IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

Process Innovations in the Vegetable Oils Industry

to keep you fed, healthy and safe

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Outline

1. The role of oils & fats in your diet
2. Nutrition and health
3. Global vegetable oils
4. Sustainability of vegetable oils
5. Feeding the world in 2050
6. Role of chemical engineers

- **Examples of innovations**

7. Protecting nutritional value
8. Increasing oil extraction rates
9. Value from waste
10. Mitigation of contamination
11. Packaging reform

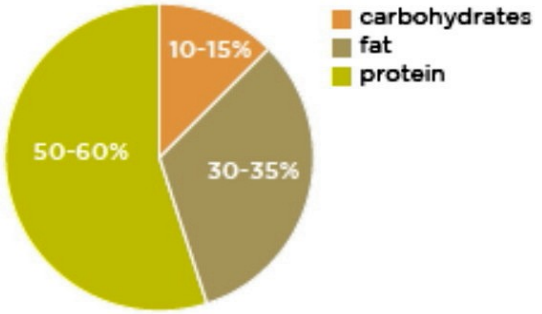
1. The role of oils and fats in your diet

- Concentrated source of energy (9kcal/g)
- Storage form of excess energy
- Cushion organs during movement
- Structural componens of cell membrane & hormones

- Some vitamins eg A, D, E & K rely on fat for absorption and storage

2. Nutrition and Health

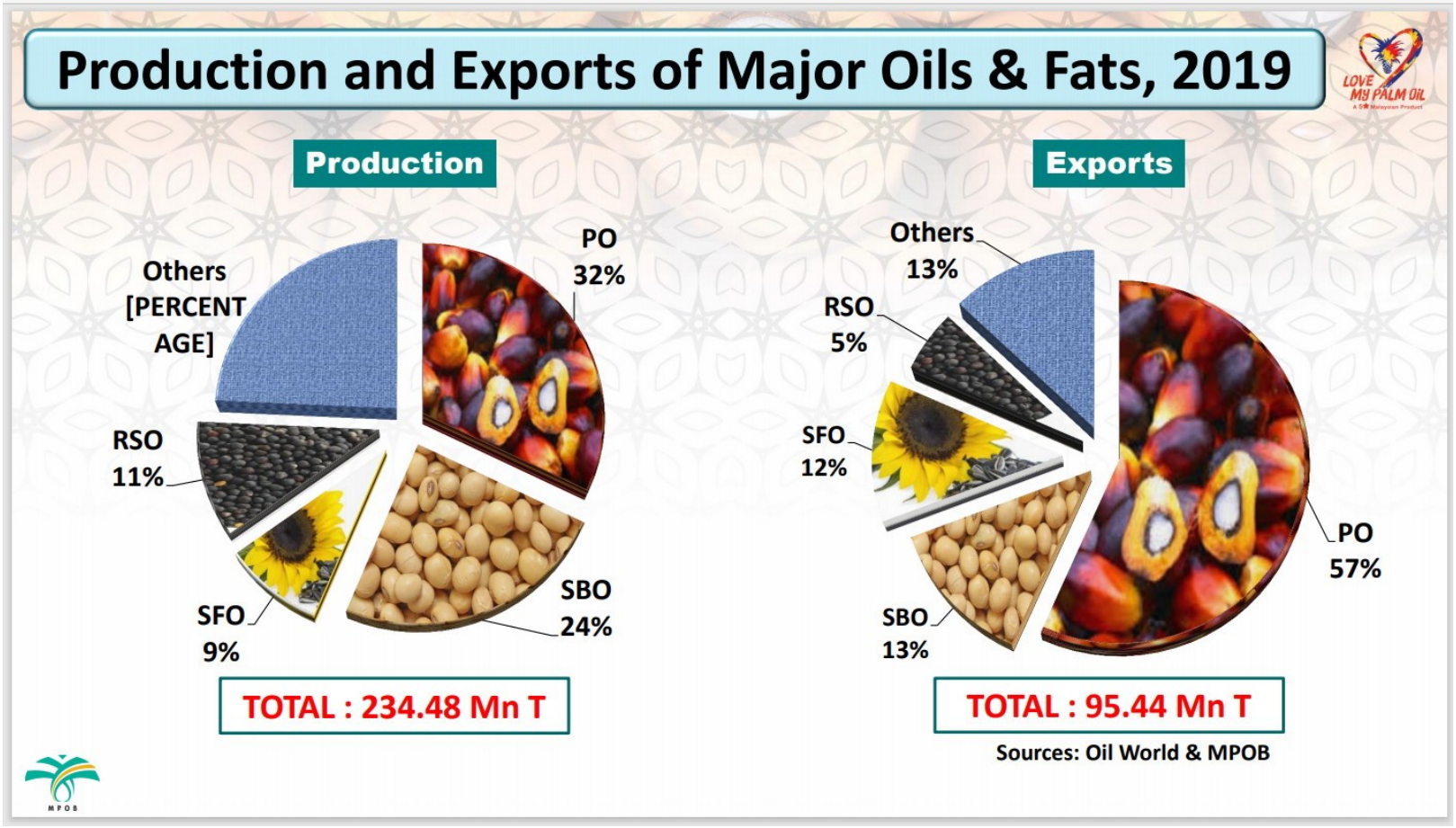
- Healthy eating is total diet
- Consumption in moderation
- Three elements
  - variety
  - balanced energy intake*
  - physical activity and sufficient sleep
- Lots of fruits & vegetables, balanced carbohydrate, fat & protein intake and avoid high intake of salt, refined carbohydrates, saturated fats and trans fats.



