 Hydrolysed vegetable protein (30)</td>
<td>20</td>
</tr>
<tr>
<td>4.1.2 Soy sauce (30)</td>
<td>20</td>
</tr>
<tr>
<td>4.2 Glycidyl fatty acid esters expressed as glycidol</td>
<td></td>
</tr>
<tr>
<td>4.2.1 Vegetable oils and fats placed on the market for the final consumer or for use as an ingredient in food with the exception of the foods referred to in 4.2.2</td>
<td>1000 = 1 ppm</td>
</tr>
<tr>
<td>4.2.2 Vegetable oils and fats destined for the production of baby food and processed cereal-based food (3)</td>
<td>500 = 0.5 ppm</td>
</tr>
</tbody>
</table>
| 4.2.3 Infant formula, follow-on formula and foods for special medical purposes intended for infants and young children (powder) (3,29) | 75 until 30.06.2019
50 as from 1.07.2019 |
| 4.2.4 Infant formula, follow-on formula and foods for special medical purposes intended for infants and young children (liquid) (3,29) | 10.0 until 30.06.2019
6.0 as from 1.07.2019 |

Max. levels expressed as free glycidyl

EFSA concluded that glycidol is carcinogenic and genotoxic

EU decided that max. levels for GE in vegetable oils

New max. levels adopted in 2018

No max. levels (yet) for 3-MCPD in food oils
Edible Oil Refining: 3-MCPD and GE

3-monochloropropane diol (3-MCPD) Esters

3-MCPD mono-ester  3-MCPD di-ester

Glycidyl Esters (GE)

H₂C
\( \text{C} \)
\( \text{O} \)
\( \text{CH}_2 \)

OR
OR'

Main precursors

3-MCPDE ← “Chlorine”

Critical Refining Stage: Degumming/Bleaching

Main precursors

GE ← “DAG”

Critical Refining Stage: Deodorising
GE Formation: Effect of Time and Temperature

- Almost no \textbf{net} formation of Glycidyl esters at T < 230°C.
- Very fast formation at T > 240°C.
GE Formation: Effect of Packed FFA Stripping Column

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>GE (ppm)</th>
<th>Color (R – 5,25”)</th>
<th>FFA (% C16:0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>220</td>
<td>0.10</td>
<td>20</td>
<td>0.12</td>
</tr>
<tr>
<td>230</td>
<td>0.14</td>
<td>19</td>
<td>0.09</td>
</tr>
<tr>
<td>240</td>
<td>0.17</td>
<td>14</td>
<td>0.07</td>
</tr>
<tr>
<td>260</td>
<td>0.20</td>
<td>12</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Short residence time at high(er) temperature gives:
- Almost no formation of glycidyl esters, even at T > 240°C
- Very efficient FFA stripping but only limited heat bleaching

Dual temp high temp fast stripping / low temp mild deodorisation
GE Mitigation: Dual Temperature Deodorisation

Qualistock* dual temp deodorising
GE Mitigation: Post Stripping

GE Post-stripping will not only reduce GE, but will also create additional losses as other components will also be stripped (Toco, MAG, …)
GE Mitigation: Post Refining

Elimination of GE from Refined Palm Oil

Post-bleaching: 0.5% Activated BE, 110°C, 30 min.  Post-deodo: 0.5% stripping steam, 3 mbar, 60 min.

GE may again be formed during post-deodorization

low deodorization temperature required
Conventional Barometric Water Vacuum System

Steam

Condensate

841A VACUUM PRODUCTION UNIT

Barometric Water

832A HOT WELL

From Deodorization Section Item 822

Steam

Steam

Condensate

To Dirty Water Cooling System Item 832B

ATM
To introduce a sublimation step ahead of the compression step, turning steam to ice.
Ice Condensing Vacuum System: Advantages

- Motive steam and cooling water for downstream vacuum production unit (designed for deaeration only) saves motive steam or cooling water as compared to conventional vacuum system.
- Vacuum system related utilities can be optimised based on different processing parameters.
- Example: Plant designed to accommodate GE stripping (which uses more sparging steam). When low GE oil is not required, sparging steam is reduced. Icing time of sublimators can be increased, thus reducing the frequency for de-icing (optimisation of heat).
Desmet Ballestra Sublimax™ 2G

