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

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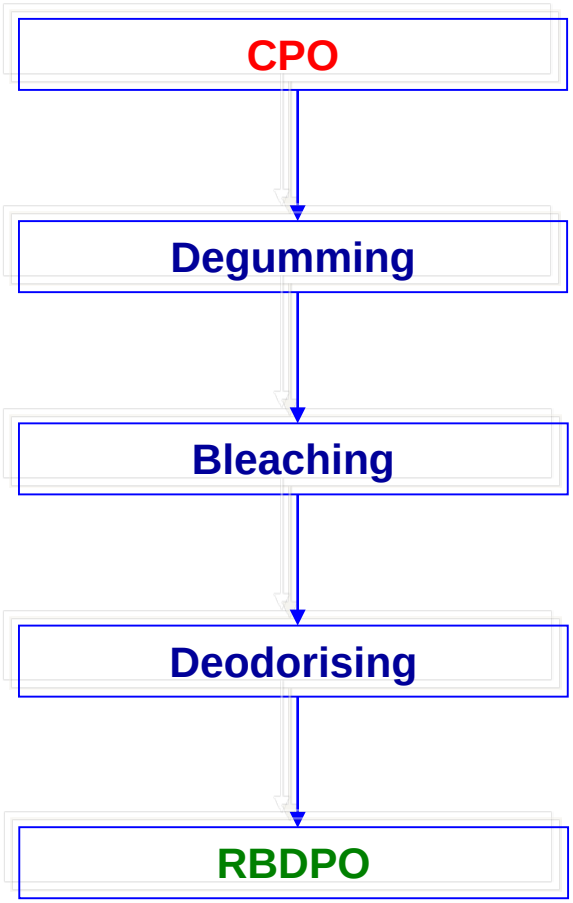
Deodorising: Crucial Part of The Refining Process



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

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Deodorising: RBDPO Specifications

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

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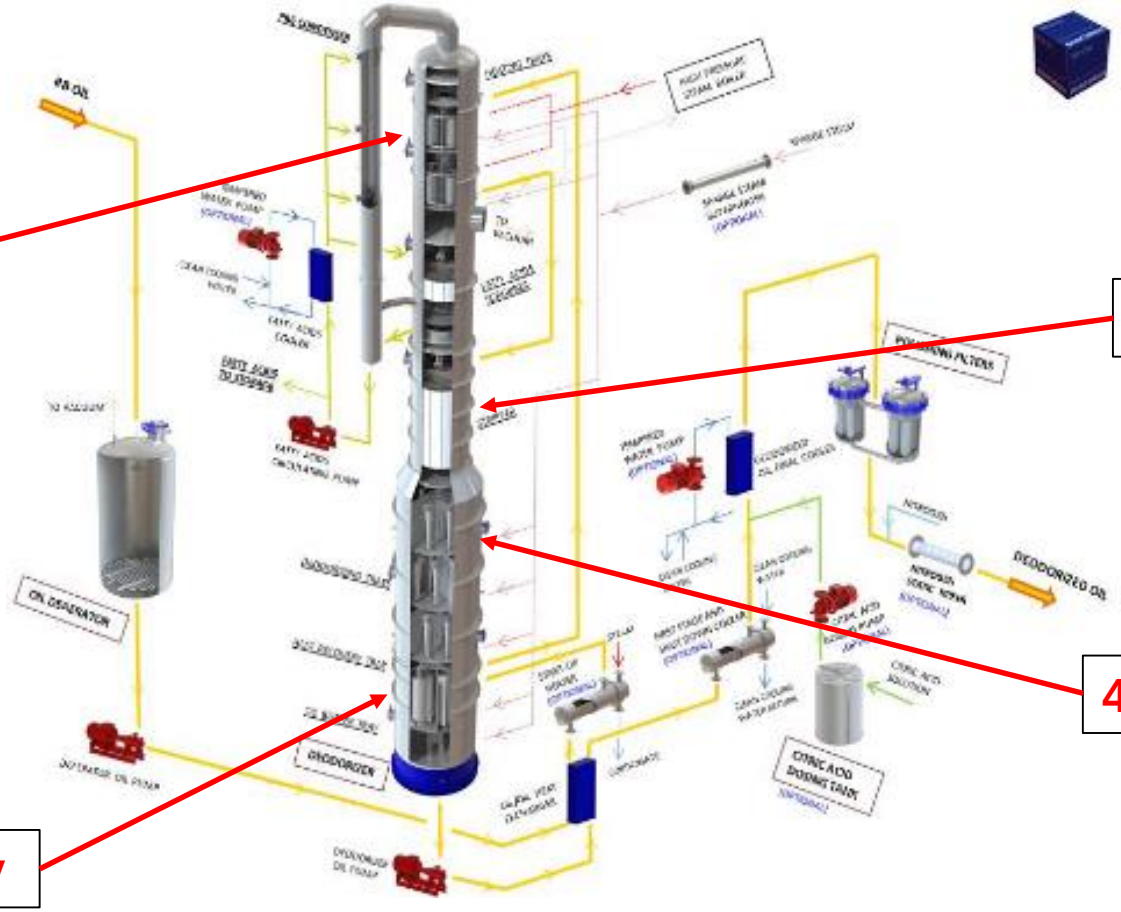
Deodorising: The Conventional Route



2. Final Heating

3. FFA Stripping

4. Retention Time

1. Heat Recovery

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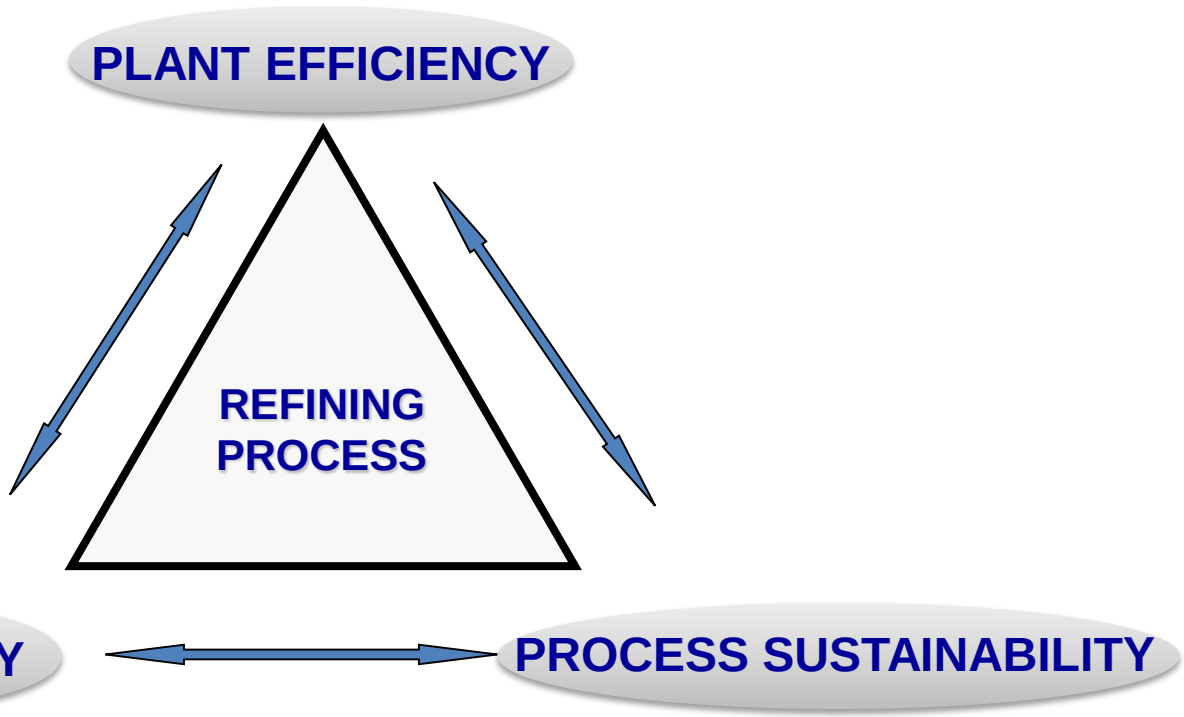
Deodorising: Driving Force for Development