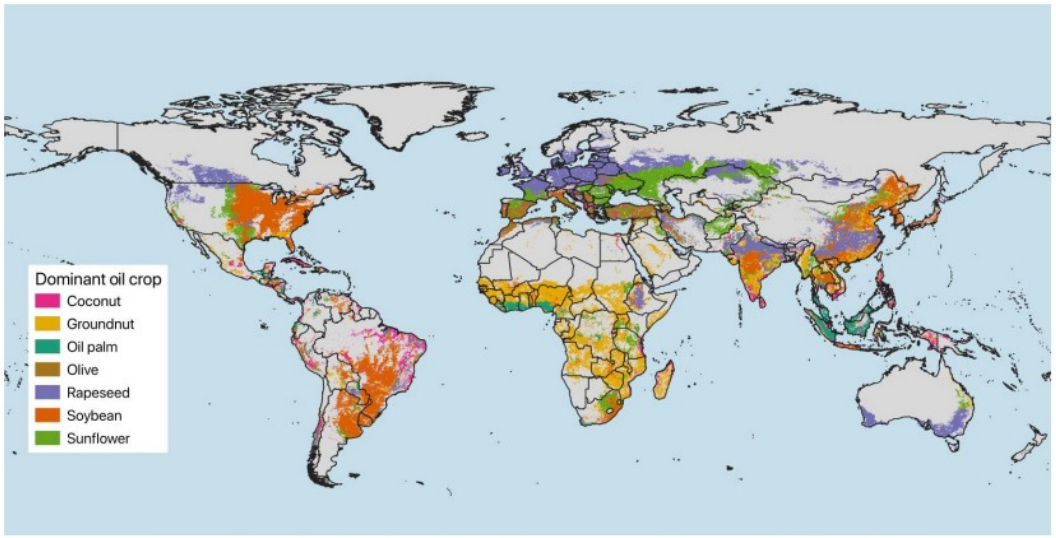
Source EPOA

* avoids risk of being overweight

3. Global Vegetable Oils



4. Sustainability of vegetable oils



- Maize: 187 mha
- Soy: 121 mha
- Rapeseed: 33 mha
- Peanut: 28 mha
- Sunflower: 26 mha
- Oil palm: 22 m ha
- Coconut: 12 mha
- Olive: 11 mha

Where vegetable oils are produced

4a. A few facts about vegetable oils

Oil crop	Type of crop	Oil yield (t ha-1)	Main oil production countries	Main biome impacted
Oil palm	25 years cycle	**1.9–4.8**	Indonesia, Malaysia,	Tropical rainforest
Coconut	30 – 50 y cycle	0.4–2.4	Philippines, Indonesia,	Tropical and subtropical
Olive	Long lived	0.3–2.9	Spain, Italy, Greece	Mediterranean
Soybean	Annual	0.4–0.8	China, USA, Brazil	Subtropical
Rapeseed	Annual	0.7–1.8	China, Germany, Canada	Temperate
Cotton	Annual	0.3–0.4	China, India	Subtropical
Groundnuts	Annual	0.5–0.8	China, India	Subtropical
Sunflower	Annual	0.5–0.9	Ukraine, Russia	Temperate
Maize	Annual	0.1–0.2	USA, China,	Temperate

Source

International Union for Conservation of Nature (IUCN) Palm Oil Task Force

(2016 - 2021)

4b. Sustainability Standards

- Palm oil

  - Roundtable on Sustainable Palm Oil (RSPO) [20%]
  - International Sustainability Standard (ISCC)
  - Rainforest Alliance
  - Indonesian Sustainable Palm Oil (ISPO)*
  - Malaysian Sustainable Palm Oil (MSPO)*

* mandatory
[certified sustainable]

