



Palm Oil Processing
Special Interest Group

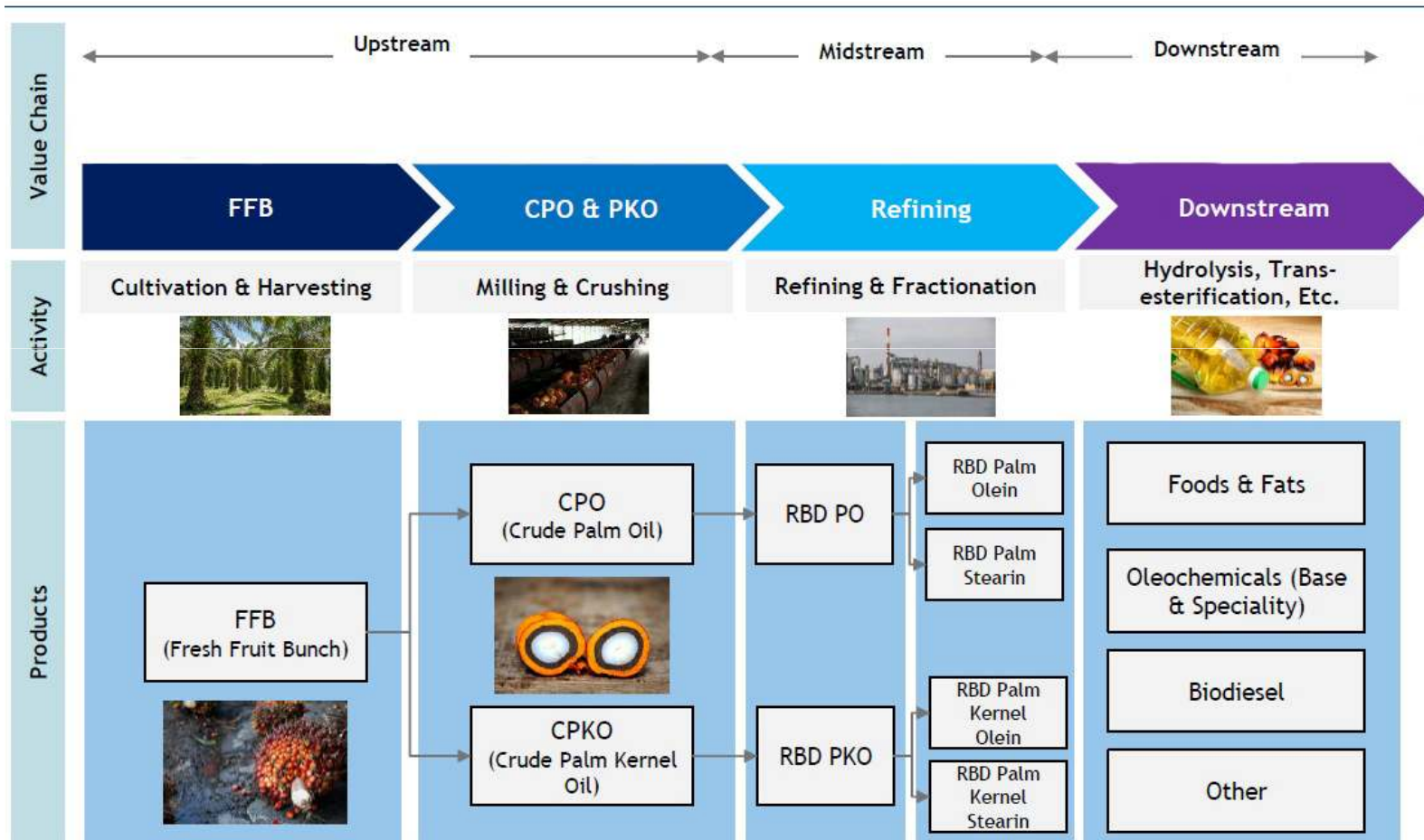
Introduction to Oleochemicals

18th September 2017

Monash University Malaysia

Ir Qua Kiat Seng CEng FIChemE

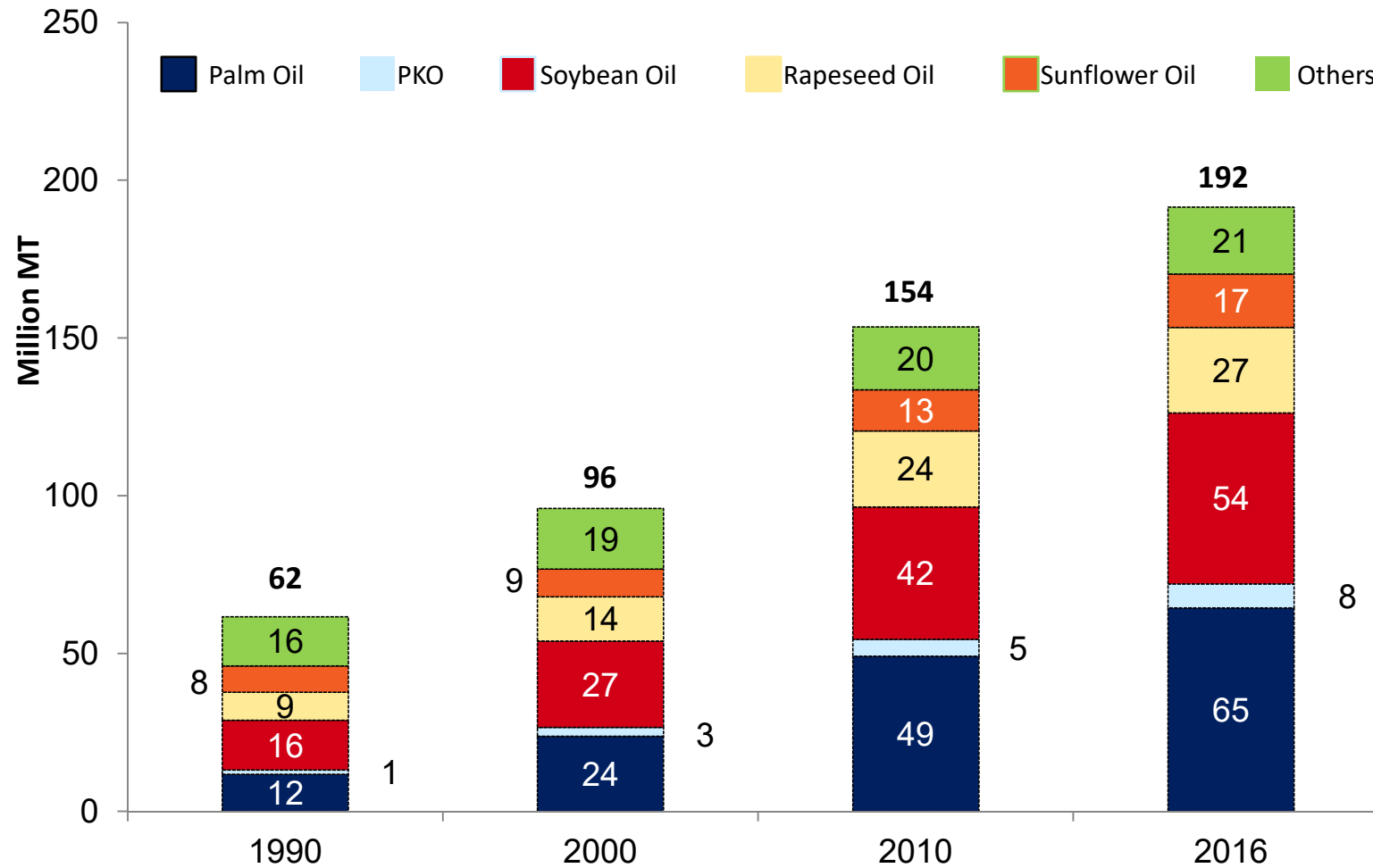
PO & PKO supply chain



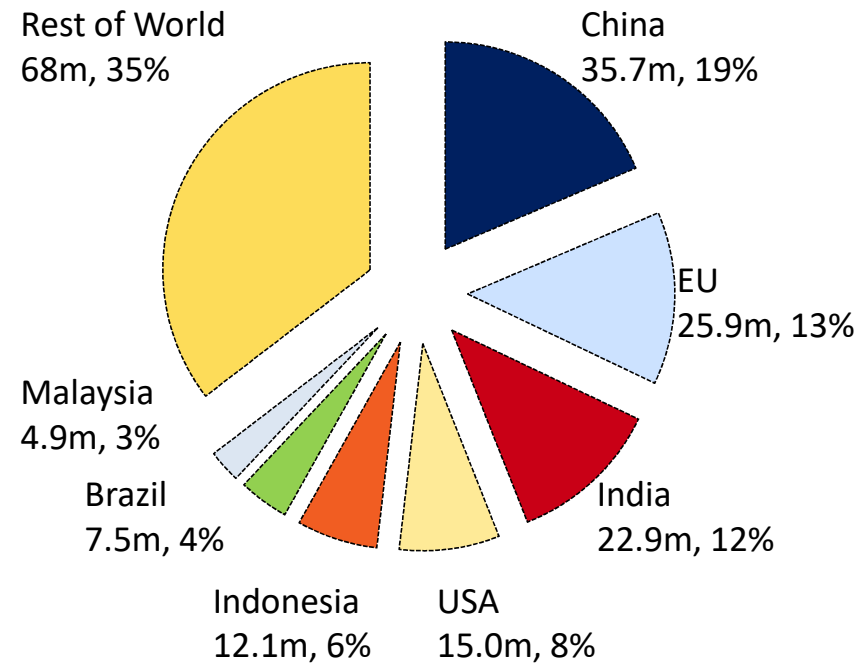
What will be covered

1. Vegetable Oil Market
2. Oleochemistry
3. Oleochemicals
4. Oleochemical Market

1. Global Vegetable Oil Production

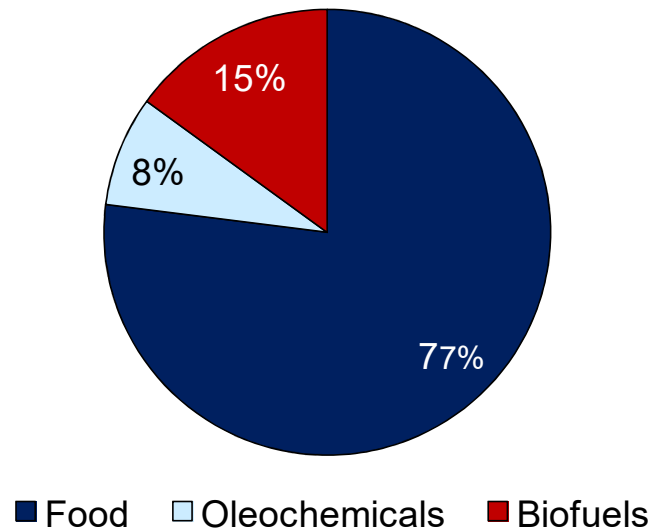


Market Share by Region, 2016

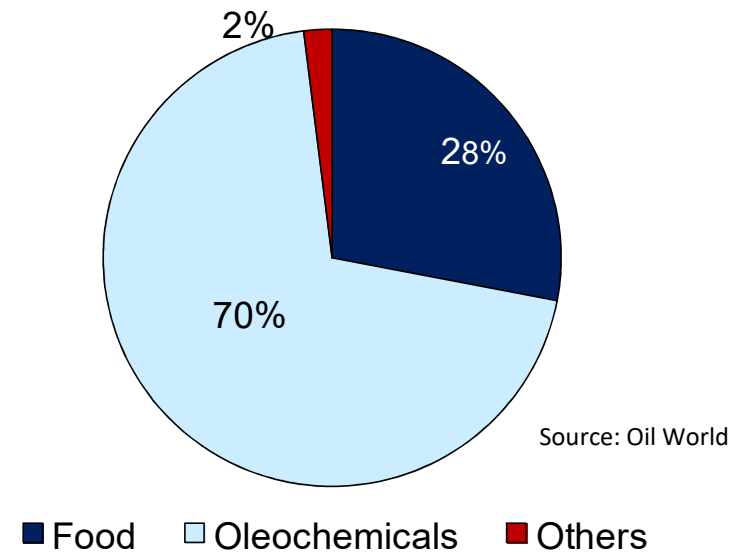


Where PO and PK is used

Global Palm Oil Consumption – Split by Applications,
2016



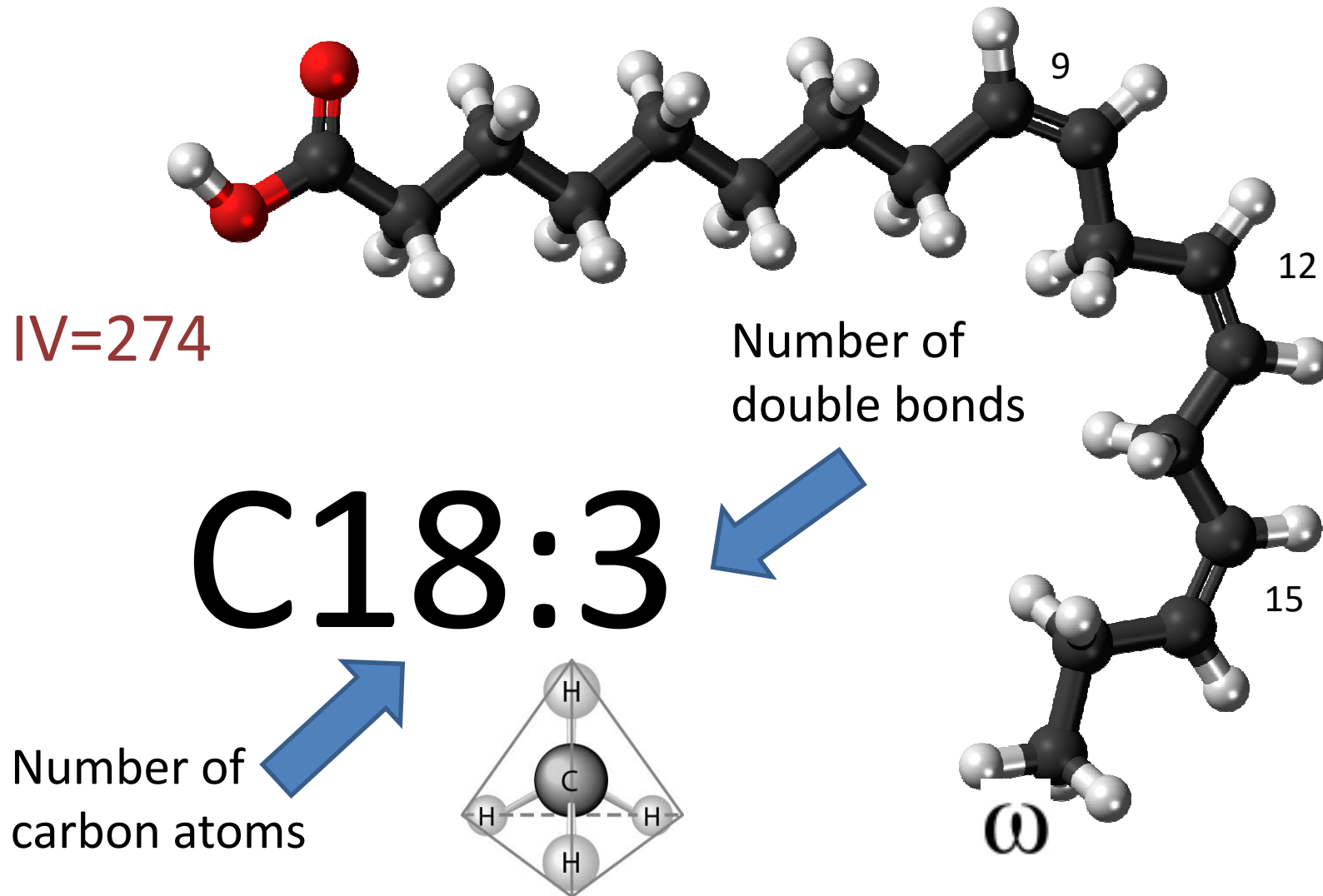
Global Palm Kernel Oil Consumption – Split by
Applications, 2016