Drivers for new developments in Edible Oil Processing



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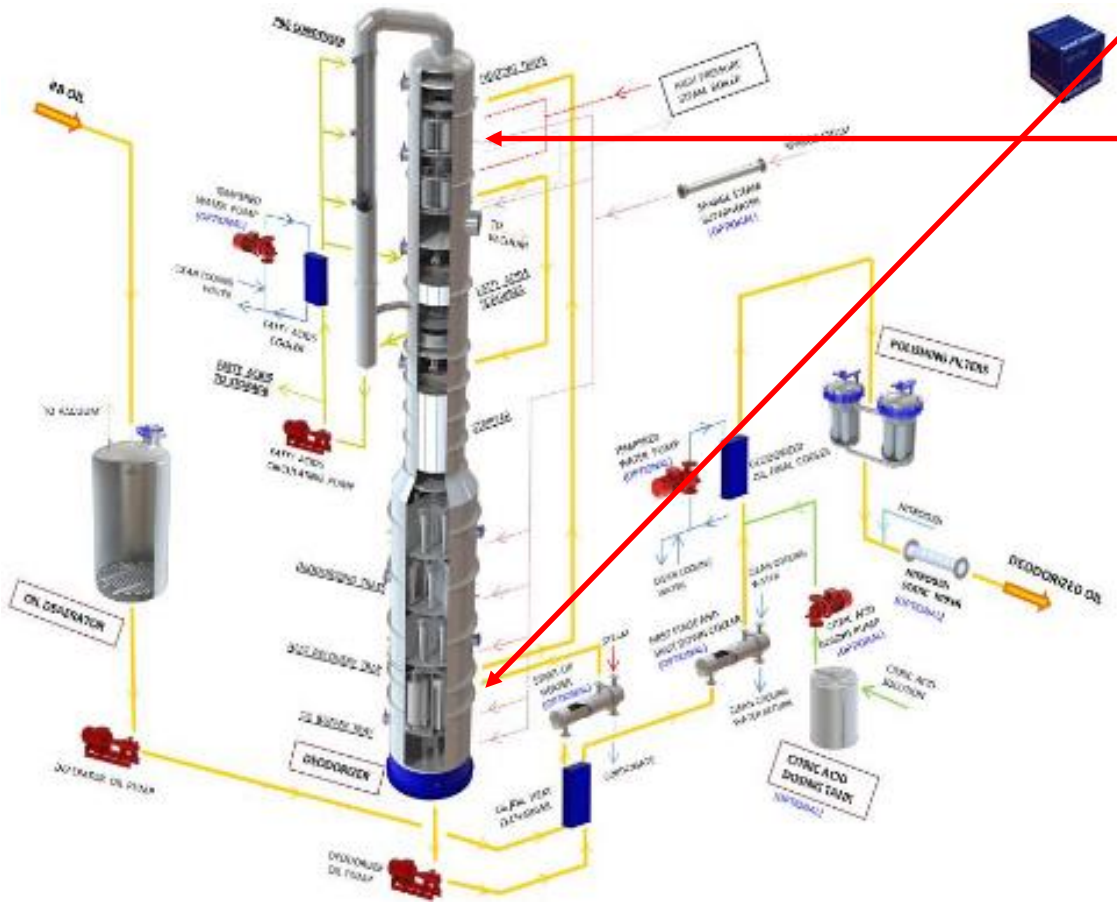
Desmet Ballestra Qualistock™+ Deodoriser



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.

- Oil heating and cooling under vacuum conditions, reduced oxidation potentials.
- Space saving, reduced installation and structural cost as compared to external heat exchanger.

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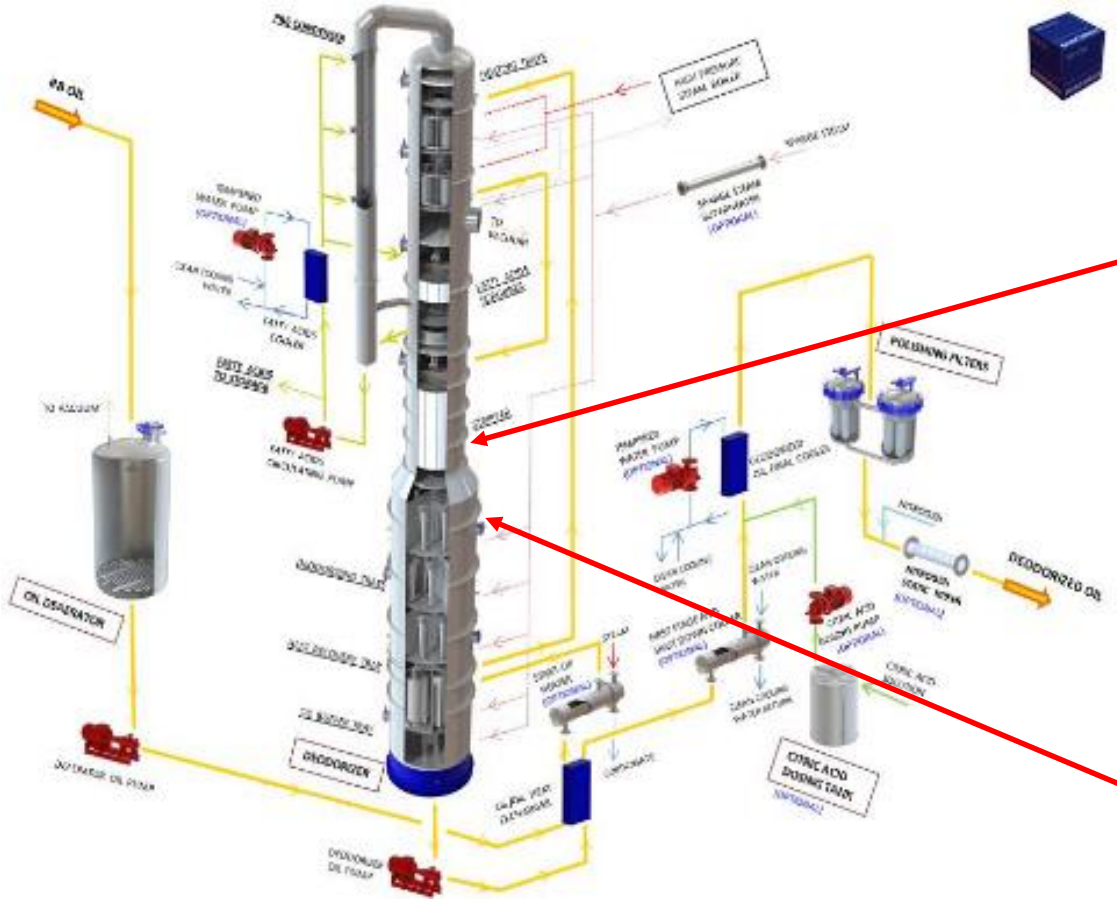
Desmet Ballestra Qualistock™+ Deodoriser



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.