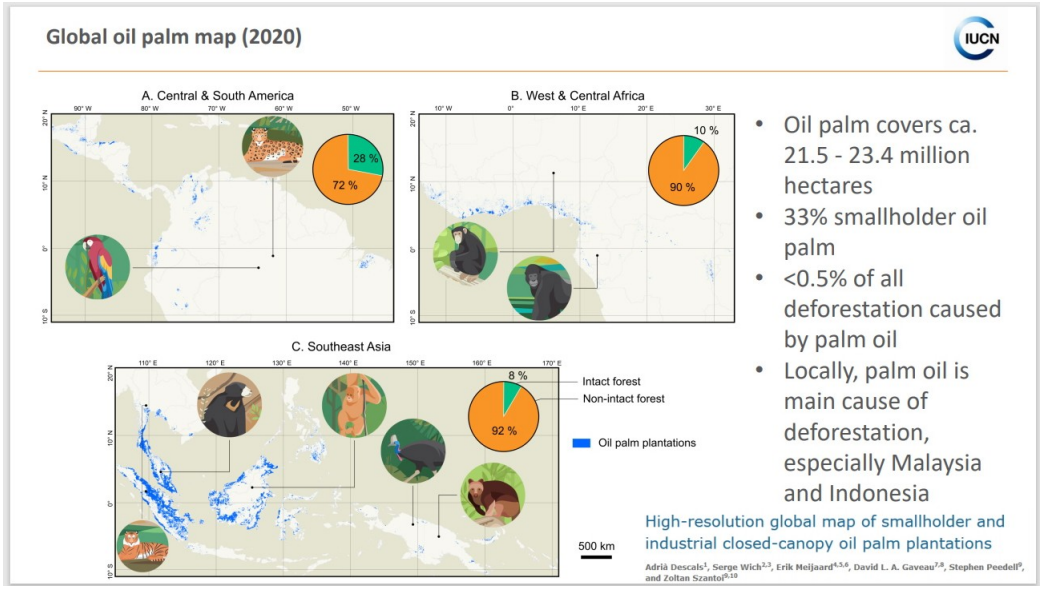
- Soybean

  - Round Table on Responsible Soy (RTRS) [8%]

- Coconut

  - Rainforest Alliance

4c. Some knowledge gaps



- Where are the major crops grown?
- What have their past environmental impacts been?
- How do yields vary and why?
- Socio-economic benefits and costs
- We need better information to objectively inform consumers and policy-making

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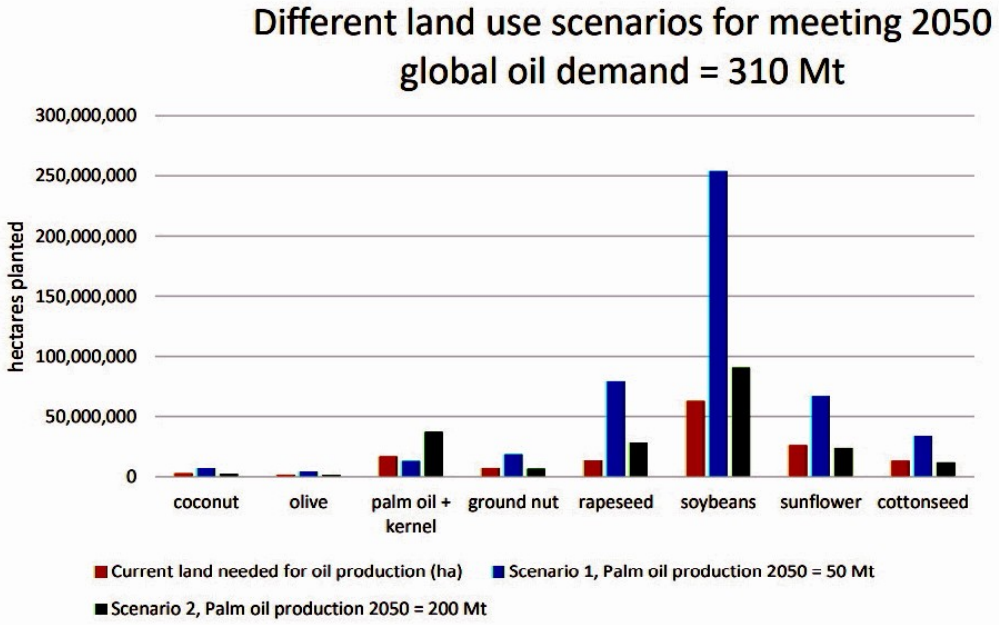
5. Feeding the world in 2050



Global demand for vegetable oil

2020 165 Mt (7.8 billion people)
2050 310 Mt (9.7 billion people)

Current land	145 Mha
Extra land 2050	
Scenario 1	278 Mha
Scenario 2	4 Mha

A role for the FAO?

The Food and Agriculture Organization of the United Nations is an agency that leads international efforts to defeat hunger.

6. The role of chemical engineers

- In upstream in agriculture, oil extraction and refining.
  In downstream in food and non-food processing.
- Make the operations safer, more efficient with less waste
- Apply hard science, look for gaps and innovate for more sustainable processes
- Embrace all aspects of chemical engineering including biochemical and digitalisation
- In the food sector protect its nutritional value, enhance shelf life, uphold safe food handling practices and reform packaging

7. Protecting Nutritional Value

7a Red palm oil

- Retain most of the carotene and vitamin using molecular distillation in refining
- Patented by PORIM in the 1990s
- Upscaled by chemical engineers

PORIM = Palm Oil Research Institute of Malaysia.
Today known as MPOB = Malaysian Palm Oil Board

Levels of minor beneficial components in palm oil			
Sample	**Carotenes (ppm)**	**Vitamin E (ppm)**	**Phytosterols (ppm)**
Crude palm oil	643	869	210-620
RBD palm olein	Nil	561	109-170
Red palm olein	513	707	325-365