Sublimax 2G ice condensing
Desmet Ballestra Sublimax™ 2G

Sublimax: Vertical, with Falling film ammonia evaporation

Classical: Horizontal, with convective boiling liquid tubes

Ammonia liquid

Ammonia vapour

NH₃ mass: <100 kg

NH₃ mass: >>100 kg
Desmet Ballestra Sublimax™ 2G

Benefits
- Long icing time: Energy saving and reduced chiller peak load.
- Low pressure drop: Low suction deaeration group not required.
- Self draining: Both refrigerant and melted ice.
- De-icing: Hot water spraying for effective tube cleaning
- Safety: Minimal welding joints, low ammonia hold up volume.
CPO quality key determining factor in mitigation of 3-MCPDE & GE

Industry to adopt new best practices to ensure highest CPO quality for food
Clear need for segregation of good & excellent Q for food vs rest for non-food

PO Industry today can produce good-excellent quality food oil (70% FFA < 3.5%, DOBI >2.5) which equals the amount of PO used in food, so where is the problem?
**Effect CPO origin on 3-MCPDE/GE formation: Quality does matter!**

<table>
<thead>
<tr>
<th>3 types of CPO tested:</th>
<th>FFA %</th>
<th>DOBI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>1.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Good</td>
<td>3.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Poor</td>
<td>6.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

- **Washing of fresh CPO:** at 90°C, addition of 5% water followed by mechanical agitation (5 min) & centrifugation
- **Bleaching:** CPO mixed with 0.15% citric acid (30% solution) at 85°C for 10 min, followed by bleaching with BE (Oil- Dri Pure Flo B-80), at 105 °C, 50 mbar, 30 min, & then filtered (1% for good-excellent; 1.5% average-poor quality)
- **Deodorization:** dual temperature deodorization at 240°C for 10 min followed by 220°C for 120 min; steam 2% (0.8+1.2%); 3 mbar vacuum.
- **Neutralization:** CPO high shear mixed at 85°C with NaOH solution (14%; 10% molar excess). 3% water added, maturation 10 min & centrifugation
Effect CPO origin: Quality does matter!

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>CPO: 3.4% FFA / DOBI 2.6</th>
<th>CPO: 1.3% FFA / DOBI 3.4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RBD PO</td>
<td>RBD PO</td>
</tr>
<tr>
<td></td>
<td>Good quality</td>
<td>Good quality</td>
</tr>
<tr>
<td>Treatment</td>
<td>Unwashed physical refining</td>
<td>Washed physical refining</td>
</tr>
<tr>
<td>FFA % (16:0)</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Color Lovibond 5¹/₄ cell</td>
<td>2.0R/51Y</td>
<td>2.2R/57Y</td>
</tr>
<tr>
<td>3-MCPD (ppm)¹</td>
<td>1.21</td>
<td>0.34</td>
</tr>
<tr>
<td>2-MCPD (ppm)</td>
<td>0.66</td>
<td>0.21</td>
</tr>
<tr>
<td>GE (ppm)</td>
<td>0.40</td>
<td>0.42</td>
</tr>
</tbody>
</table>

1 CPO: 3.4% FFA / DOBI 2.6
2 CPO: 1.3% FFA / DOBI 3.4

Quality does matter!
**Effect CPO origin:**

**Quality does matter!**

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>CPO: 3.4% FFA / DOBI 2.6</th>
<th>CPO: 6.0% FFA / DOBI 1.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBD PO</td>
<td>RBD PO</td>
<td>RBD PO</td>
</tr>
<tr>
<td>Good quality</td>
<td>Good quality</td>
<td>Poor quality</td>
</tr>
<tr>
<td>Washed physical refining</td>
<td>Washed physical refining</td>
<td>Unwashed physical refining</td>
</tr>
<tr>
<td>Unwashed physical refining</td>
<td>Unwashed physical refining</td>
<td>Unwashed Chemical refining</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>FFA % (16:0)</th>
<th>Color Lovibond 5(^1/4) cell</th>
<th>3-MCPD (ppm)(^1)</th>
<th>2-MCPD (ppm)</th>
<th>GE (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unwashed physical refining</td>
<td>0.04</td>
<td>2.0R/51Y</td>
<td>1.21</td>
<td>0.66</td>
<td>0.40</td>
</tr>
<tr>
<td>Washed physical refining</td>
<td>0.04</td>
<td>2.2R/57Y</td>
<td>0.34</td>
<td>0.21</td>
<td>0.42</td>
</tr>
<tr>
<td>Unwashed physical refining</td>
<td>0.06</td>
<td>6.0R/70Y</td>
<td>2.78</td>
<td>1.31</td>
<td>0.59</td>
</tr>
<tr>
<td>Unwashed Chemical refining</td>
<td>0.02</td>
<td>2.4R/39Y</td>
<td>1.76</td>
<td>0.79</td>
<td>0.52</td>
</tr>
</tbody>
</table>
Thank You for Your Attention

ICC@desmetballestra.com