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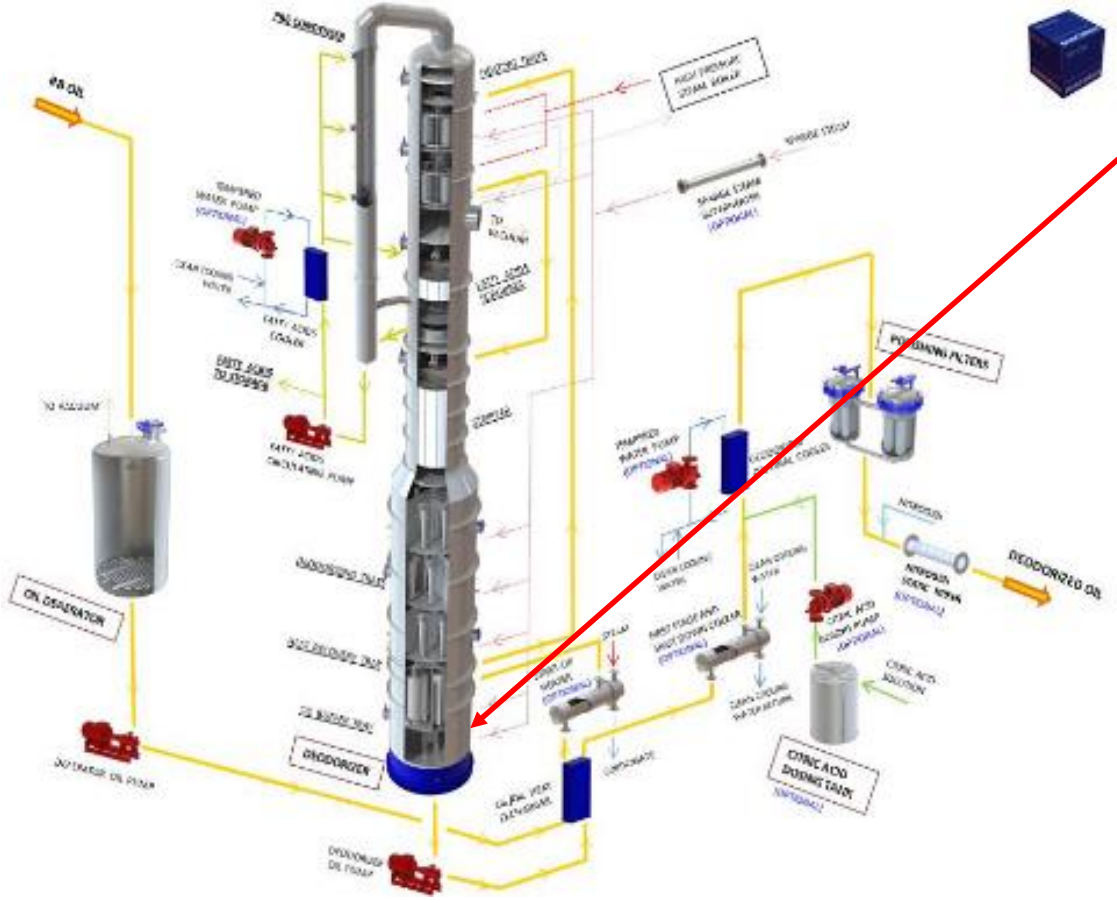
Desmet Ballestra Qualistock™+ Deodoriser



Deodorised Oil Buffer Tray

- Sparging steam to prevent FFA vapour from condensing back into product oil.
- Possibility of antioxidant dosage under vacuum conditions.

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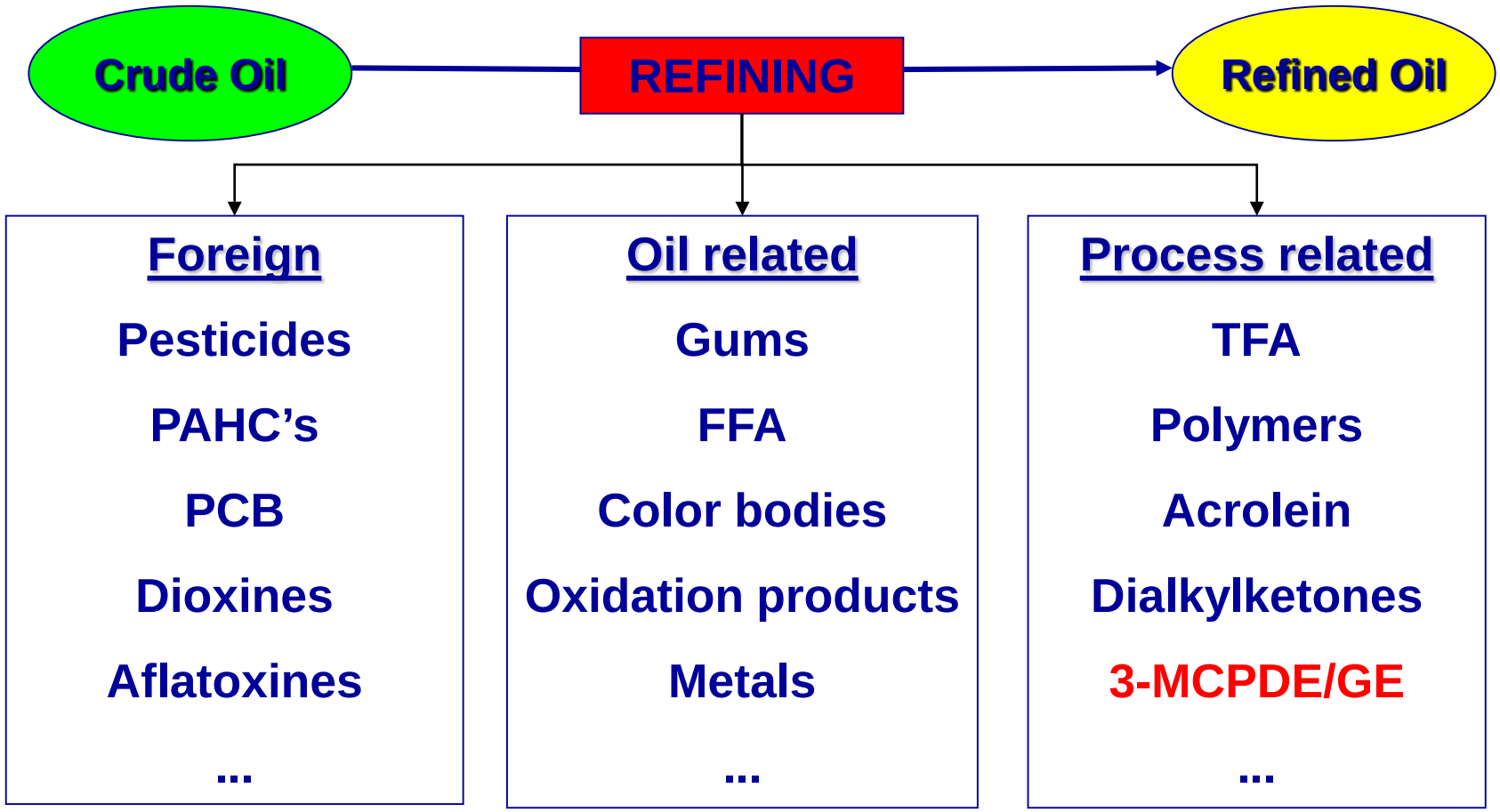
Edible Oil Refining: Unwanted Components and Contaminants



With improving analytical detection methods more "unwanted" componenents are and will be found in the oil (eg. 3-MCPDE/GE)

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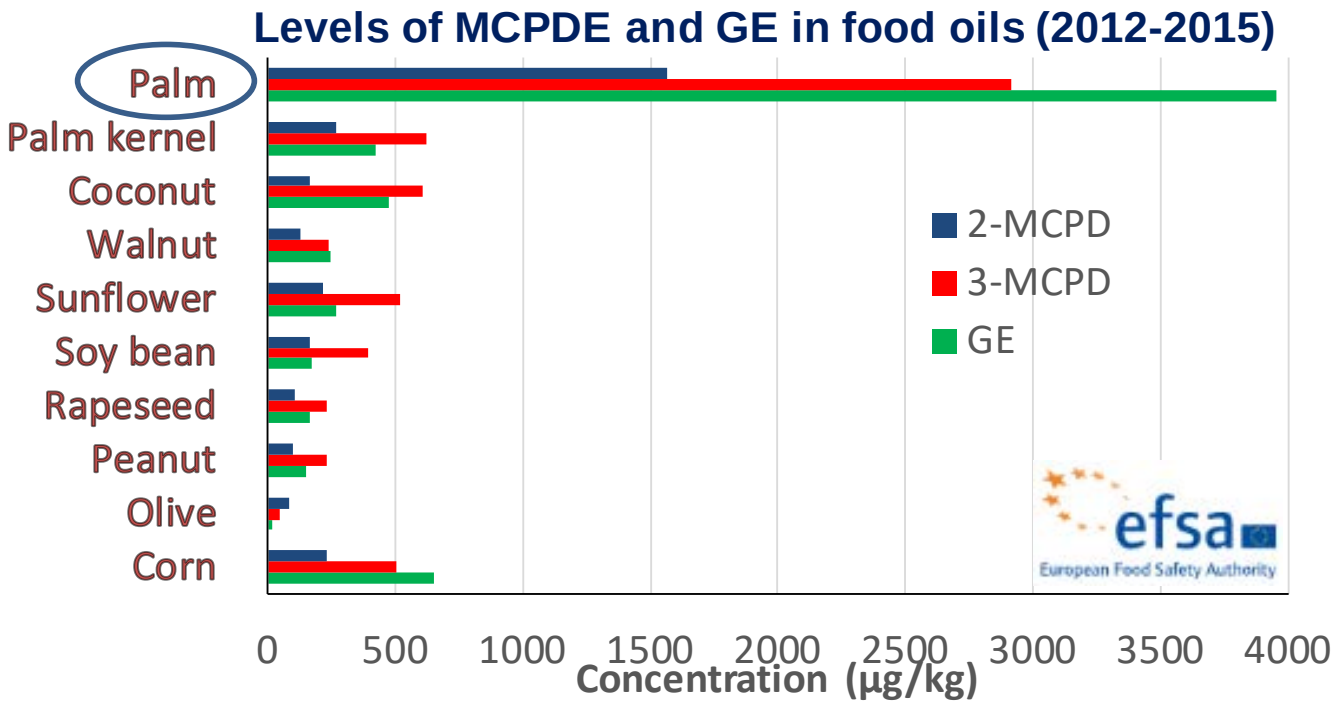
Edible Oil Refining: 3-MCPD and GE