2. Oleochemistry

- What is a fatty acid
- The structure of triglycerides
- SAFA, MUFA, PUFA, Omega-3
- Trans Fatty Acids
- Composition of selected oils

Understanding a fatty acid molecule



The fatty acids in palm oil

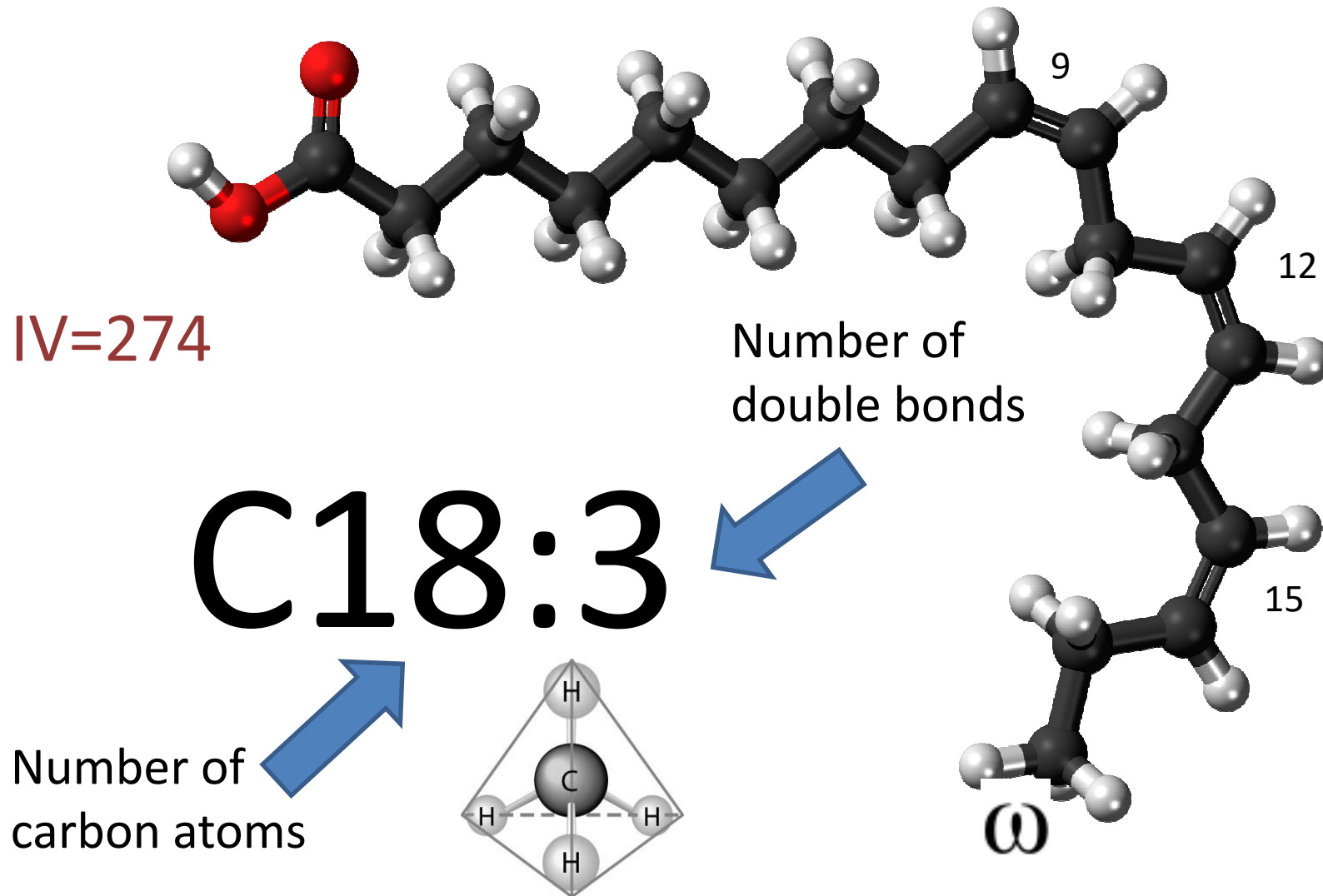
C8 to C16

- C8:0
- C10:0
- C12:0
- C14:0
- C16:0

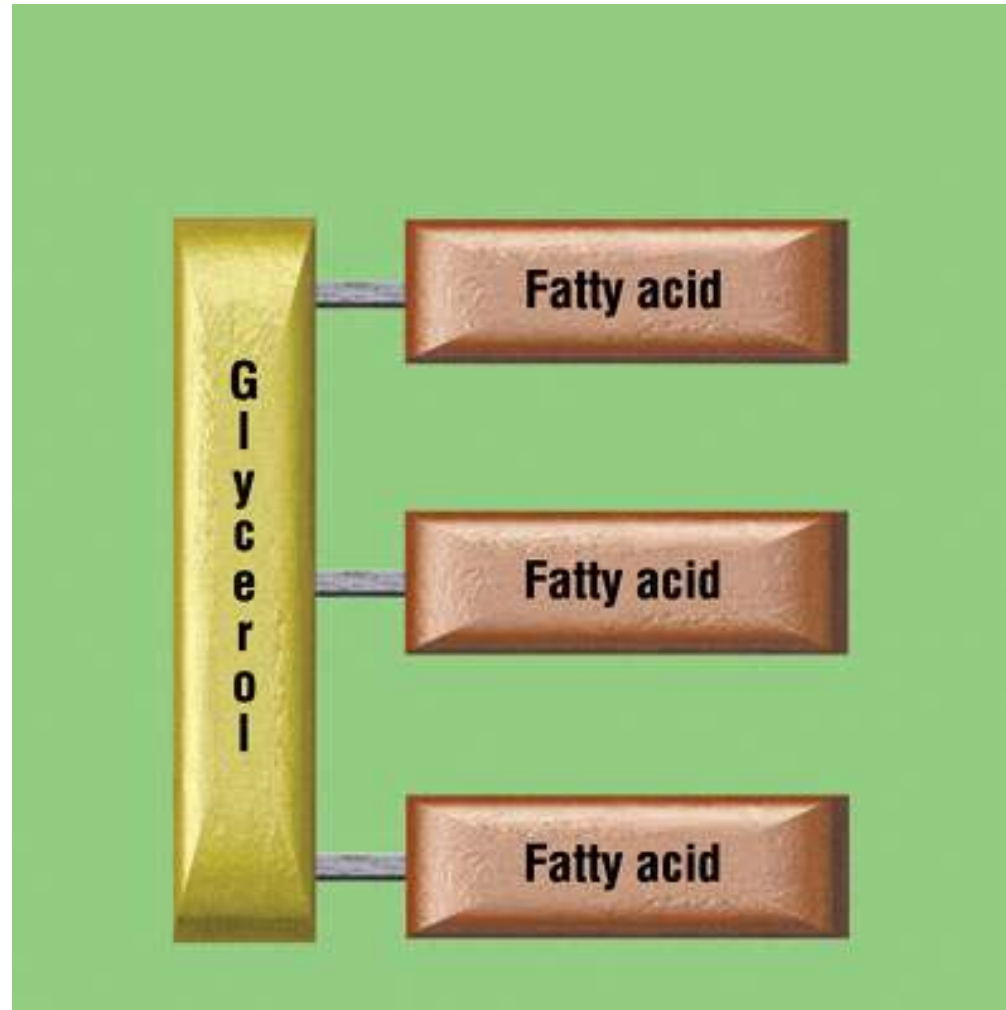
C18

- C18:0
- C18:1
- C18:2
- C18:3

Understanding a fatty acid molecule



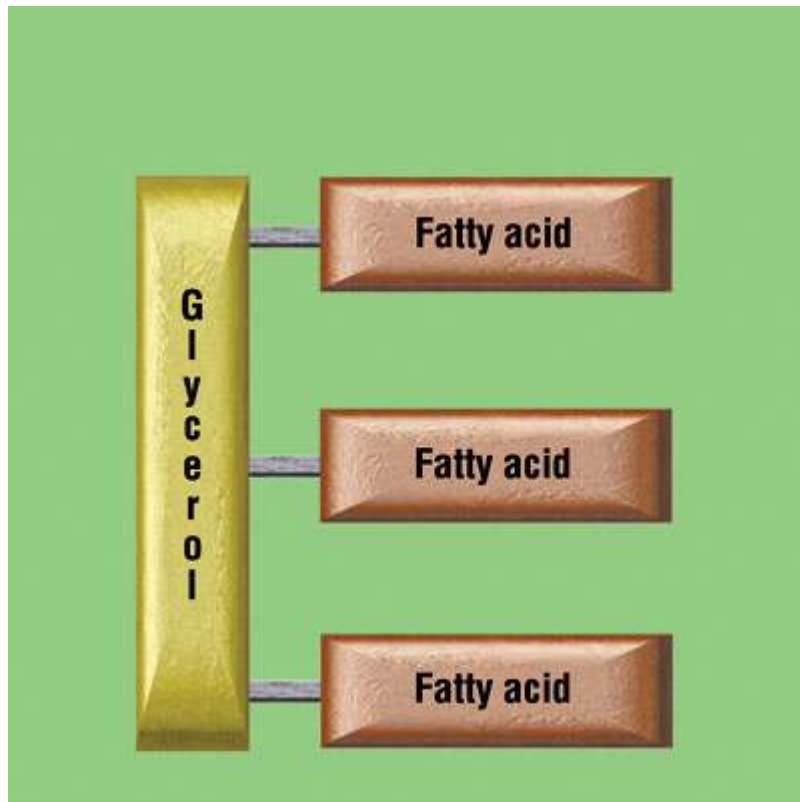
Structure of triglyceride



Placement of fatty acids in PO

(40 possible combinations)

eg. POP at 23.7%

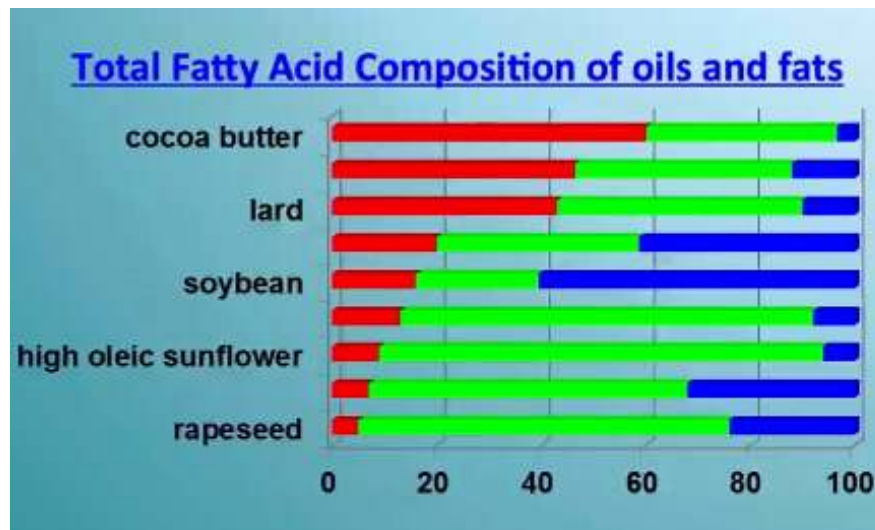


sn-1 Palmitic 16:0

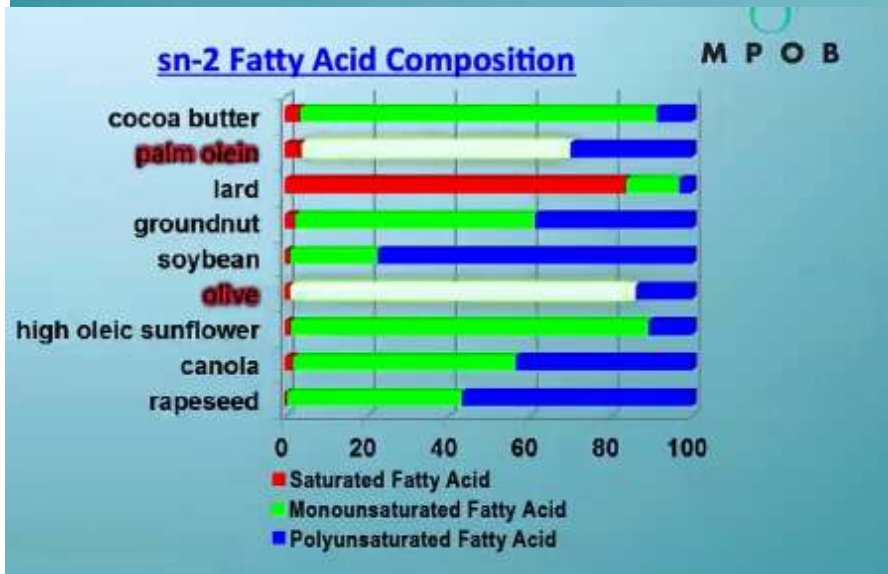
sn-2 Oleic 18:1 (n-9)

sn-3 Palmitic 16:0

Palm Olein behaves more like Olive Oil



Oleic acid situated at sn-2 has neutral influence on cholesterol levels.