Adapted from data in B. Nagendran, U. R. Unnithan, Y. M. Choo, and Kalyana Sundram "Characteristics of red palm oil, a carotene- and vitamin E–rich refined oil for food uses" 2000

7b Extraction of tocotrienol & carotene

- From crude palm oil using molecular distillation technology
- By products biodiesel and glycerine

CPO PHYTONUTRIENTS	PPM
Carotenes (alpha- & beta-carotene)	500 – 700
Vitamin E (Predominantly Tocotrienols)	600 – 1000
Phytosterols	360 – 620
Squalene	200 – 500
Co-Enzyme Q10	10 – 80
Triterpene Alcohol	40 - 80
Phospholipids	5 - 130

Source Gunstone, 2011

IChemE Malaysia Awards 2017 Palm Oil Award "Novel integrated process for the extraction of phytonutrients and production of biodiesel from crude palm oil" by ExcelVite Sdn Bhd

POPSIG evening talk delivered by WH Leong (ExcelVite), 16 May 2018 "Novel Process for Palm Phytonutrient Extraction"

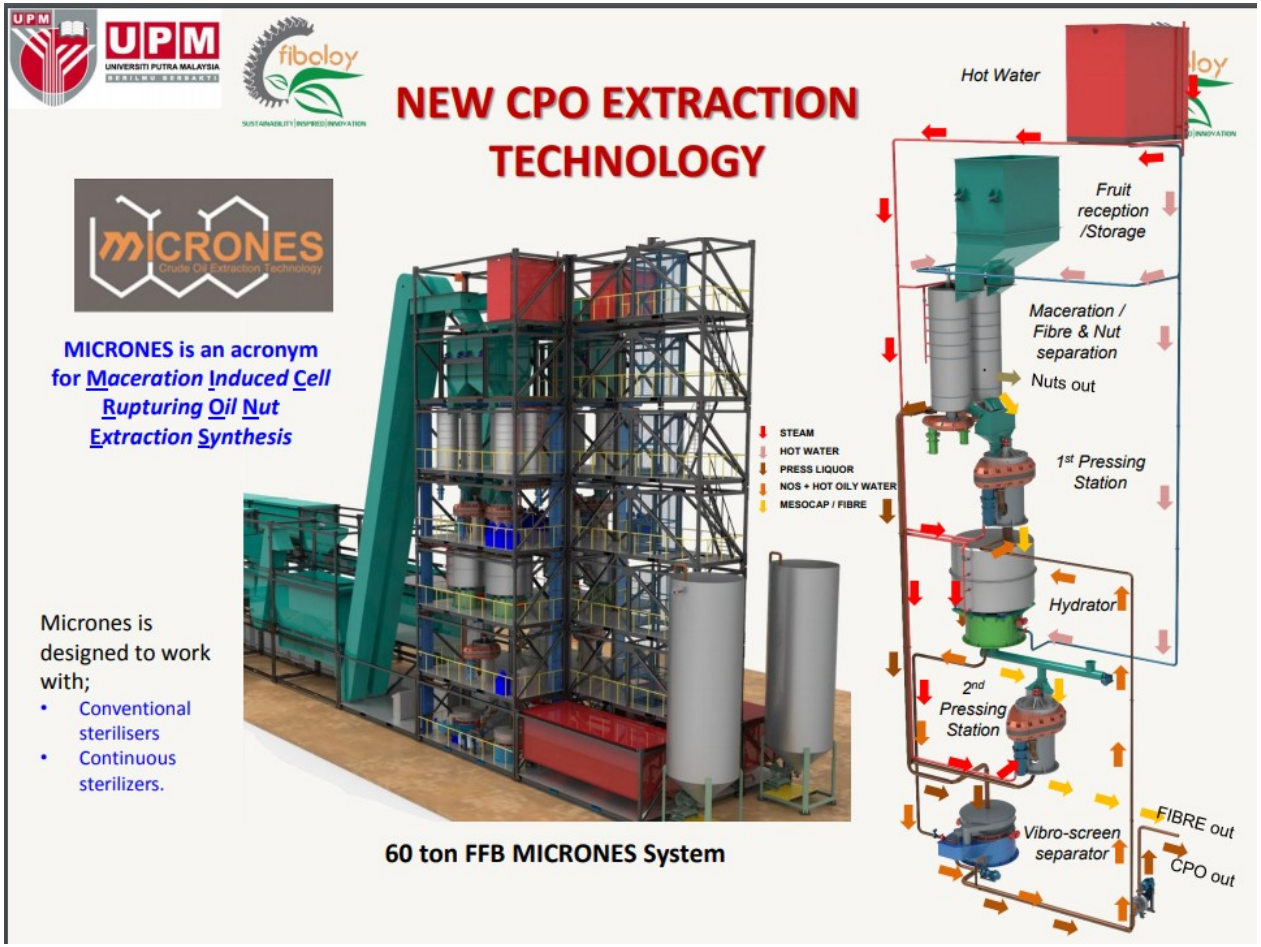
8. Increasing oil extraction rates

8a (i) Increasing oil extraction rate I

- Example of chemical engineers working with mechanical engineering and biology
- A key is the separation of the kernel from the mesocarp
- 1% OER recovered saves 250,000 hectares of land