Mean Concentration (ppm) in 2015		
Oil	3-MCPD	GE
soybean	0.4	0.2
rapeseed	0.2	0.2
palm	3	4

Highest levels of 3-MCPD esters and GE are found in palm oil

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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"

Foodstuffs ([1])		
4.1	**3-monochloropropanediol (3-MCPD)**	Maximum level (µg/kg)
4.1.1	Hydrolysed vegetable protein ([30])	20
4.1.2	Soy sauce ([30])	20
4.2	**Glycidyl fatty acid esters expressed as glycidol**	
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	1000 = 1 ppm
4.2.2.	Vegetable oils and fats destined for the production of baby food and processed cereal-based food ([3])	500 = 0.5 ppm
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

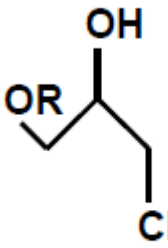
EU decided that max. levels for GE in vegetable oils

New max. levels adopted in 2018

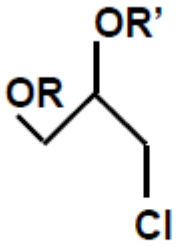
No max. levels (yet) for 3-MCPD in food oils

Edible Oil Refining: 3-MCPD and GE

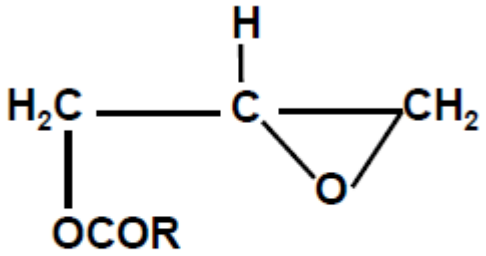
3-monochloropropane diol (3-MCPD) Esters ≠ **Glycidyl Esters (GE)**



3-MCPD mono- ester



3-MCPD di-ester



Glycidyl-ester

Main precursors

3-MCPDE ← "Chlorine"

Critical Refining Stage:
Degumming/Bleaching

Main precursors

GE ← "DAG"

Critical Refining Stage:
Deodorising

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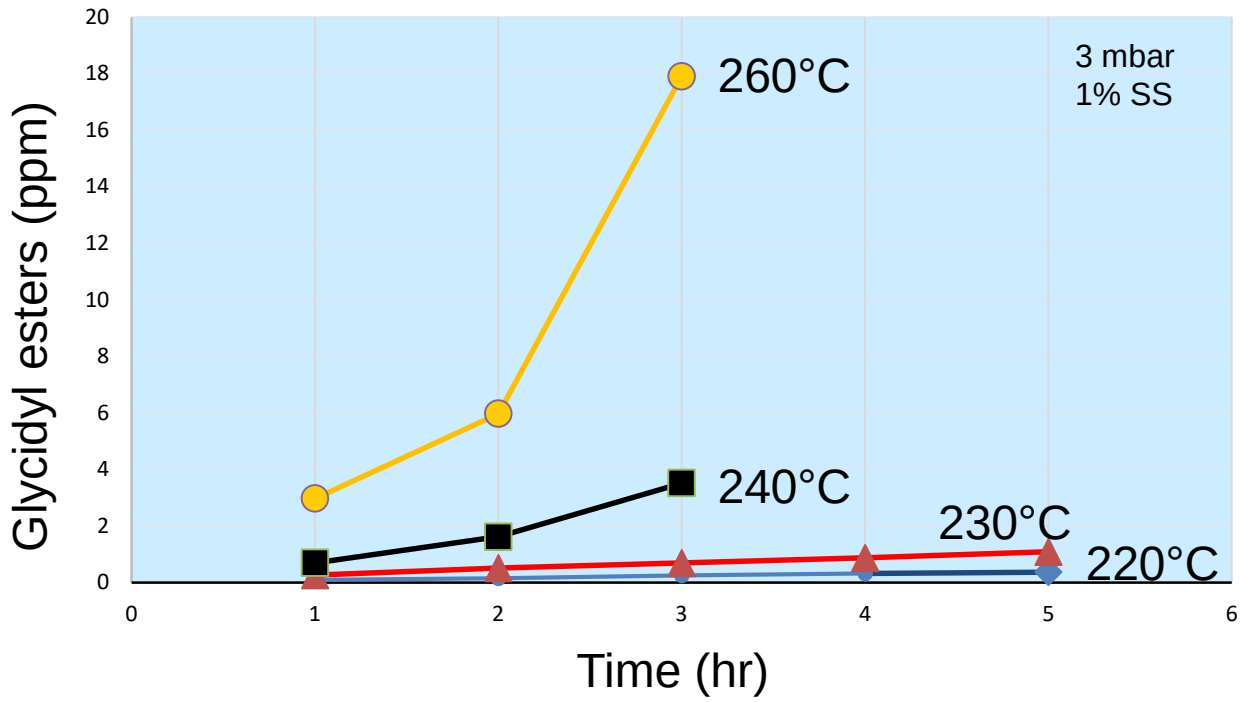
GE Formation: Effect of Time and Temperature



- **Almost no net formation of Glycidyl esters at T < 230°C.**
- **Very fast formation at T > 240°C.**

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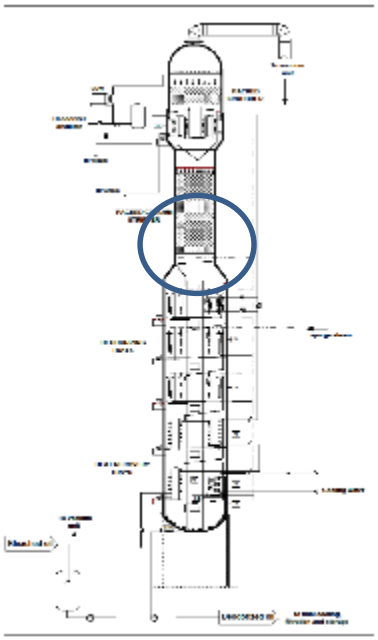
GE Formation: Effect of Packed FFA Stripping Column

10 min, 0.5% SS

Temperature (°C)	GE (ppm)	Color (R – 5,25")	FFA (% C16:0)
220	**0.10**	20	0.12
230	0.14	19	0,09
240	0.17	14	0,07
260	**0.20**	12	0,04