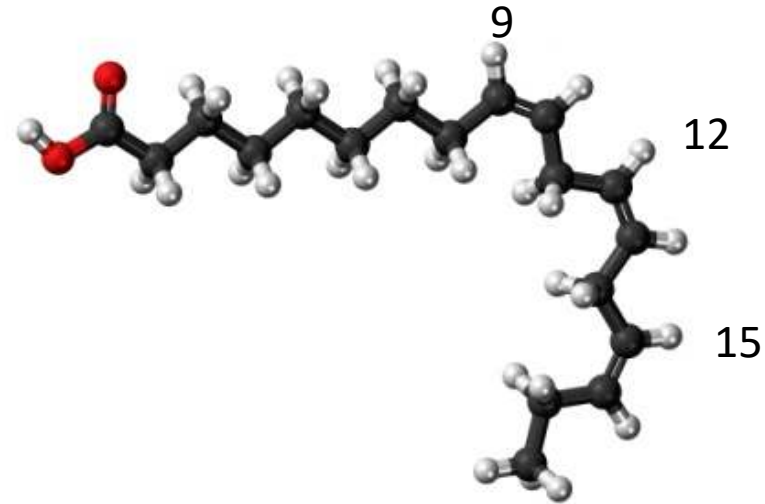
Palmitic acid at the first and third positions tend to exhibit lower fat deposition in the body

Molecular structure fatty acids

PUFA

Polyunsaturated Fatty Acid

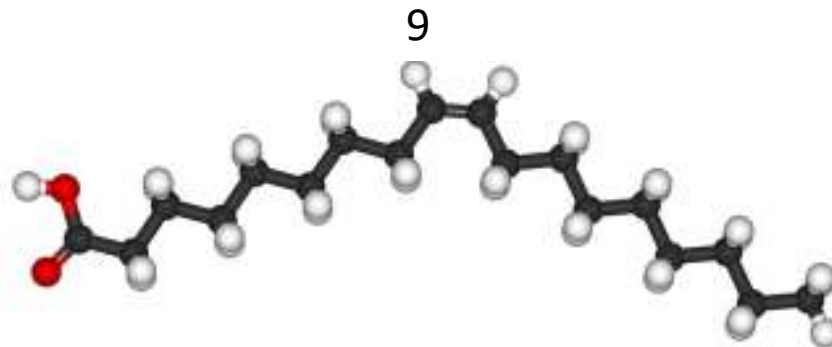
9,12,15-octadecatrienoic
or α -linolenic 18:3(n-3)



MUFA

Monounsaturated Fatty Acid

oleic acid 18:1 (n9)



SAFA

Saturated Fatty Acid

stearic acid 18:0



Omega fatty acids

- Omega-3 (EPA & DHA) and Omega-6 are EFAs (essential fatty acids)
- Protect our hearts, joints, pancreas, mood stability and skin
- Too much Omega-6 eg in corn oil can raise BP

Common name	Lipid name	Chemical name
<u>α-Linolenic acid</u> (ALA)	18:3 (<i>n</i> -3)	<i>all-cis</i> -9,12,15-octadecatrienoic acid
<u>Eicosapentaenoic acid</u> (EPA)	20:5 (<i>n</i> -3)	<i>all-cis</i> -5,8,11,14,17-eicosapentaenoic acid
<u>Docosahexaenoic acid</u> (DHA)	22:6 (<i>n</i> -3)	<i>all-cis</i> -4,7,10,13,16,19-docosahexaenoic acid

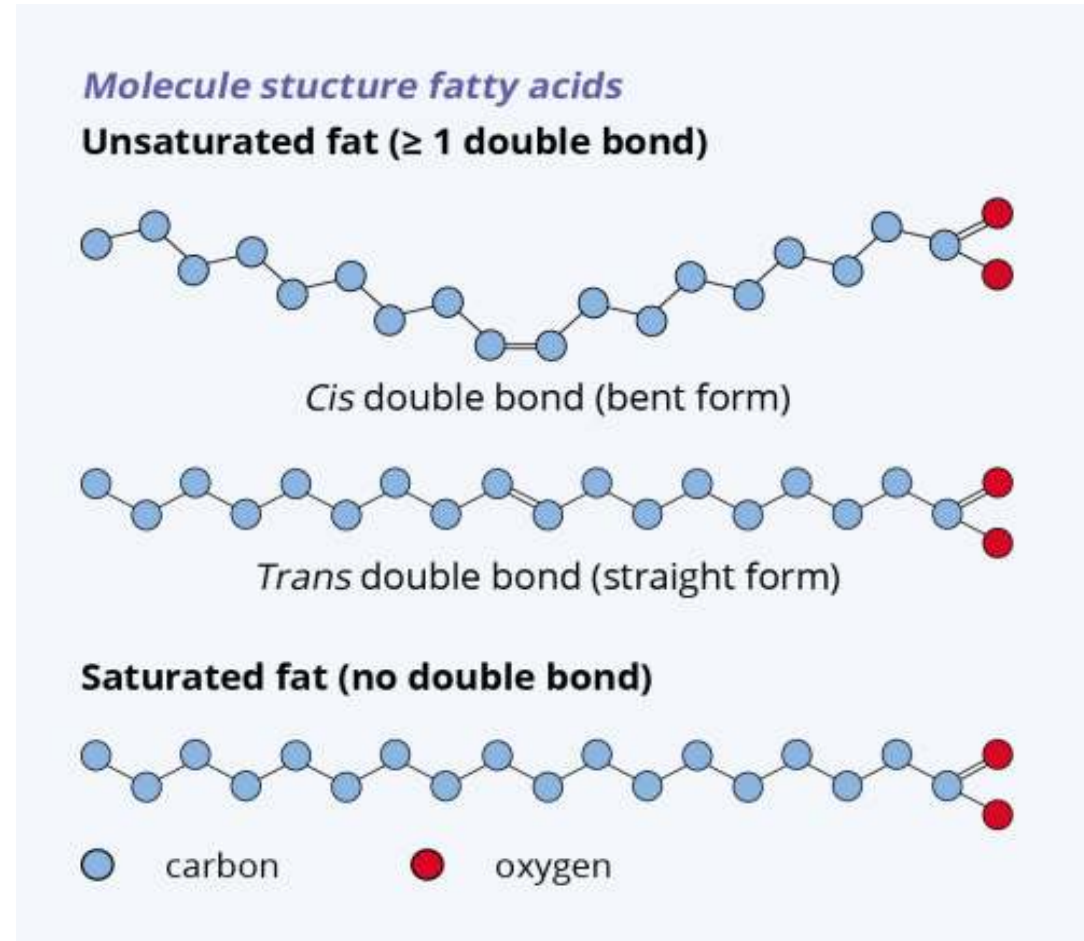
TFA

(Trans Fatty Acids)

Oleic acid 18:1 (n-9c)

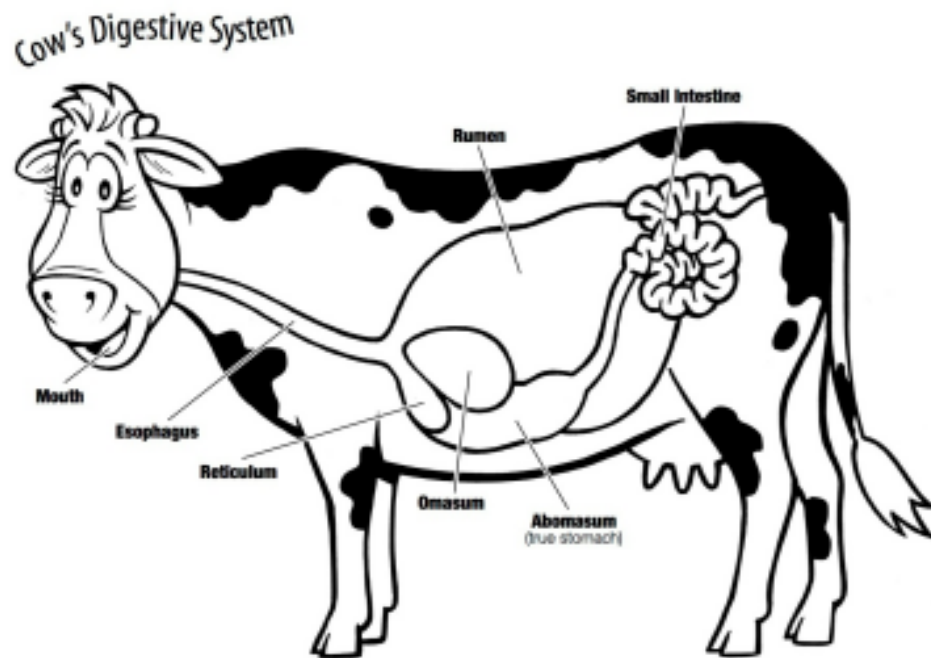
Elaidic acid 18:1 (n-9t)

Stearic acid 18:0



Trans (unsaturated) fatty acid is a result of the hydrogenation process. It increases the risk of developing heart disease and stroke

Natural Trans Fat



One stomach with 4 compartments
viz rumen, reticulum, omasum and
abomasum

The digestion process, particularly the stomach bacteria, in ruminant animals naturally adds hydrogen in the rumen.

Conjugated linoleic acid (mainly 9-*cis*, 11-*trans*-octadecadienoate) is present in butter (ca 3%). There have not been sufficient studies to determine whether these naturally occurring *trans* fats have the same bad effects on cholesterol levels as *trans* fats that have been industrially manufactured.

Trans Fat in margarine* is ca 15% and palm based margarine is <1%.

*from soft oils

Cows fart & burp methane

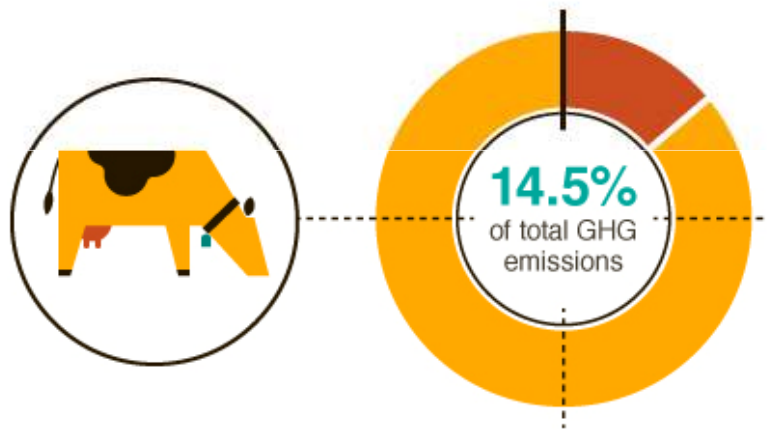
- Microbes in their stomach break down their food into methane as a byproduct
- One cow = one car. 1.5 billion cows and bulls
- Forest cover is cut for grazing pastures

We trap our methane!

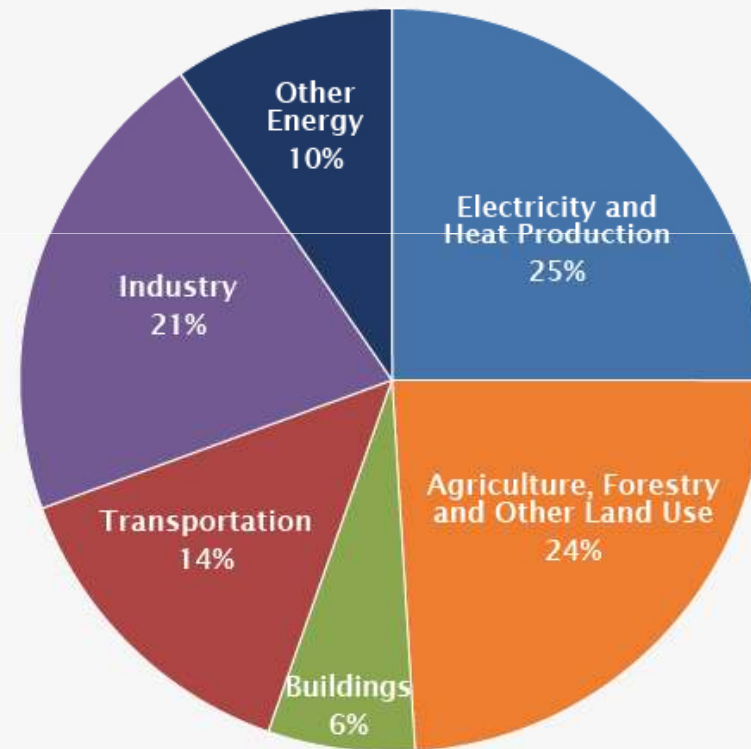
- Biomethane from anaerobic digestion of POME is used for heating and power generation