POPSIG evening talk delivered by Professor Dr Robiah Yunus (Universiti Putra Malaysia), 10 July 2017 “A more efficient oil extraction method”

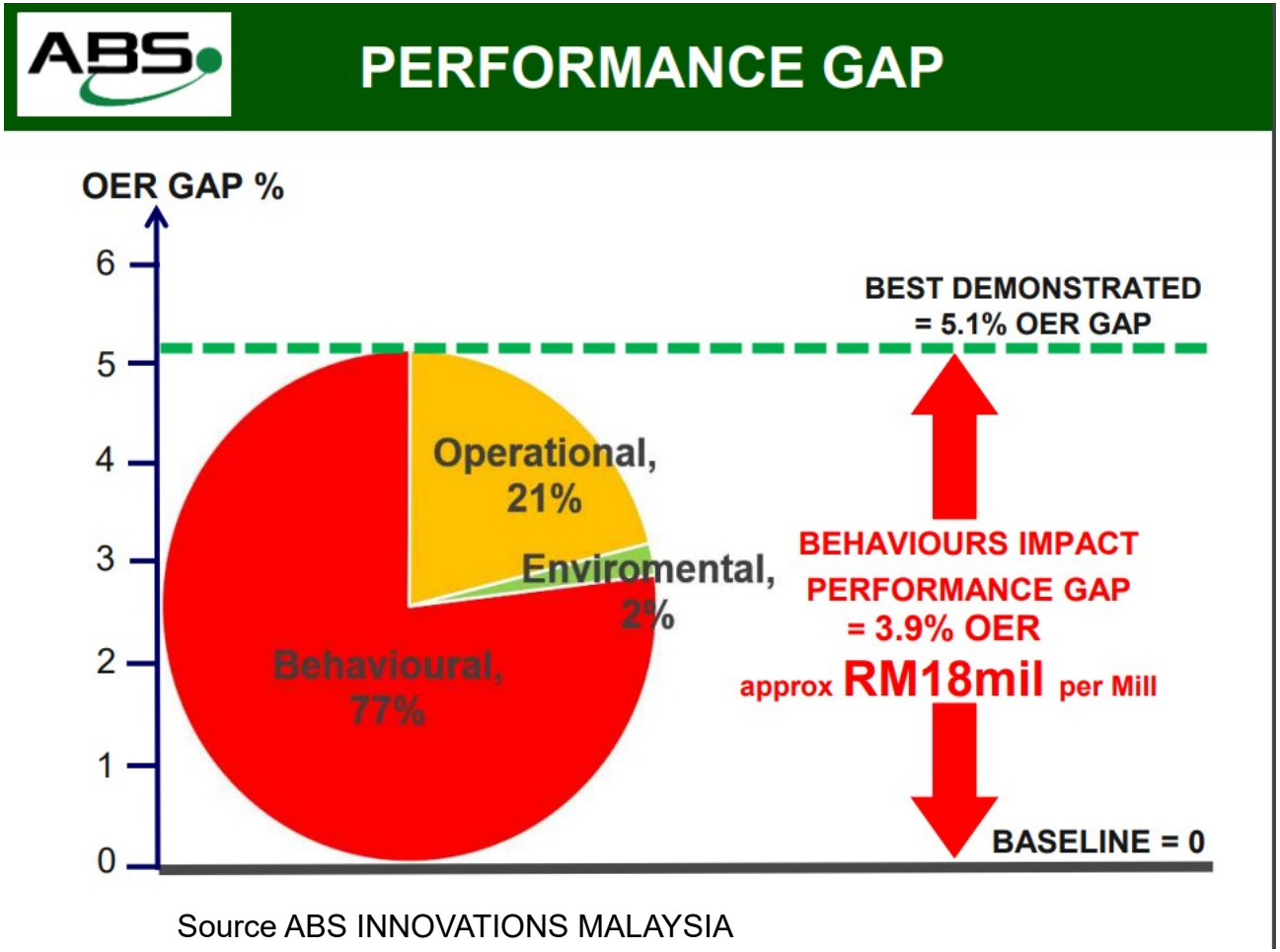
8a (ii) Increasing oil extraction rate I



8b (i) Increasing oil extraction rate II

- Digitalisation of Kaizen/TPM – gradual and methodical processes that continuously improve operations and involve all employees
- This example is for palm oil mills
- Theoretical OER is 30% with at least 20% currently achieved