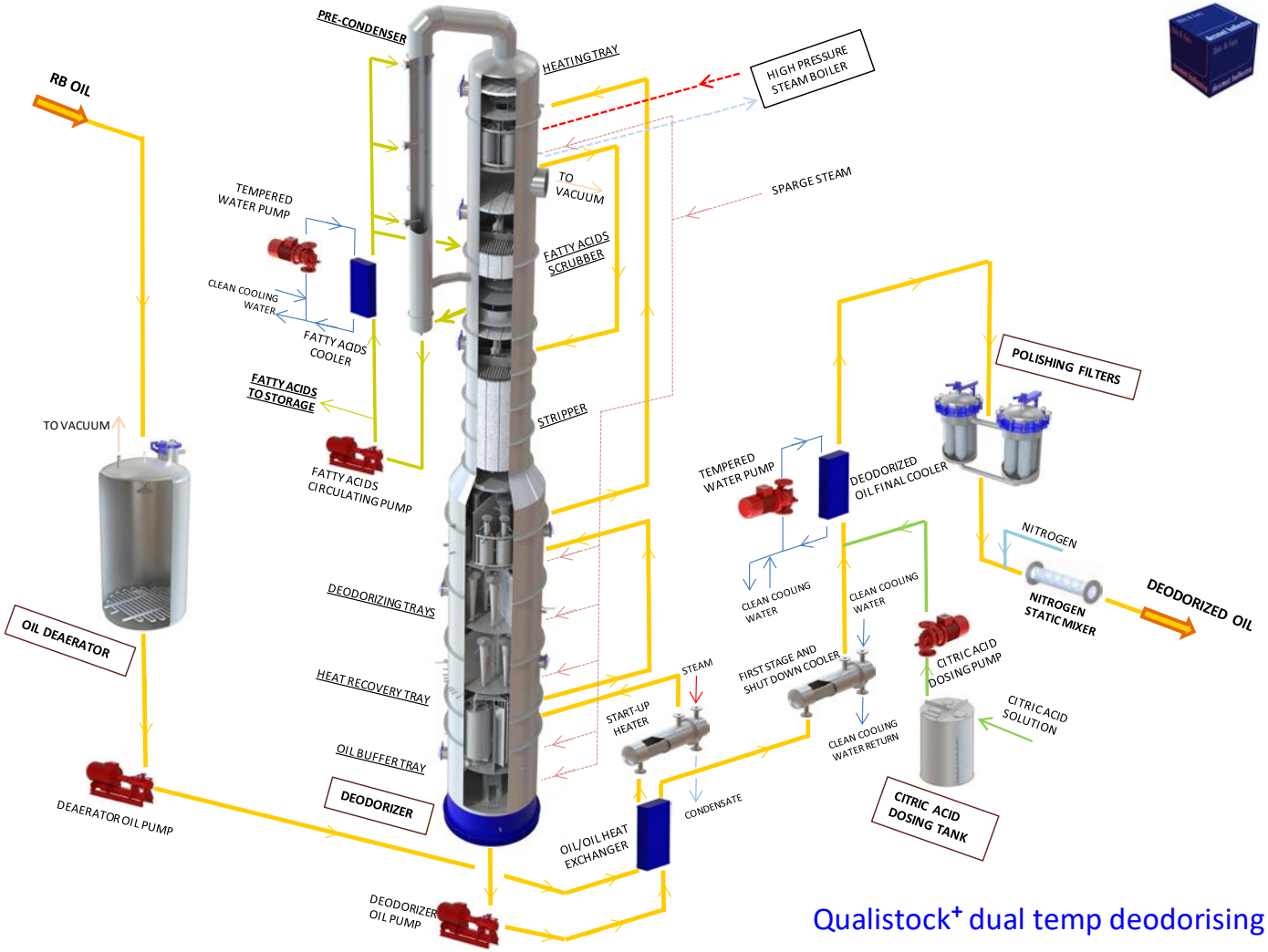


Short residence time at high(er) temperature gives:

- 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

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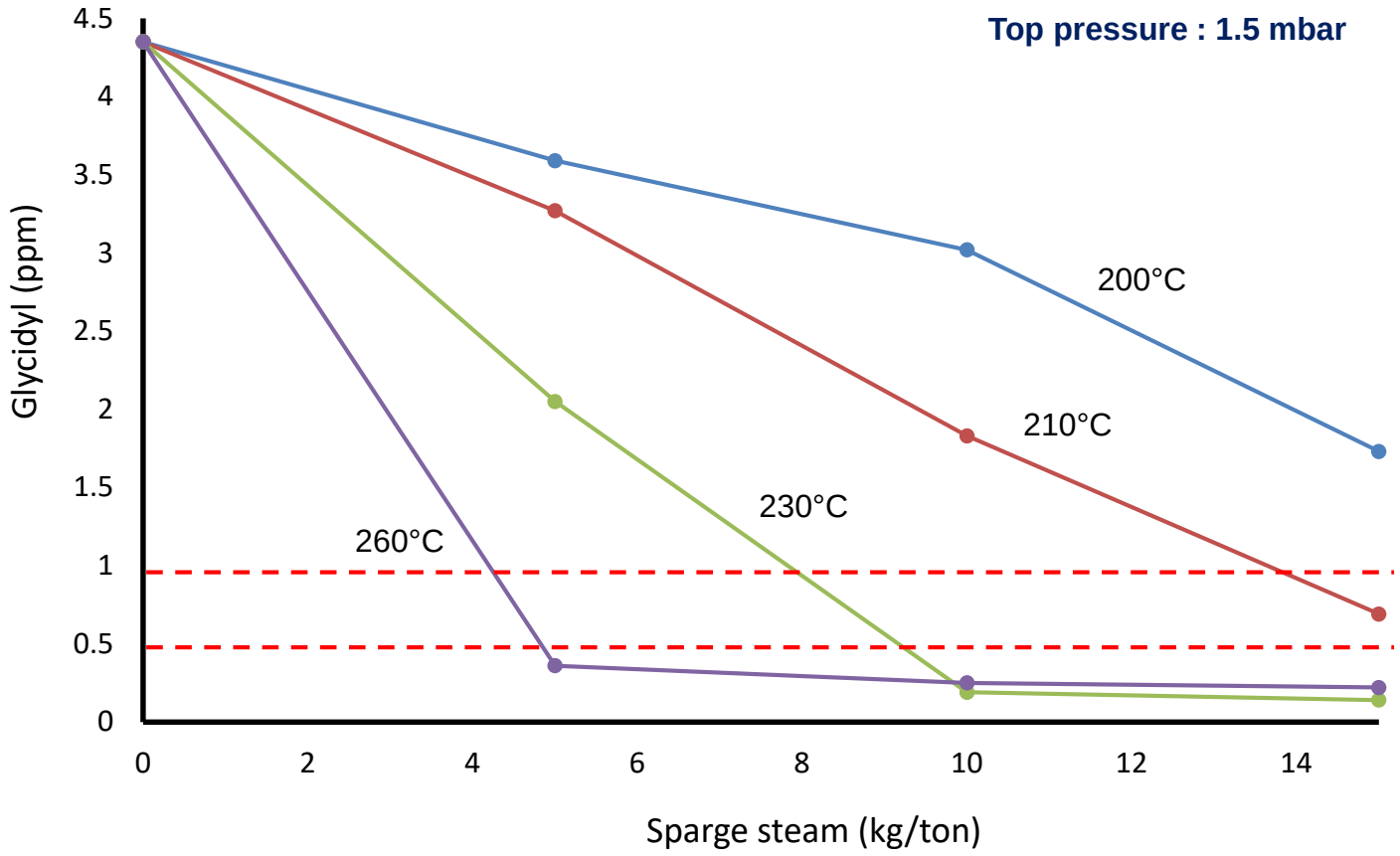
GE Mitigation: Post Stripping



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

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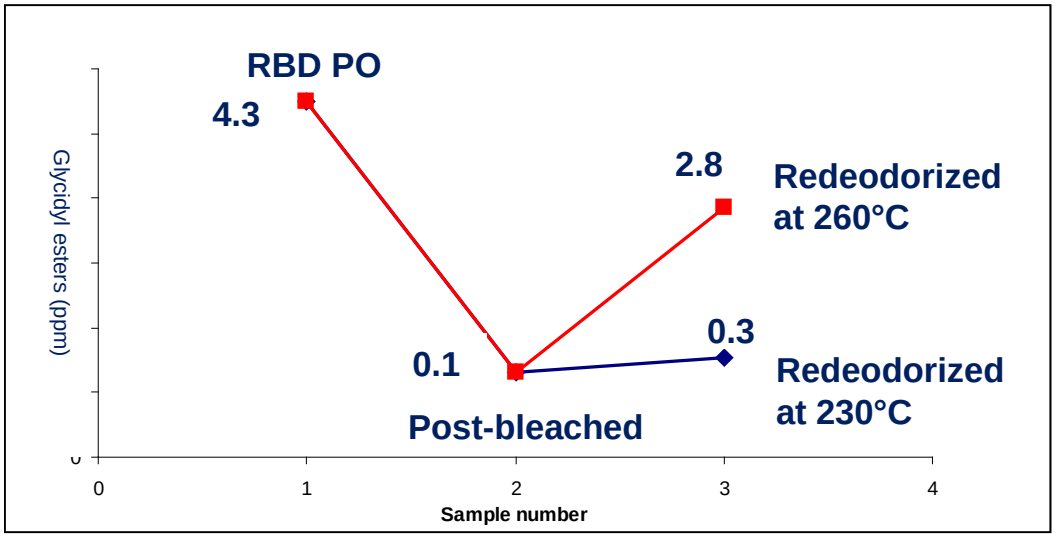
GE Mitigation: Post Refining