Global GHG Emissions

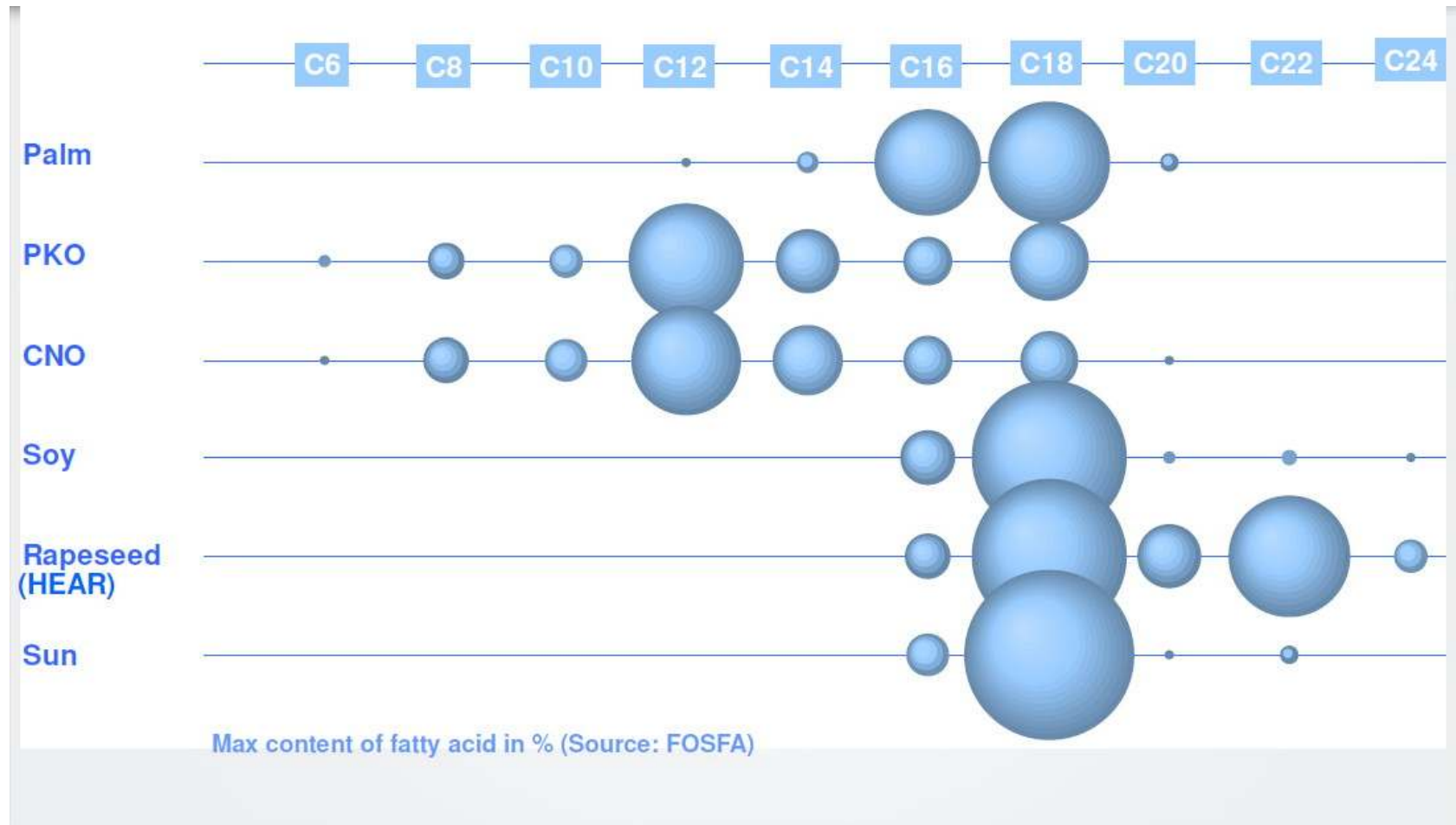
Livestock contributes **7,100 MtCO₂e/year** or **14.5%** of total global GHG emissions.



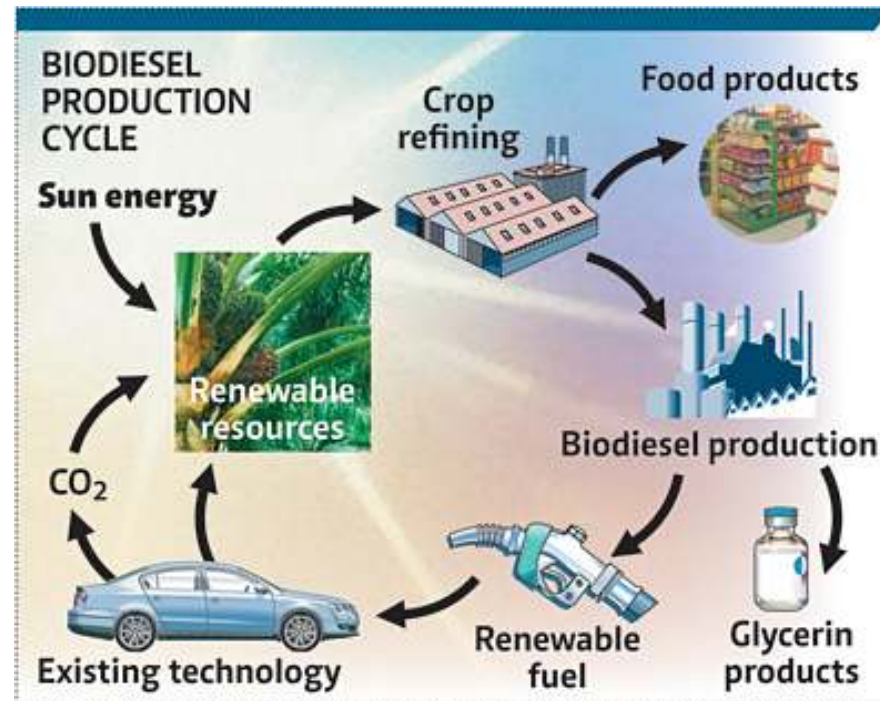
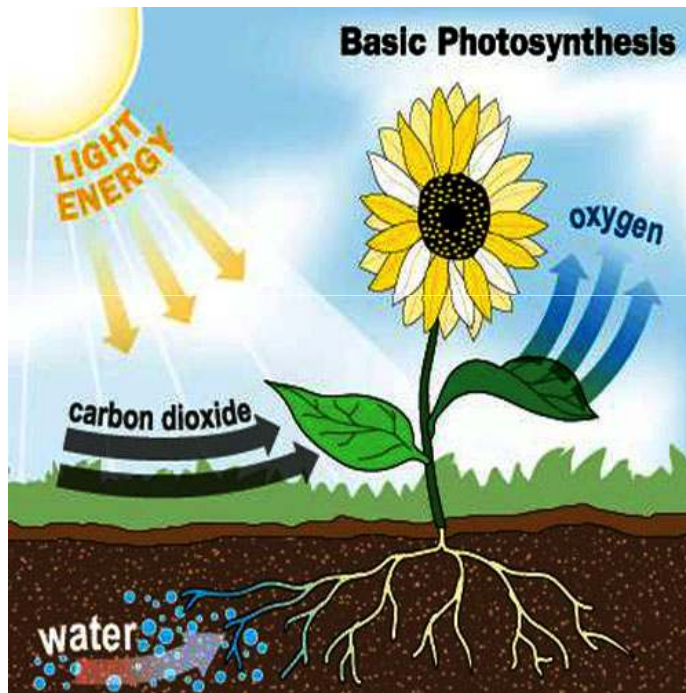
Global Greenhouse Gas Emissions
by Economic Sector



Composition of selected oils



How oleochemicals is green

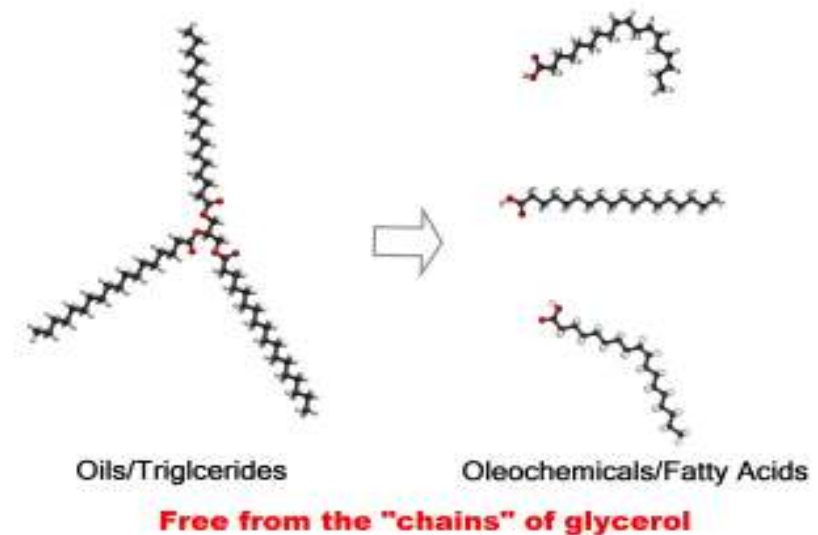
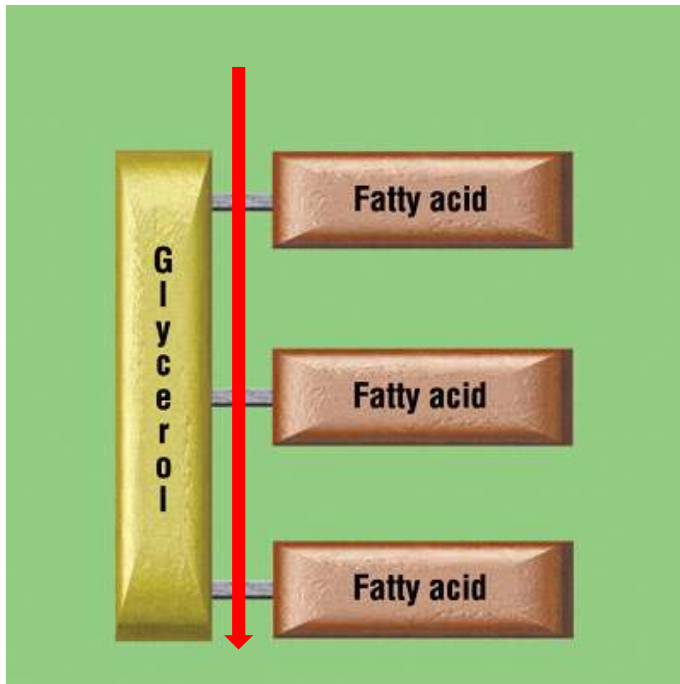


3.Oleochemicals

- What are oleochemicals?
- Oleochemical processes
- Oleochemicals in your shower cream
- Oleochemicals in your daily life
- An interesting oleochemical
- Bio-processes
- Metathesis

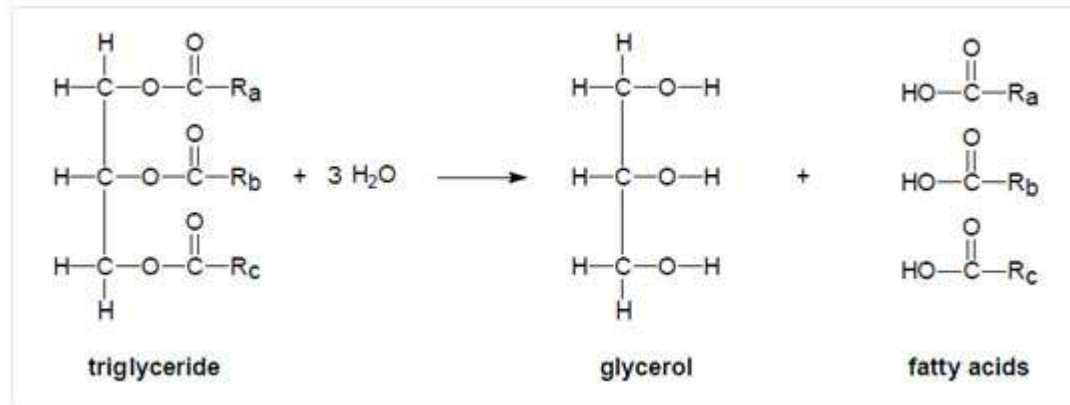
What are oleochemicals?

Oleochemicals (from Latin: oleum “olive oil”) are chemicals derived from plant and animal fats. They are analogous to petrochemicals derived from petroleum