8b (ii) Increasing oil extraction rate II



Source ABS INNOVATIONS MALAYSIA

9. Value from waste

9 (i) UCO (used cooking oil) to biodiesel

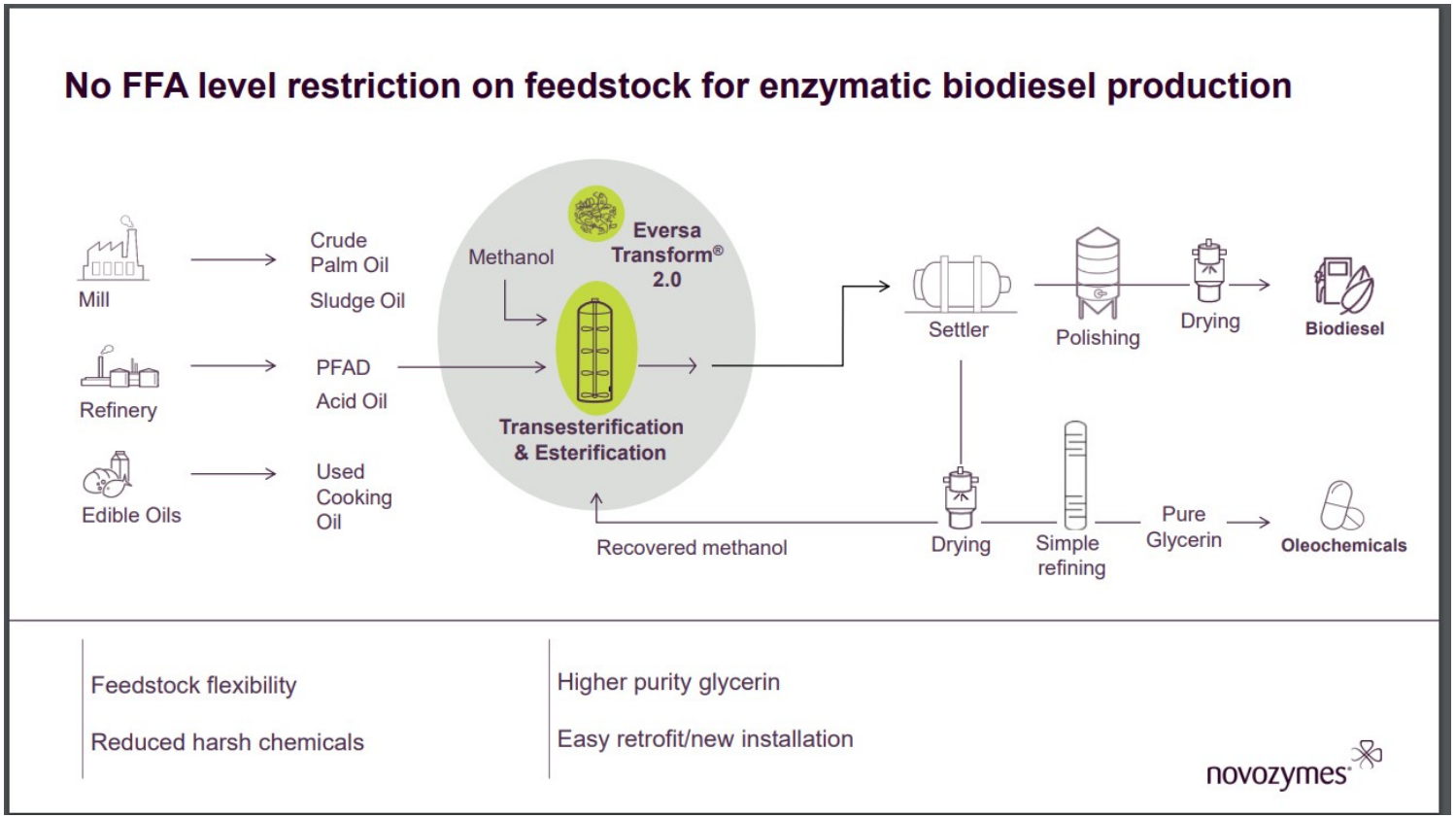
- Low ffa oil is transesterified by base catalyst
- High acidity oil esterification is acid catalysed

- UCO transesterification and esterification in a single step by enzymes.
- UCO market estimated at 20 Mt/a

POPSIG evening talk delivered by Mr. Wong Wai Seng (Novozymes Malaysia), 09 March 2020
"Converting Secondary Product from Palm Oil Process into Biodiesel via Enzymatic Way"

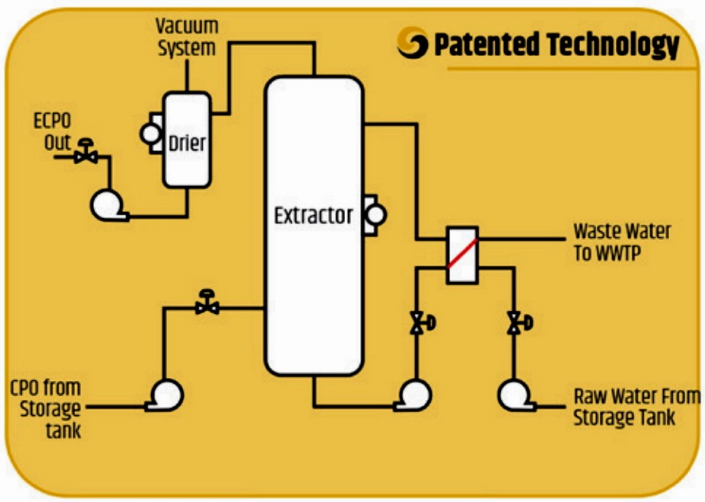
POPSIG evening talk delivered by Mr Tan Liok Min (Desmet Ballestra (M) Sdn Bhd), 03 August 2020
"Biodiesel from Low-Grade Feedstock"