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

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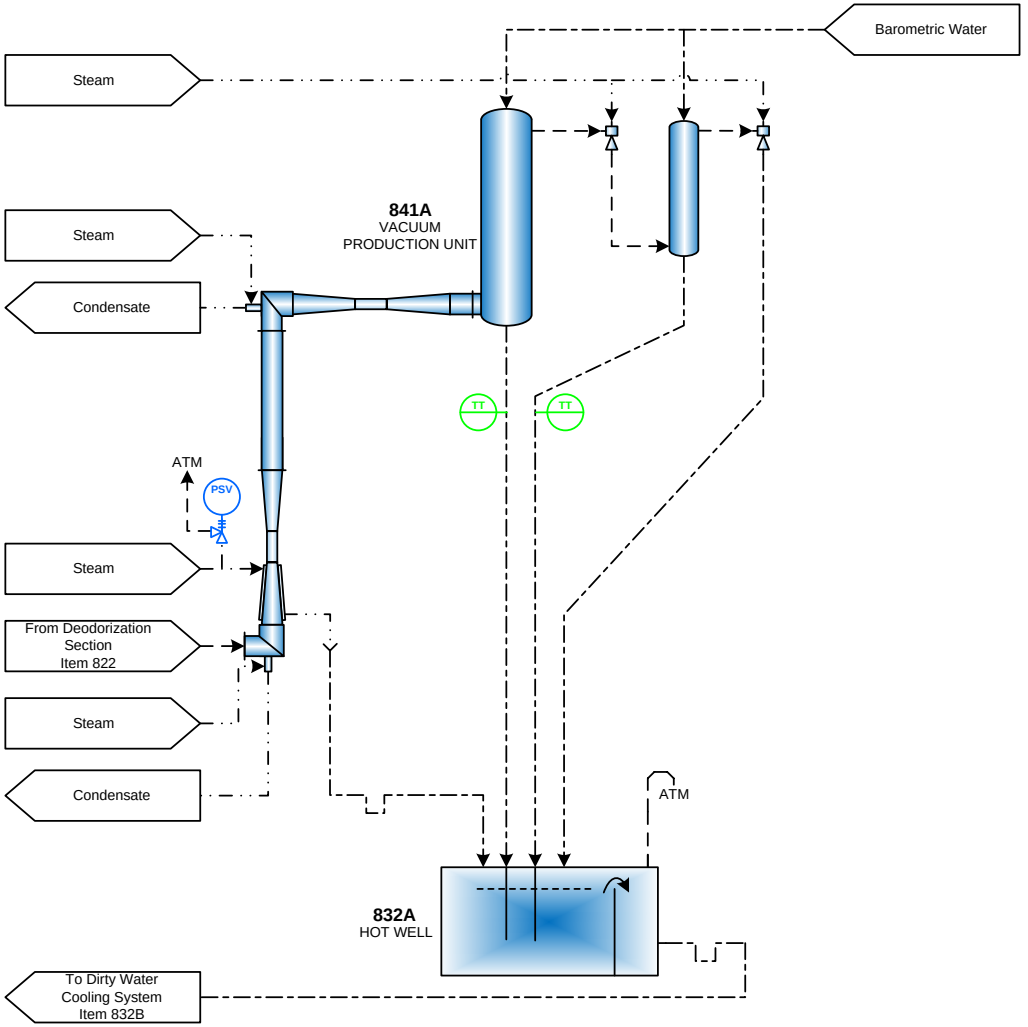
Conventional Barometric Water Vacuum System



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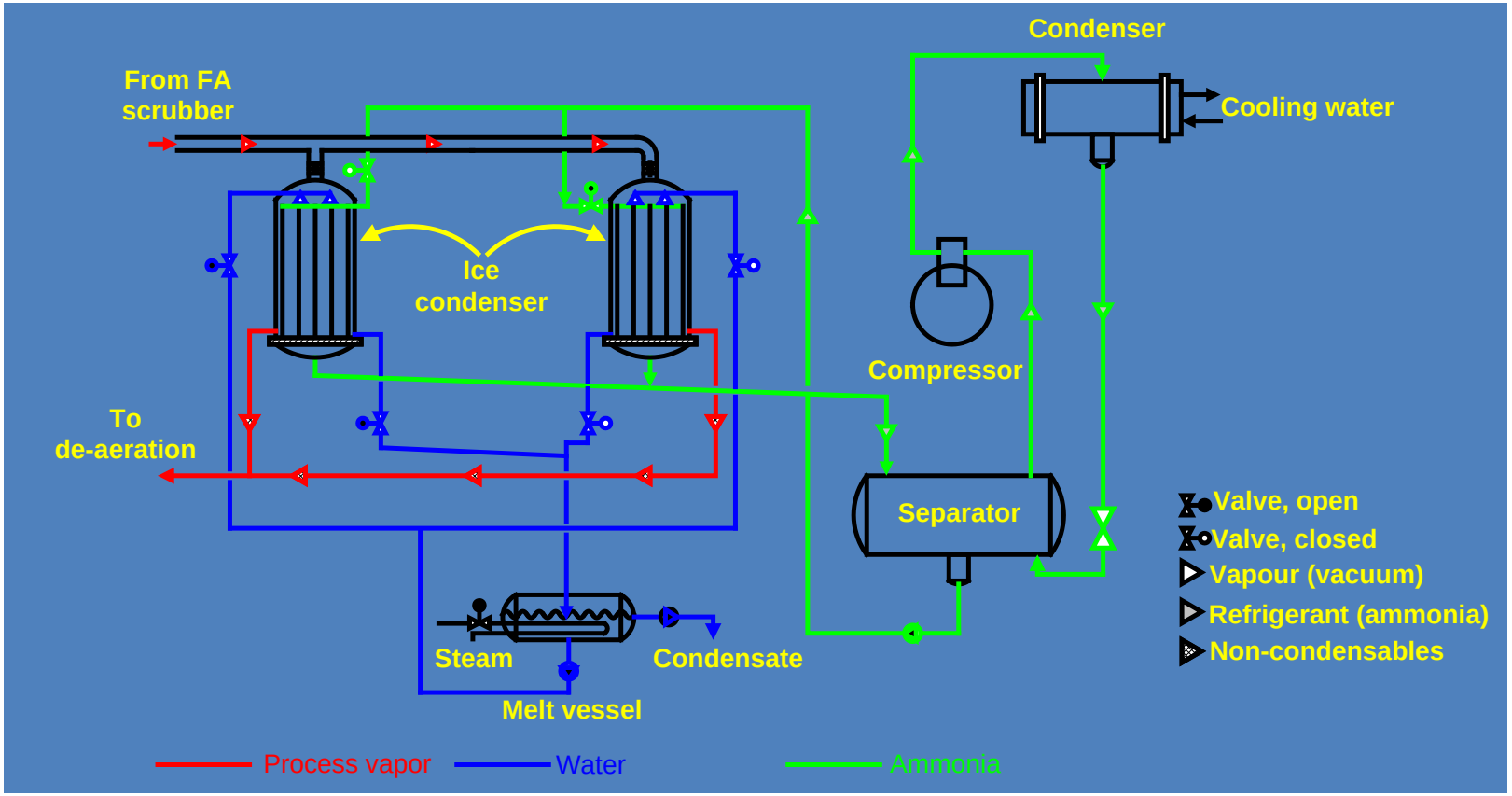
Ice Condensing Vacuum System: Working Principle



To introduce a sublimation step ahead of the compression step, turning steam to ice.