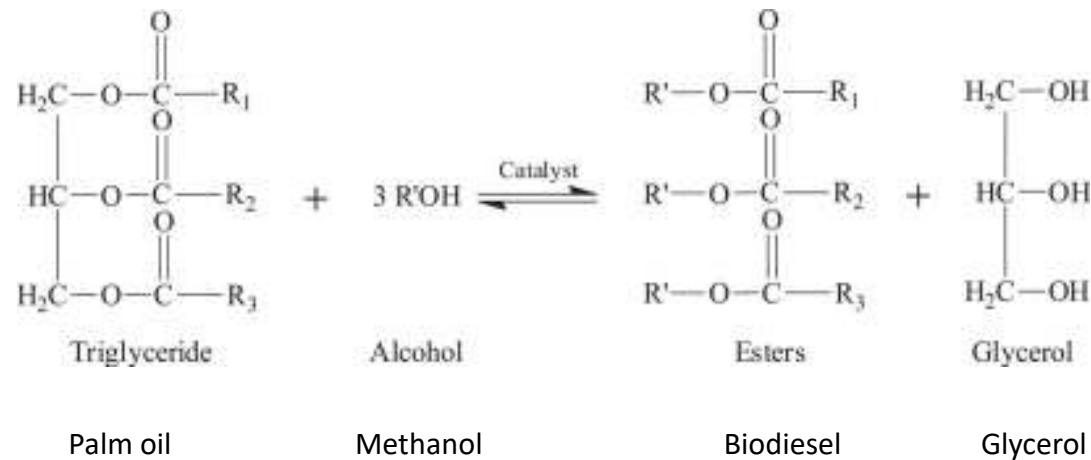


Versatility

Gateways to oleochemicals

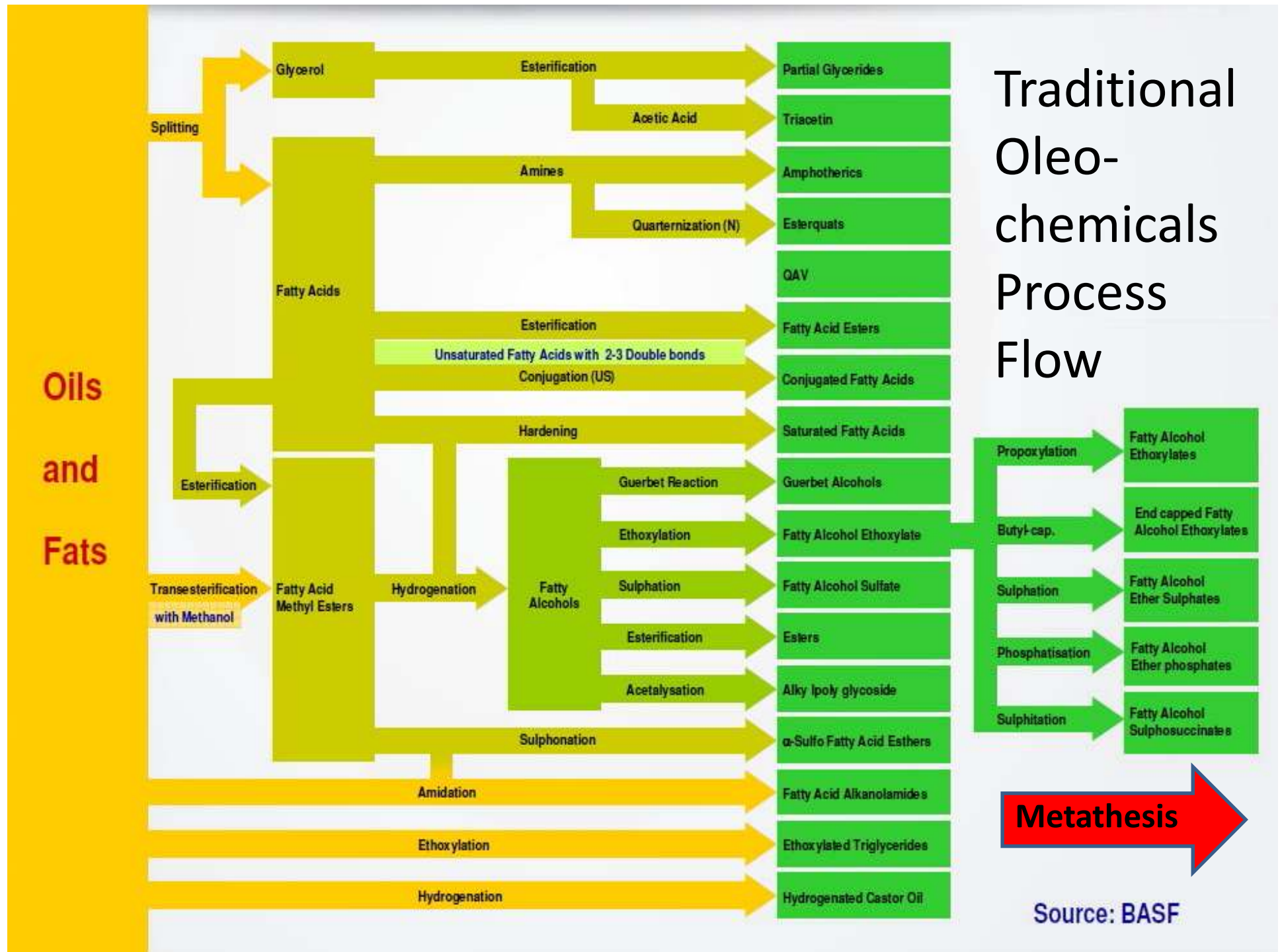


Splitting (hydrolysis)

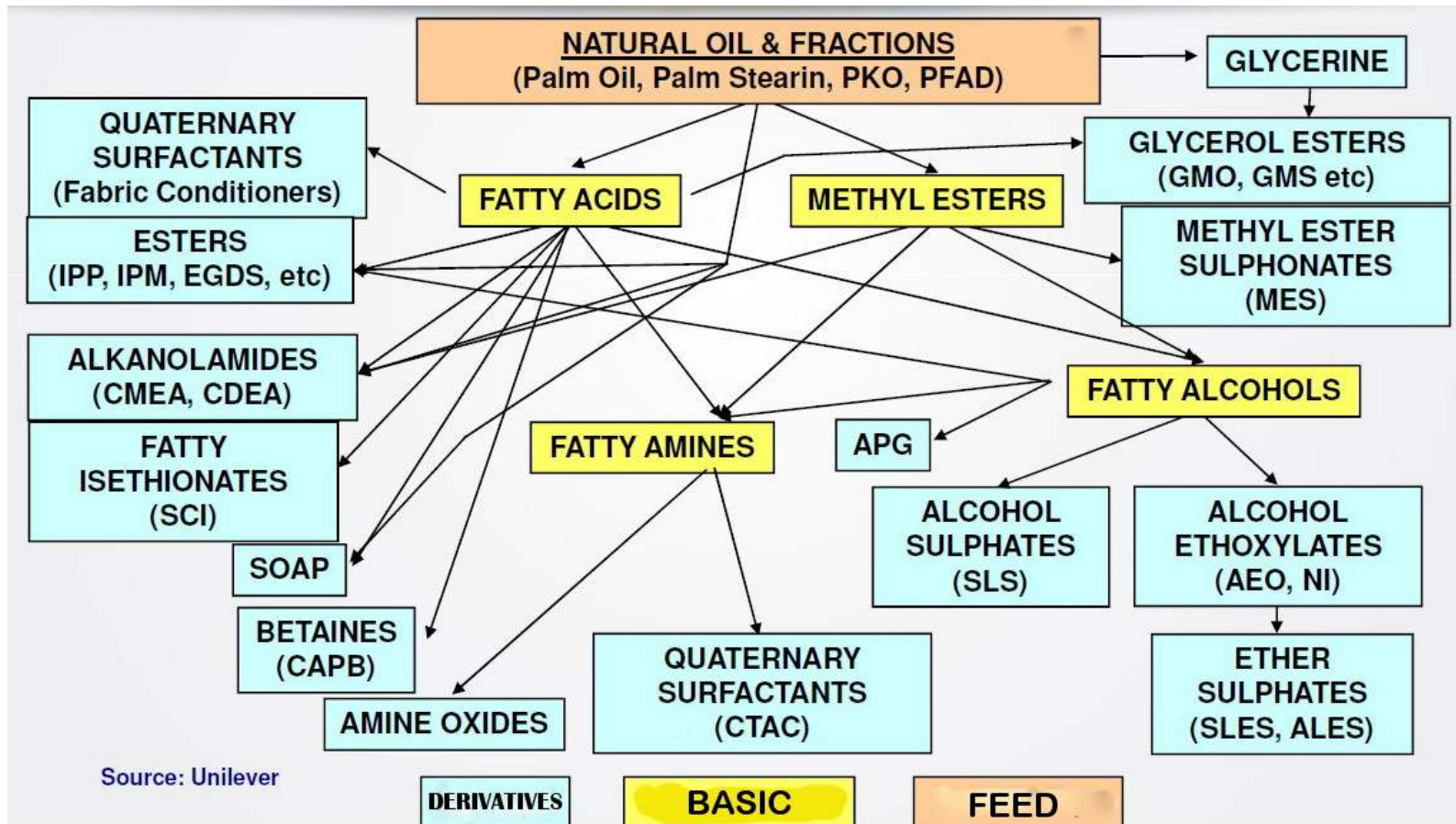


Transesterification

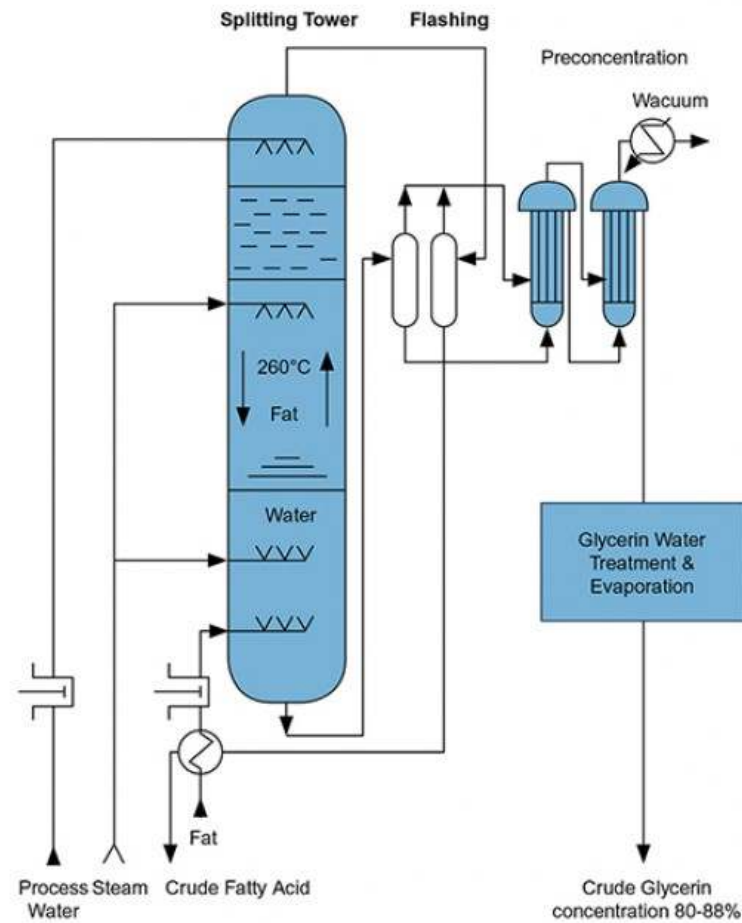
Traditional Oleo-chemicals Process Flow



Complex or Versatile?



Splitting



Transesterification

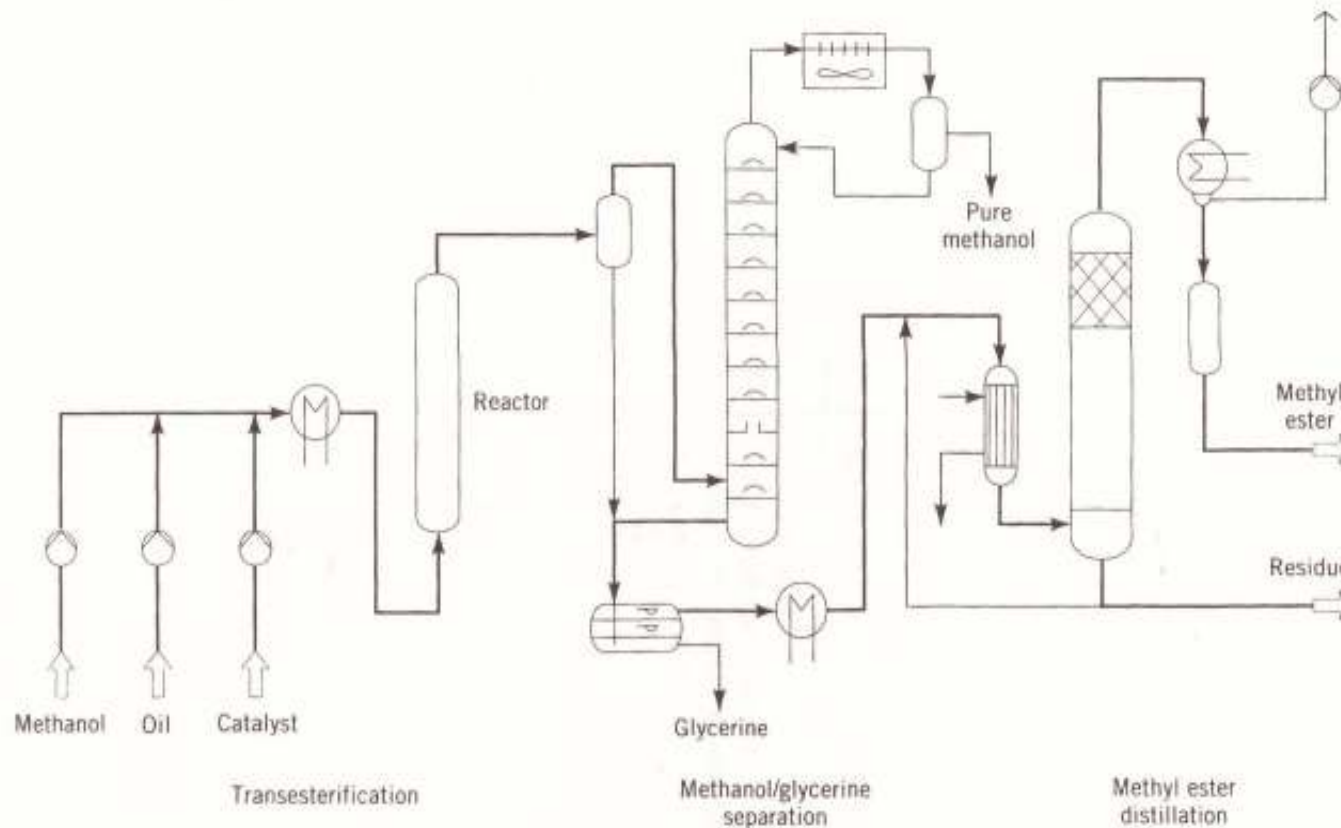
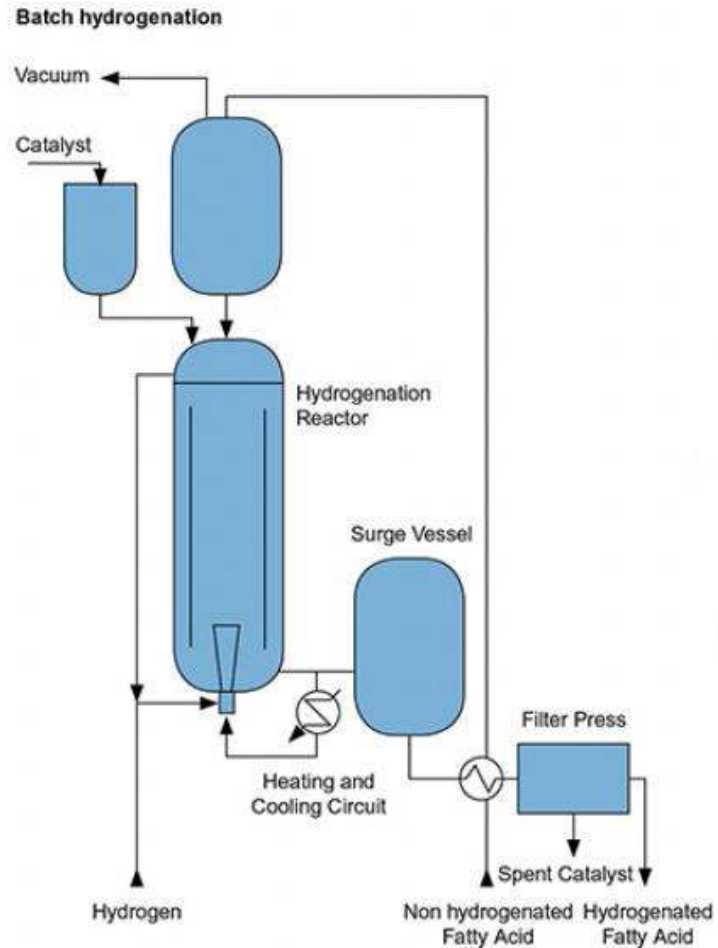