9 (ii) From restaurant to gasoline station

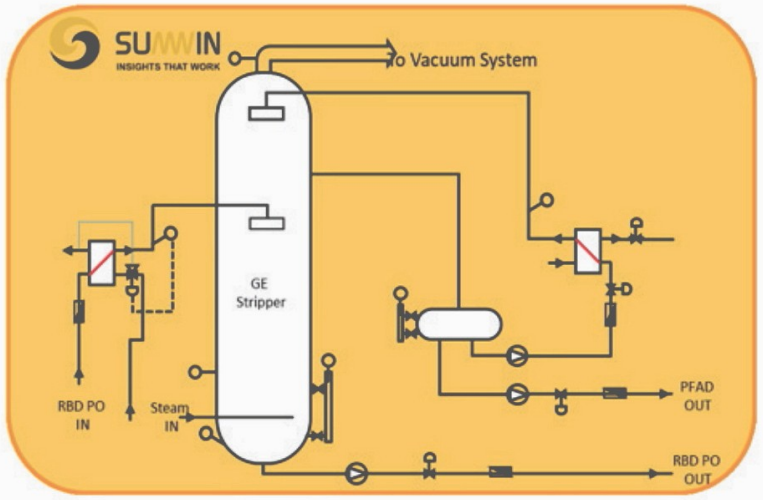


10. Mitigation of contamination

10a Reduction of 3-MCPDE & GE



CPO Chloride extractor system
[Photo reference – *Sumwin*]



GE Stripper [Photo reference – *Sumwin*]

- Unique L/L extraction design requires very low maintenance
- Use of proprietary adsorbent removes precursors
- Improve vacuum in deodoriser
- Modify stripper column to strip out GE
- Throughput maintained, low CAPEX/OPEX

IChemE Malaysia Awards 2020
Palm Oil Award
"Patented 3MCPDE and Glycidyl Esters (GE) Mitigation Technology"
by Sumwin Solutions Malaysia

Malaysia AWARDS 2020
IChemE

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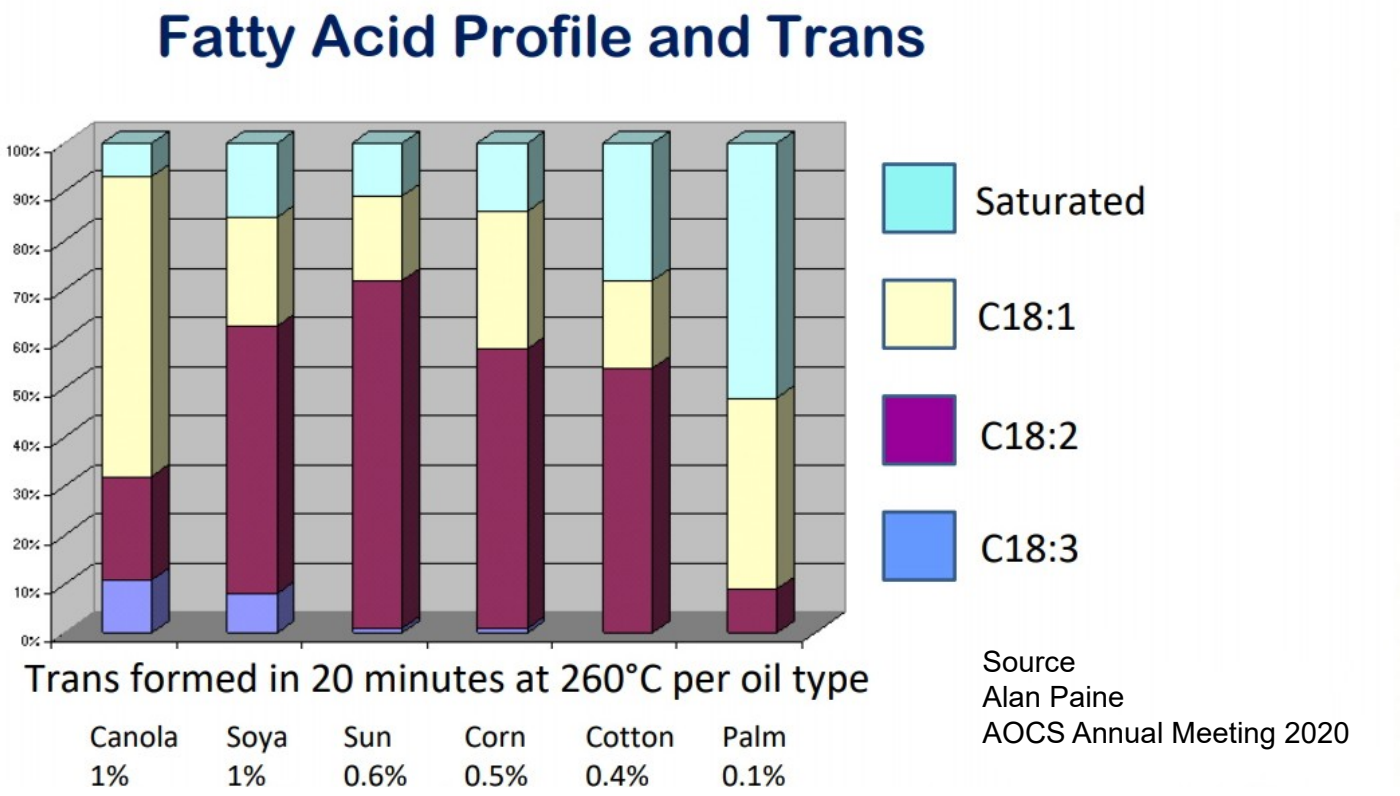
10b (i). Likelihood of trans formation