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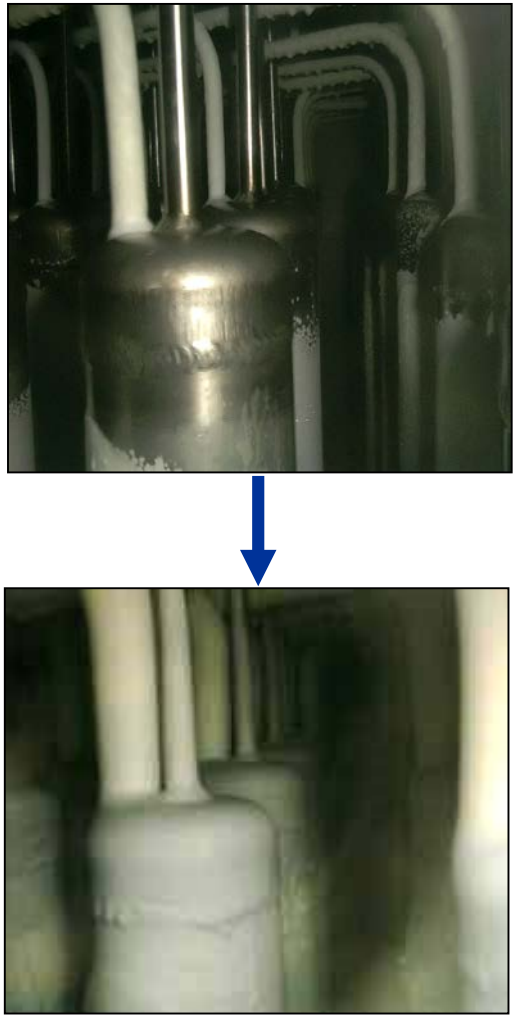
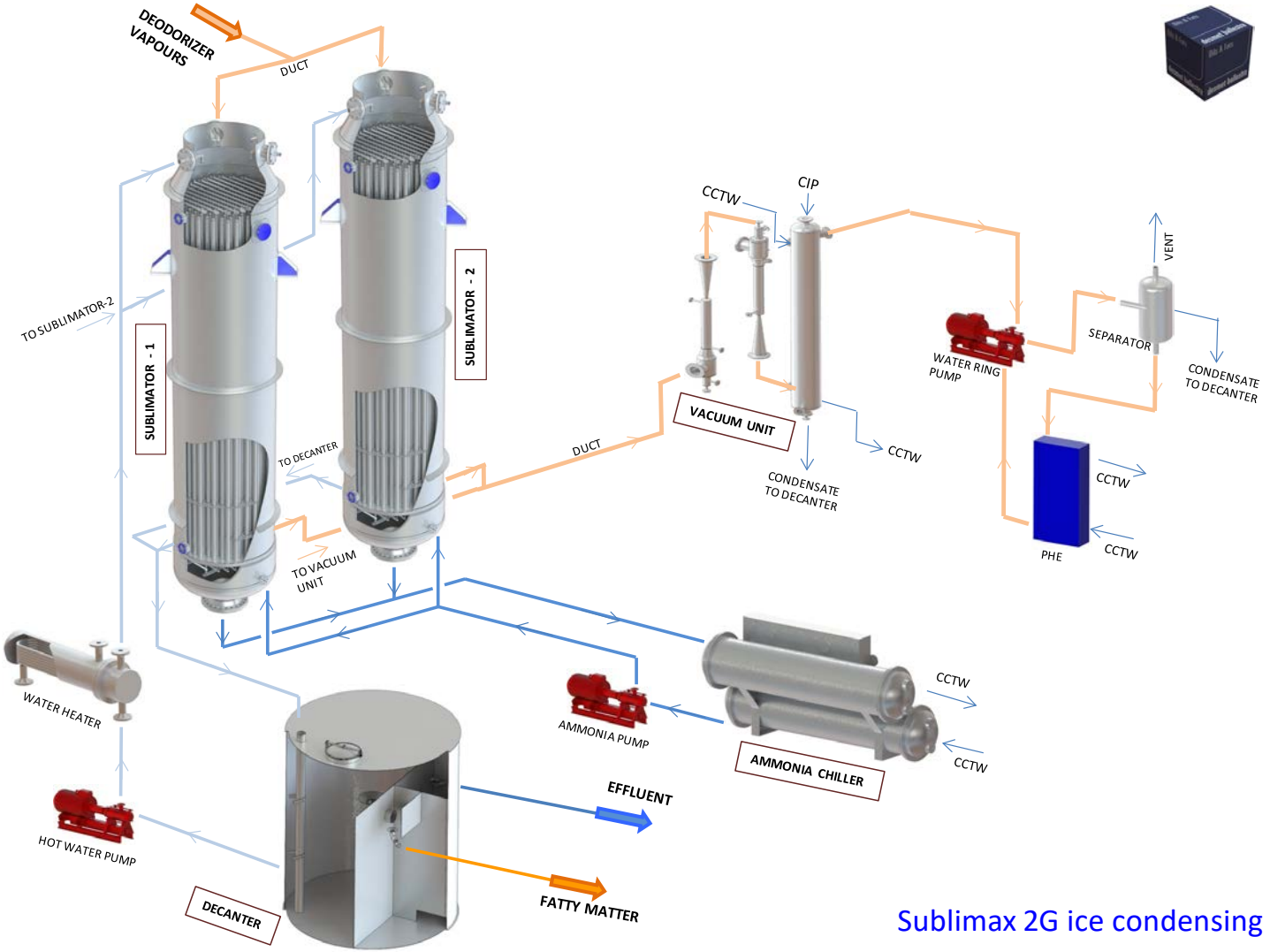
Ice Condensing Vacuum System: Advantages



- 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

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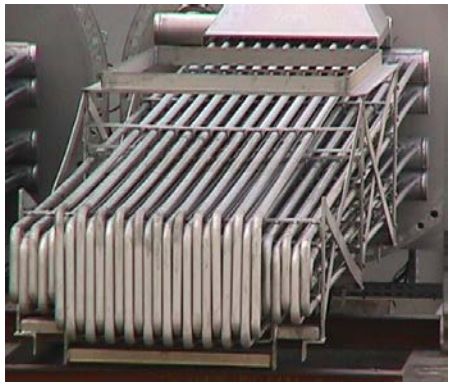
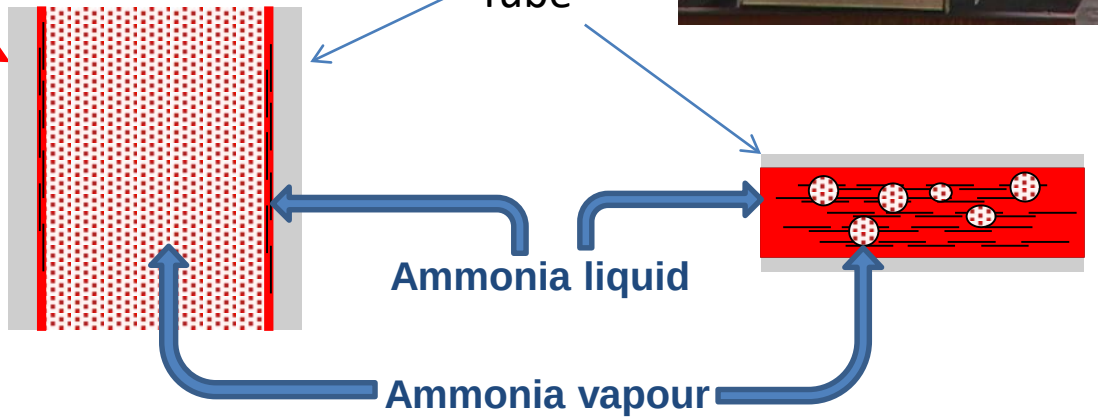
Desmet Ballestra Sublimax™ 2G