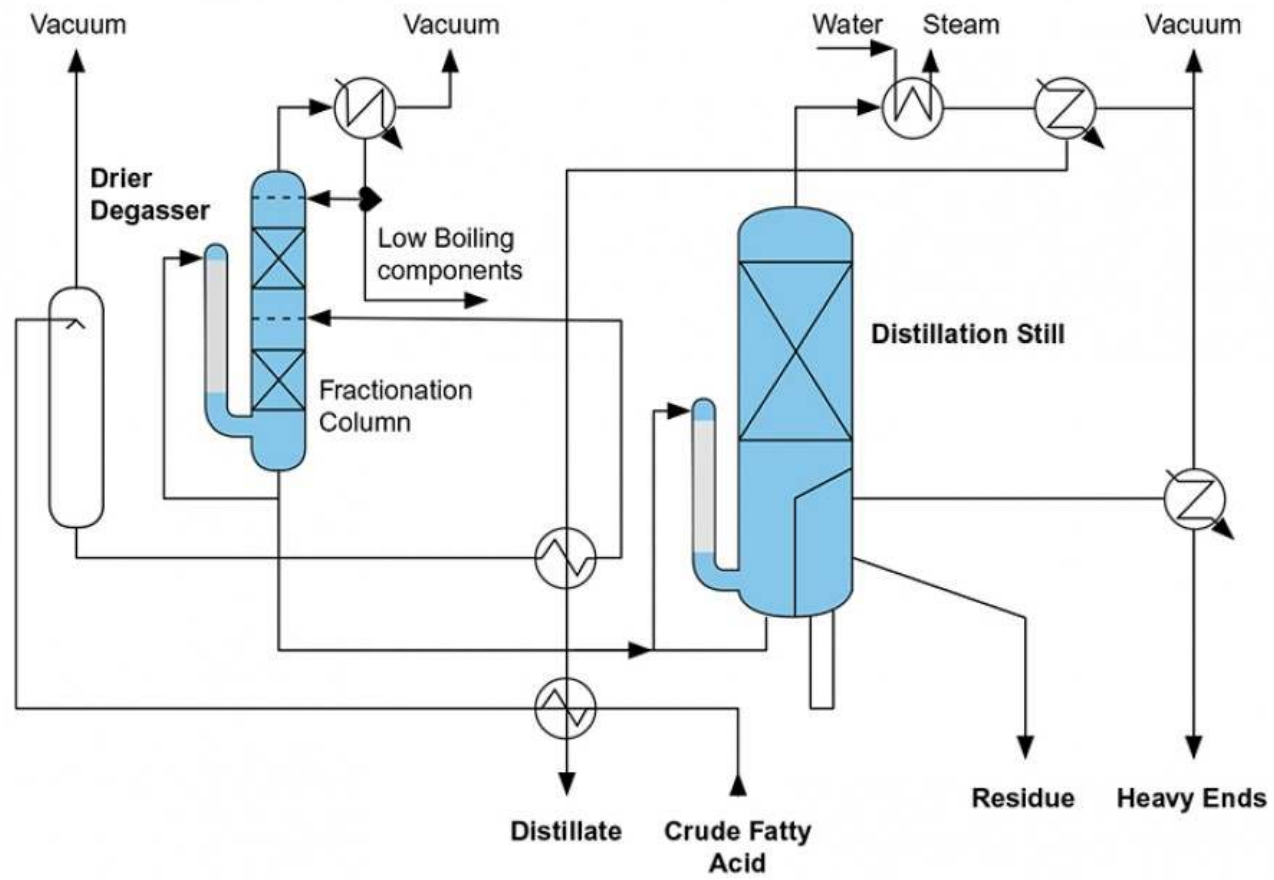
Figure 7. Manufacture of methyl ester by transesterification (15).

Hydrogenation of fatty acids

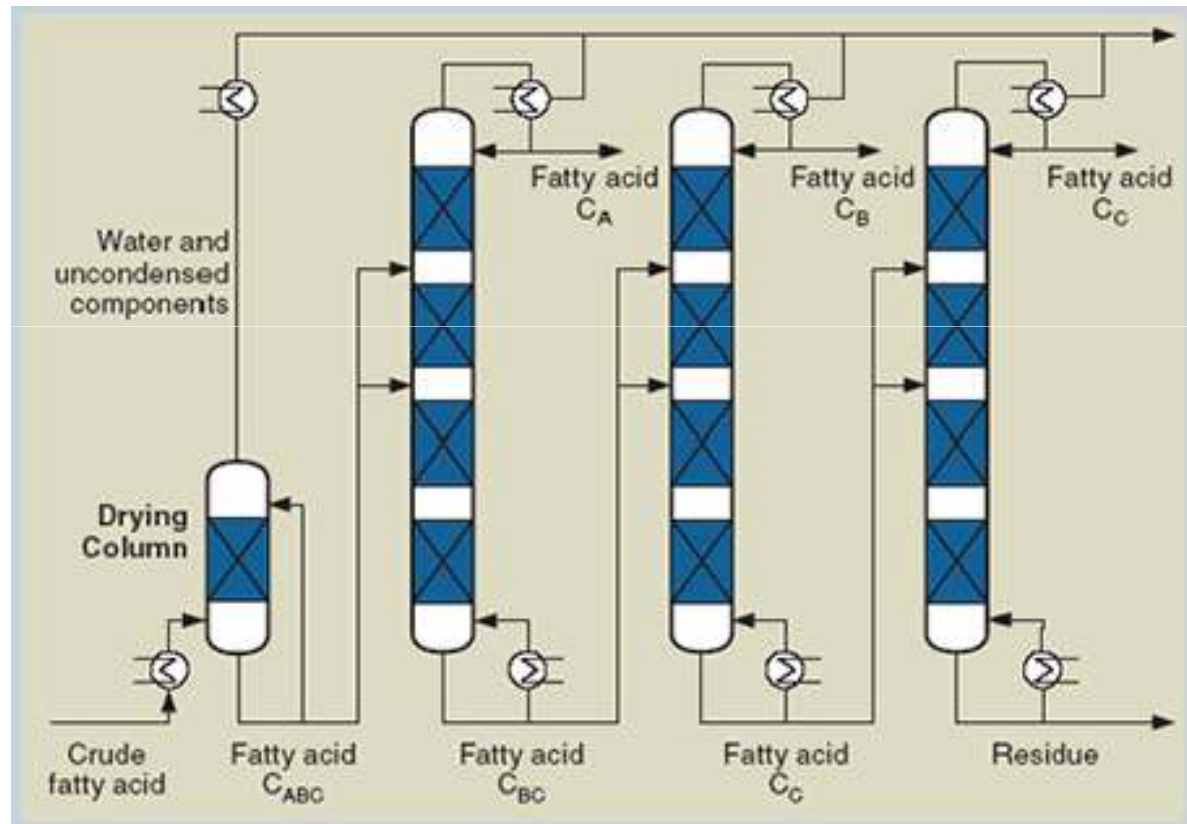


Ester		Configuration	Melting Point
Linolenic	C18:3	Three double bonds	-13C
Linoleic	C18:2	Two double bonds	-7C
Oleic	C18:1	One double bond	16C
Stearic	C18:0	No double bonds	70C

Distillation



Fractionation



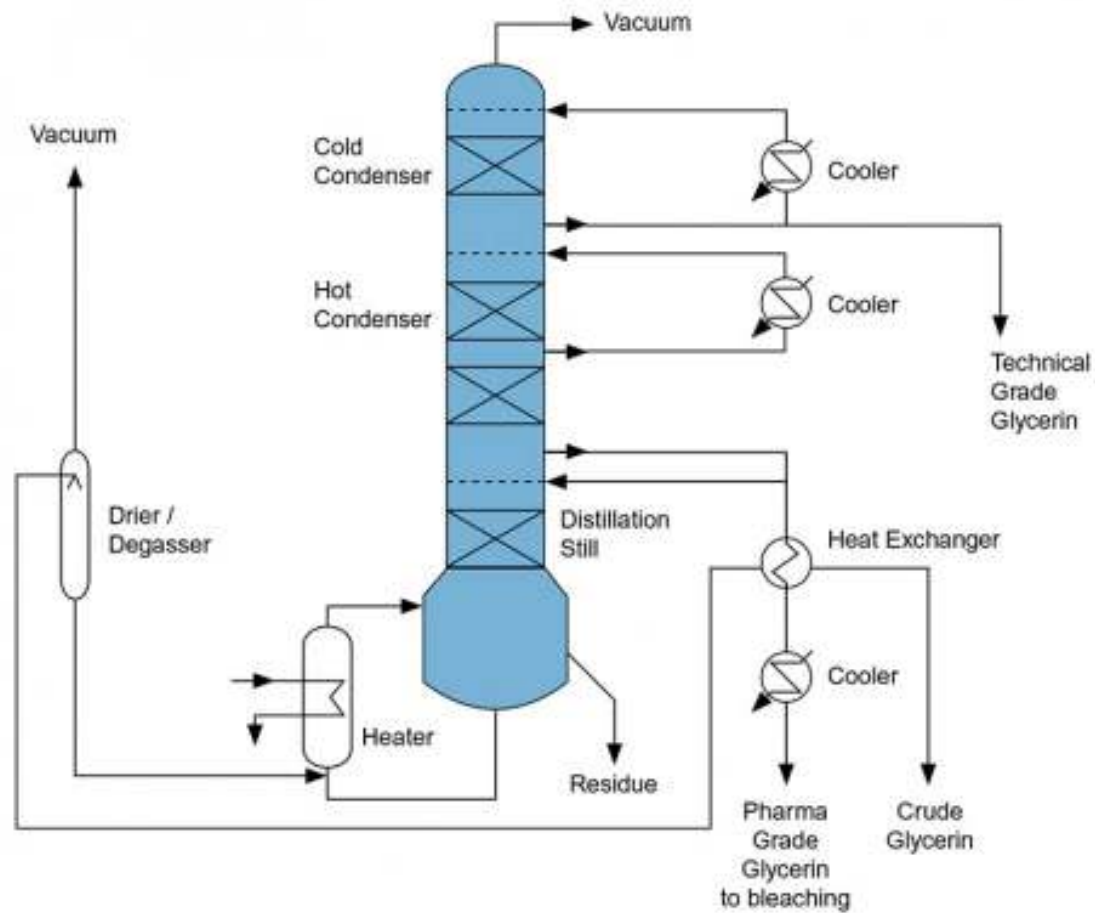
Fatty Acid Composition

Chain length	Palm Kernel Oil	Palm Oil	Palm Stearine	Palm Olein
C6	0.5	-	-	-
C8	4.5	-	-	-
C10	3.5	-	-	-
C12	48.5	0.1	0.3	0.3
C14	15.5	1.0	1.5	1.0
C16	8	44.0	62.4	40.2
C18	2	4.4	5.0	4.4
C18:1	15	40.1	24.9	42.8
C18:2	2.5	10.4	5.9	11.3