Source
Alan Paine
AOCS Annual Meeting 2020

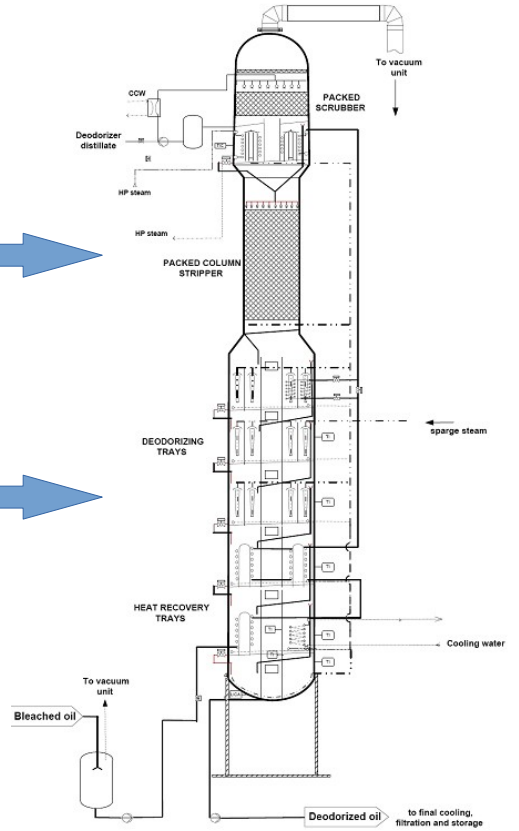
The ease with which an oil forms trans isomers rises with the proportion of poly unsaturated fatty acids present

10b (ii) Dual temperature column to minimise *trans* fat

- Integrated packed column stripper|
  - short residence time
  - high temperature 240 - 260 deg C
  - ffa/stripper and some heat bleaching

- Tray type deodoriser
  - longer residence time
  - lower temperature 220 – 240 deg C
  - final heat bleaching/deodorisation

- (Optional) Deep vacuum < 2 mbar
  - closed loop with chilled water
  - ice condensing



Source Desmet Ballestra

10c Other contaminants

Oil	Contaminant	Source	Removal
Coconut	PAHs & dioxins	Smoked dried meat	Activated carbon & deodorization
Groundnut	Aflatoxin	Mould	Alkali refining
Corn	Zearalenone	Mycotoxin	Deodorization
All	Pesticides	Agriculture fields	Deodorization
All	Mineral oil	Machinery leak	Avoid

PAHs = Polyaromatic Hydrocarbons

10. Packaging reform

10. Reduce plastic in packaging

- Cargill has reduced plastic usage by 550t/a for its vegetable oil bottles
- Only using 100% recyclable polyethylene terephthalate (PET) bottles in new line in US

- In India cut 25% of plastic used (120t/a) for *Gemini, Sweekar* and *NatureFresh* edible oil brands
- In Brazil cut 6% of plastic used (80t/a) for *Liza* soybean oil brand in 900-mL bottles

Conclusion

- The production of vegetable oils is still evolving and the benefits as well as the harm it can bring continues to unfold requiring the intervention of many including scientists and engineers.
- The industry sectors of the different types of vegetable oils must work together and learn from each other to bring benefit to the community it serves

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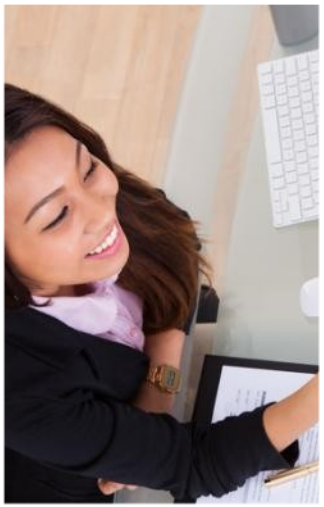







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