Sublimax: Vertical, with
Falling film ammonia evaporation

Classical: Horizontal, with
convective boiling liquid tubes





NH_3 mass: <100 kg

NH_3 mass: >>100 kg

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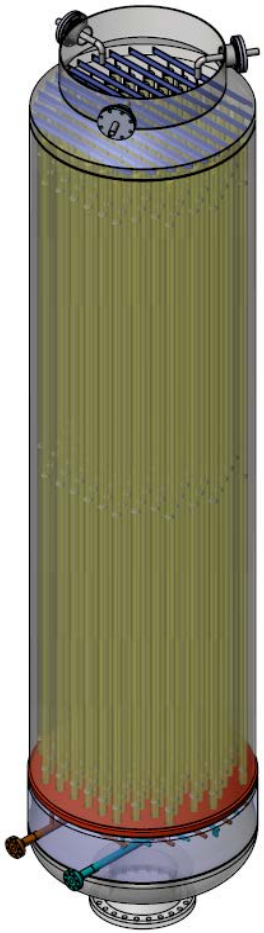
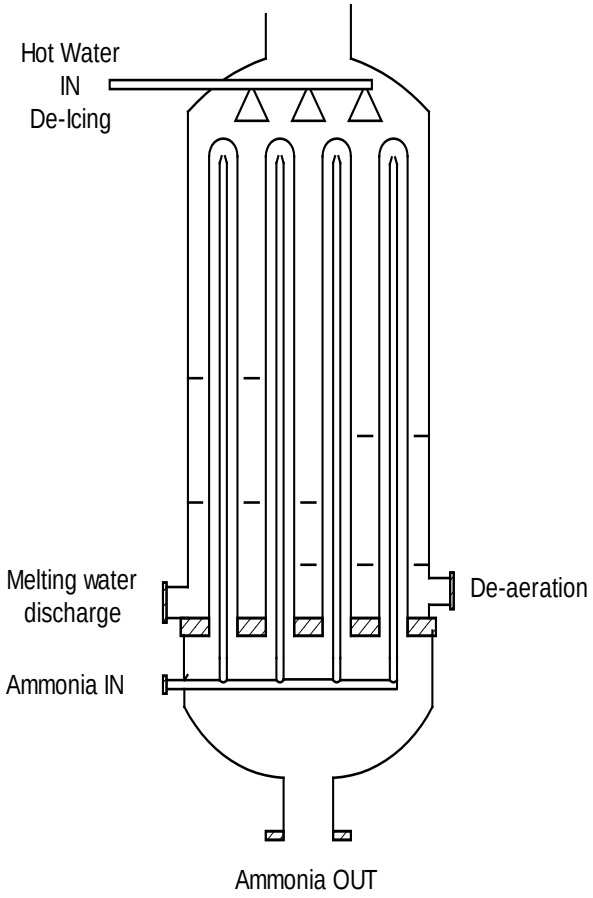
Desmet Ballestra Sublimax™ 2G





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.

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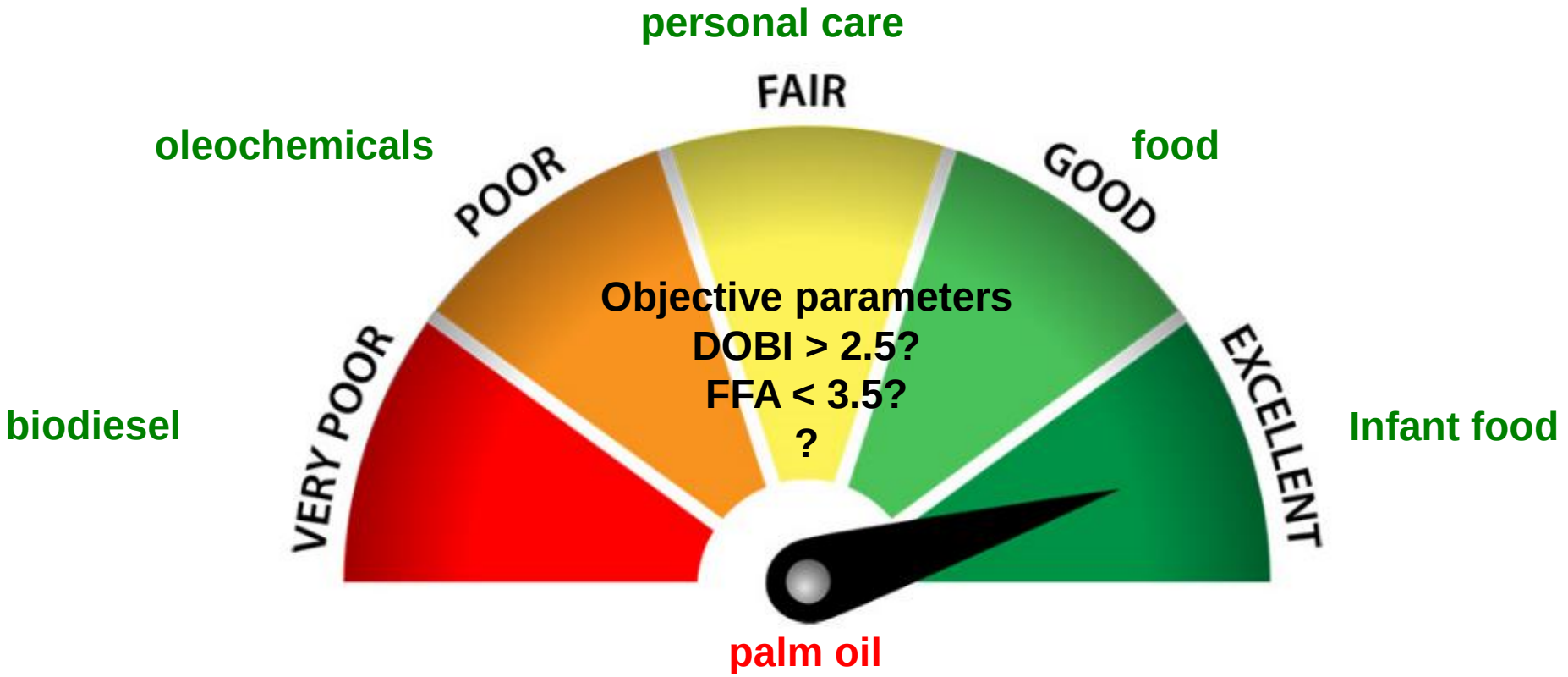
CPO quality key determining factor in mitigation of 3-MCPDE & GE

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?

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Effect CPO origin on 3-MCPDE/GE formation: Quality does matter !

3 types of CPO tested:	FFA %	DOBI
Excellent	1.3	3.4
Good	3.4	2.6
Poor	6.0	1.7

- **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 !

	CPO: 3.4% FFA / DOBI 2.6		CPO: 1.3% FFA / DOBI 3.4	
Feedstock	**RBD PO** Good quality	**RBD PO** Good quality	**RBD PO** Excellent quality	**RBD PO** Excellent quality
Treatment	**Unwashed physical refining**	**Washed physical refining**	**Unwashed physical refining**	**Unwashed Chemical refining**
FFA % (16:0)	**0.04**	**0.04**	**0.03**	**0.02**
Color Lovibond $5^{1/4}$ cell	**2.0R/51Y**	**2.2R/57Y**	**1.2R/28Y**	**0.7R/16Y**
3-MCPD (ppm)[1]	**1.21**	**0.34**	**0.46**	**0.08**
2-MCPD (ppm)	0.66	0.21	0.25	0.05
GE (ppm)	**0.40**	**0.42**	**0.27**	**0.24**

Effect CPO origin: Quality does matter !

	CPO: 3.4% FFA / DOBI 2.6		CPO: 6.0% FFA / DOBI 1.7	
Feedstock	**RBD PO** Good quality	**RBD PO** Good quality	**RBD PO** Poor quality	**RBD PO** Poor quality
Treatment	**Unwashed physical refining**	**Washed physical refining**	**Unwashed physical refining**	**Unwashed Chemical refining**
FFA % (16:0)	**0.04**	**0.04**	**0.06**	**0.02**
Color Lovibond $5^{1/4}$ cell	**2.0R/51Y**	**2.2R/57Y**	**6.0R/70Y**	**2.4R/39Y**
3-MCPD (ppm)[1]	**1.21**	**0.34**	**2.78**	**1.76**
2-MCPD (ppm)	0.66	0.21	1.31	0.79
GE (ppm)	**0.40**	**0.42**	**0.59**	**0.52**

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