PKO values are based on MS80:1987

CPO, Palm Olein and Palm Stearine values are based figures from MPOB

Glycerine Refining



Fatty Alcohol Process

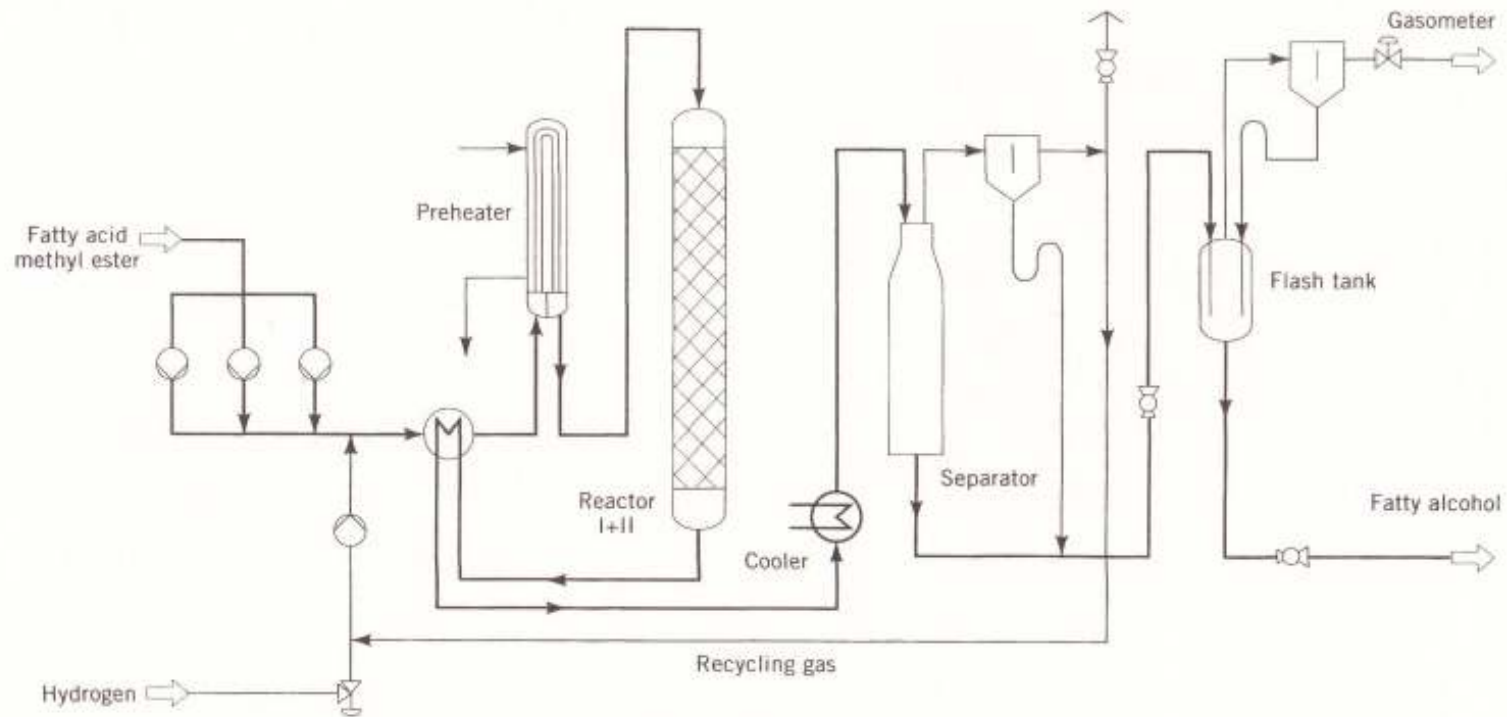
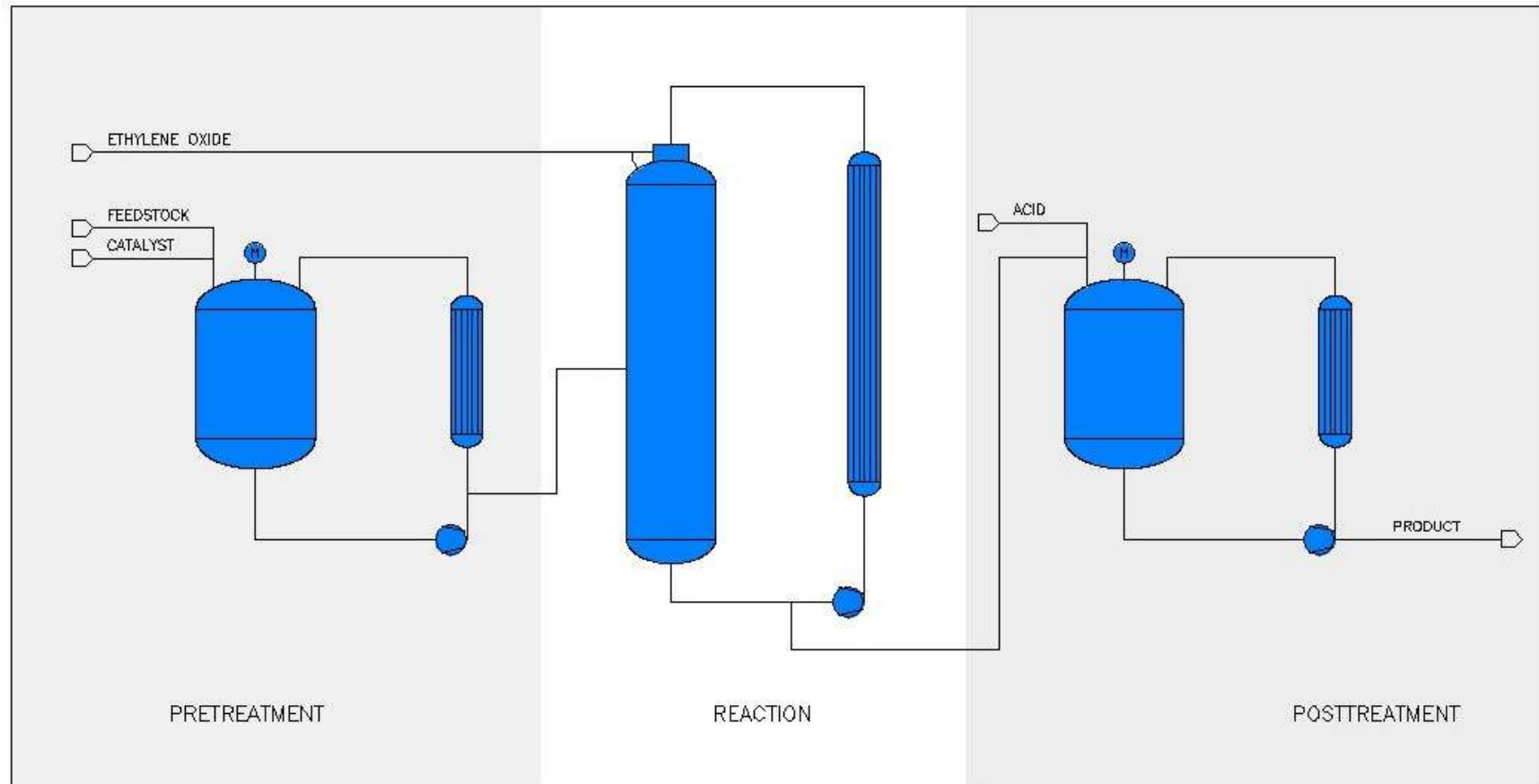


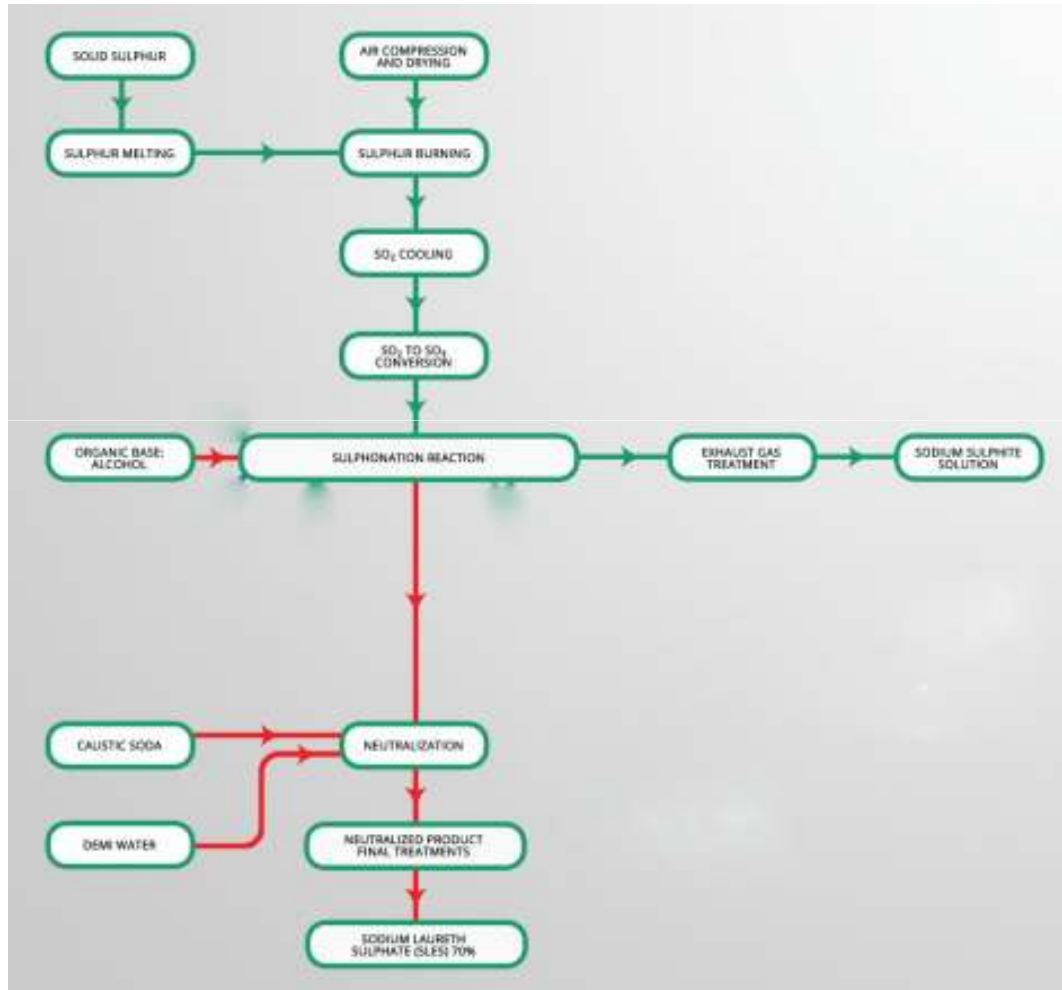
Figure 11. High-pressure hydrogenation of fatty acid methyl esters—fixed bed process (15).

Ethoxylation



Bubble ethylene oxide through the alcohol

Sulphonation



Ethoxylated alcohol is treated with sulphur trioxide and then neutralized

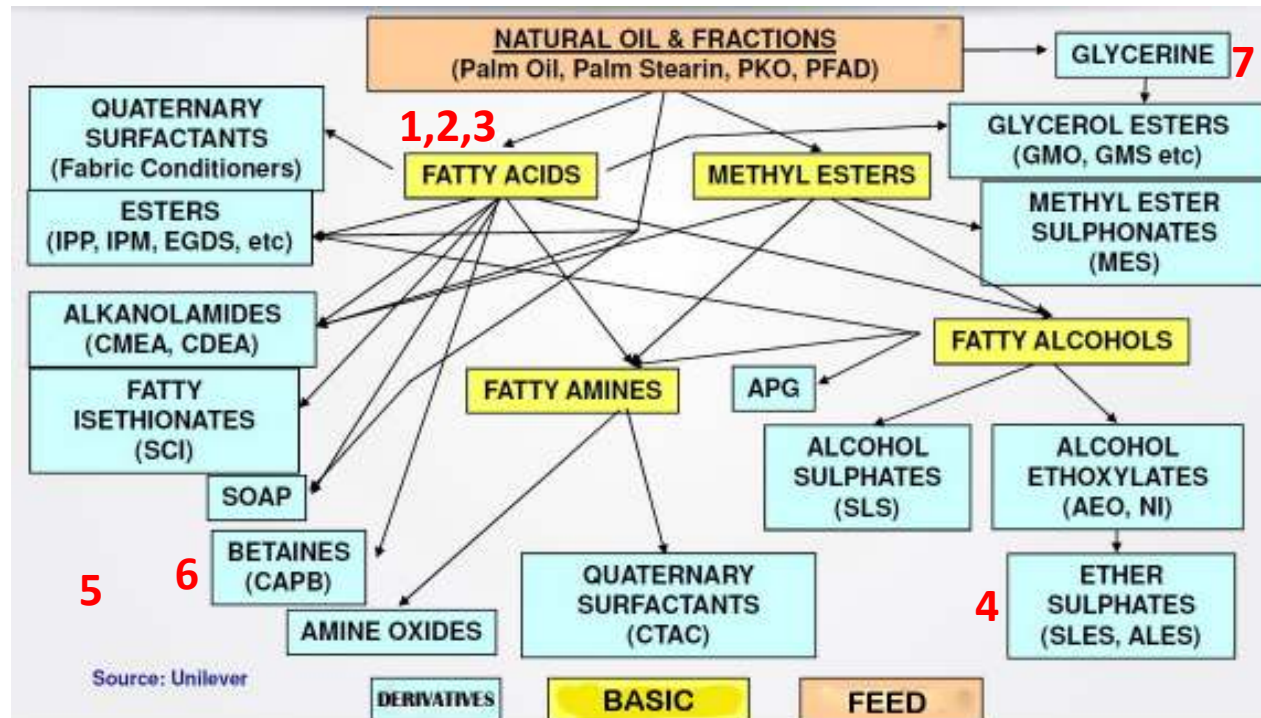
If starting ester is methyl laurate the product is sodium lauryl ether sulphate (SLES)

Oleochemicals in your shower cream



Nr	Oleochemical	Nr	Oleochemical
1	Myristic Acid	5	Glycol Distearate
2	Lauric Acid	6	Cocoamidopropyl Betaine
3	Palmitic Acid	7	Glycerin
4	Sodium Laureth Sulfate (SLES)		

Place in the value chain

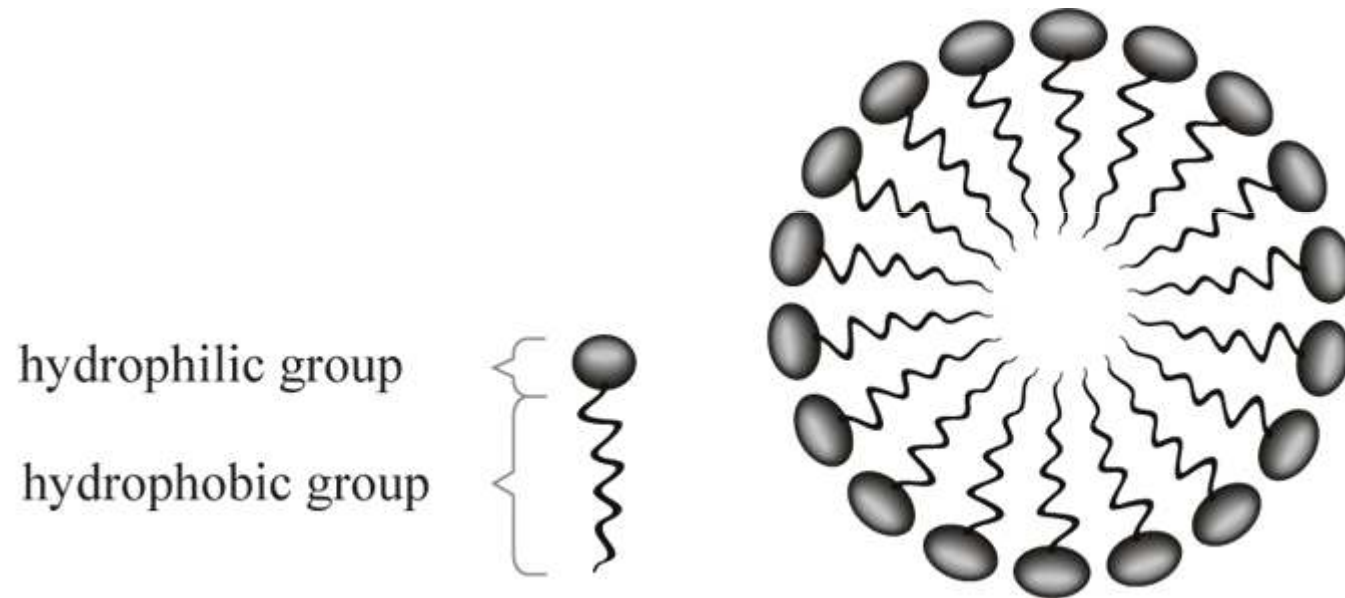


Nr	Oleochemical	Nr	Oleochemical
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2	Lauric Acid	6	Cocoamidopropyl Betaine
3	Palmitic Acid	7	Glycerin
4	Sodium Laureth Sulfate (SLES)		

Washing your hands

- Is antibacterial handwash better?
- Is there an ideal pH for soap?
- Do additives work?

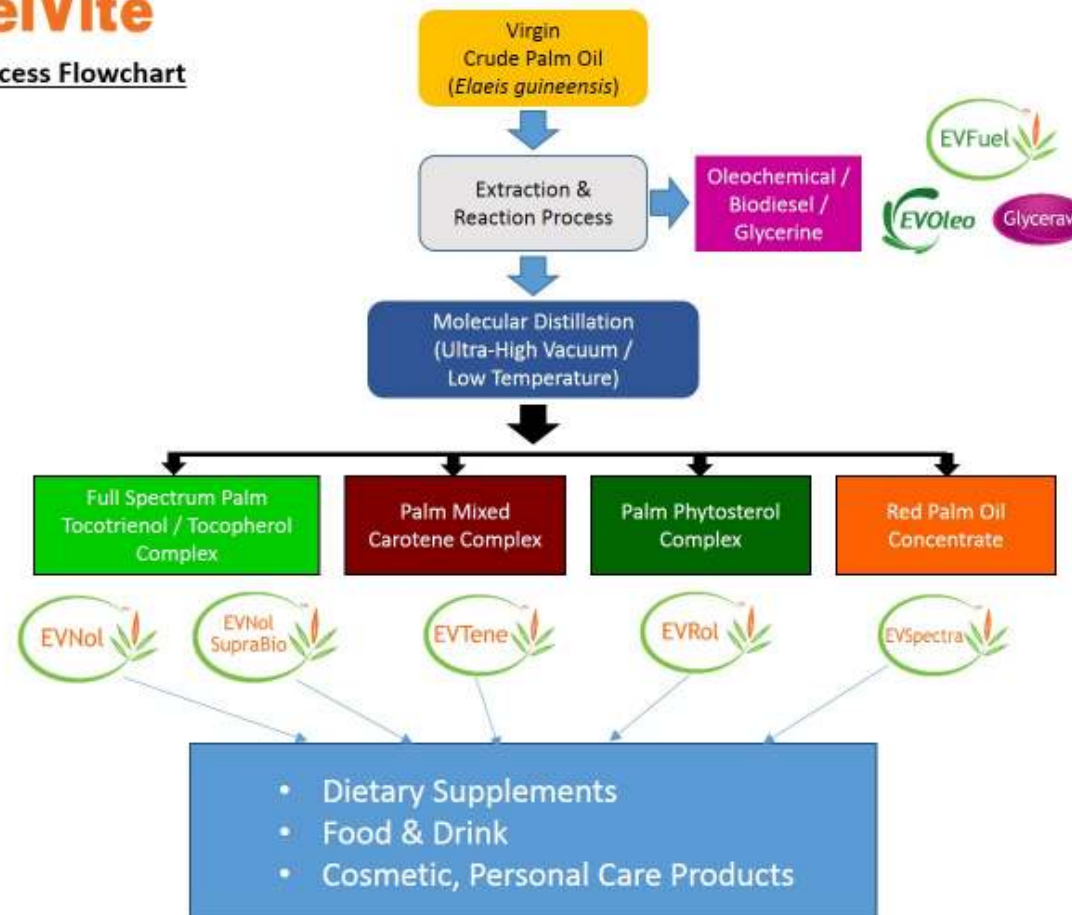
How does soap work



Molecular Distillation to extract Phytonutrients

ExcelVite

General Process Flowchart



End Consumer products ...



Soap noodles



Sodium lauryl sulfate



Stearic Acid



Esters



Glycerin, Isopropyl Myristate



Methyl Ester Sulfonate



Cetyl palmitate,
isopropyl myristate,
sorbitan monostearate,
stearyl alcohol

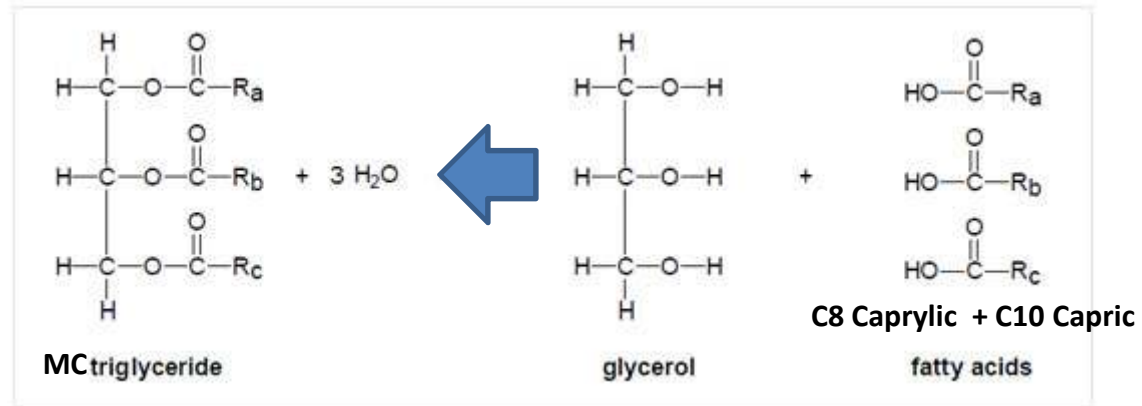


Amide as slip agent



Tocotrienols

M_{edium} C_{hain} T_{riglyceride}



Bio-processes 1

Bioprocess engineering focuses on the role of living organisms in the manufacturing process

Biodiesel

- Enzymatic process can use feedstocks with low or high free fatty acids eg UCO and PFAD
- Eliminate hazardous catalyst eg sodium methoxide
- Lower energy

Bio-processes 2

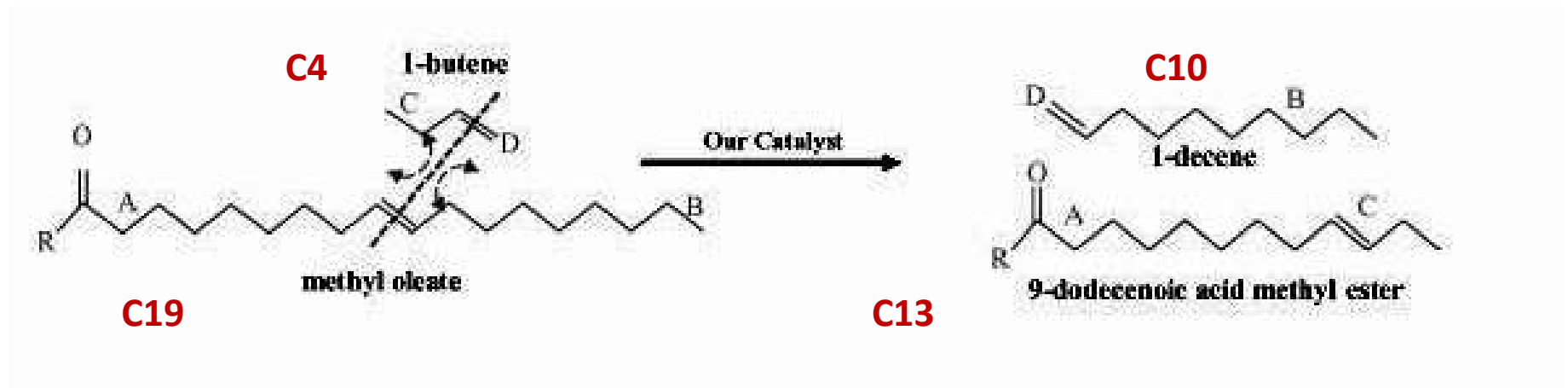
Adipic Acid

- Yeast fermentation to produce diacids
- Based on fatty acids (prev. petroleum)
- Low cost
- Less pollutants
- Key component of nylon 6,6

What is a Biorefinery

- A facility that integrates biomass conversion processes and equipment to produce fuels, power, heat and value-added chemicals from biomass
- It is analogous to a petroleum refinery which produces multiple fuels and products from petroleum

Elevance Metathesis Technology



- Metathesis can break carbon-carbon double bonds
- A petrochemical is combined with an oleochemical
- Molecules recombine into new di-functional molecules

Three product streams

1. Olefins – 1-decene for co-polymers
2. Speciality chemicals – di-functional products from oleochemicals and petrochemicals in one molecule eg 9DDA (9-dodecenoic acid) are key products for nylon 6,12
3. Oleochemicals – C16 and C18 methyl esters eg for MES

4.Oleochemical Market

- ASEAN Oleochemical Manufacturers Group
- Volume and Value
- Prices and Margins
- Growth
- Challenges
- Likely outcomes

AOMG members

Indonesia

1. PT Ecogreen
2. PT Musim Mas
3. PT Nubika Jaya
4. PT Soci Mas
5. PT Unilever
Oleochemical Indonesia

Philippines

1. Chemrez

Malaysia (MOMG)

1. Emery Oleochemicals
2. FPG Oleochemicals
3. Fatty Chemicals
4. IFFCO
5. IOI Oleochemicals
6. Natural Oleochemicals
7. Pacific Oleochemicals
8. Palm-Oleo
9. Southern Acids

(Previously Thai Oleochemicals now
Global Green Chemical was a
member)

Historically Western multinationals, Unilever, Henkel, Akzo, P&G, ICI and Croda were present

AOMG activities

- Statistics
- Annual Process Safety Management workshop
- Safety Data Sheet
- RSPO

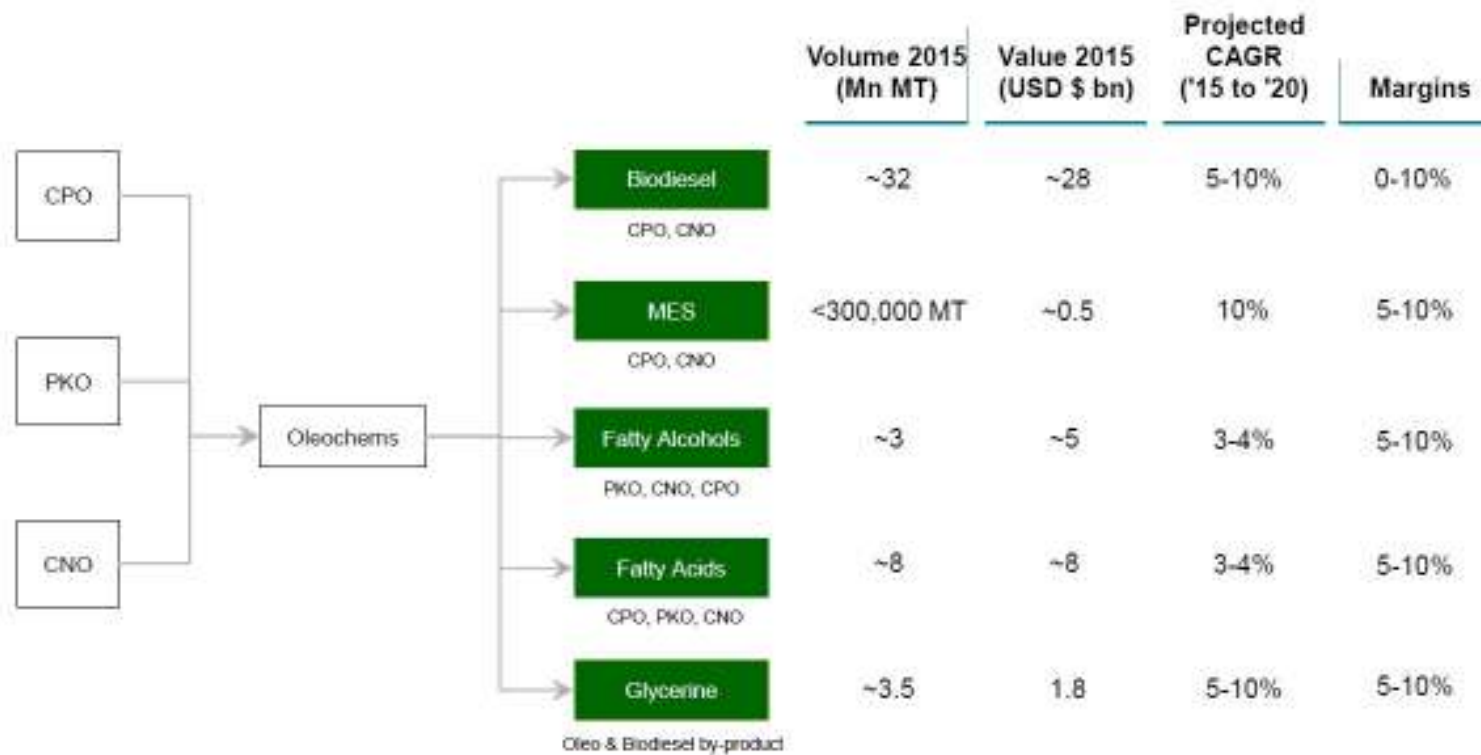
ASEAN capacity

- 4 to 6 million tonnes
- Majority of palm based oleochemical capacity globally
- And growing

Capacity growth is in Indonesia



Volume & value of oleochemicals (ca 70% PKO)



Prices and Margins 2016

KPMG



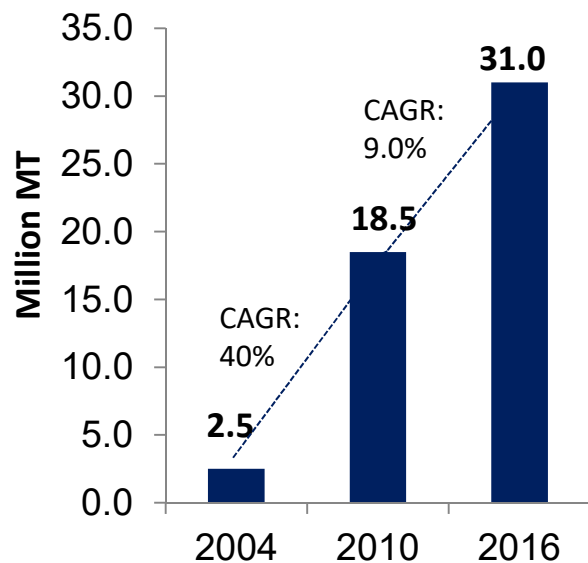
Growth is in APAC

APAC is 55-60% of production and 45-50% of consumption



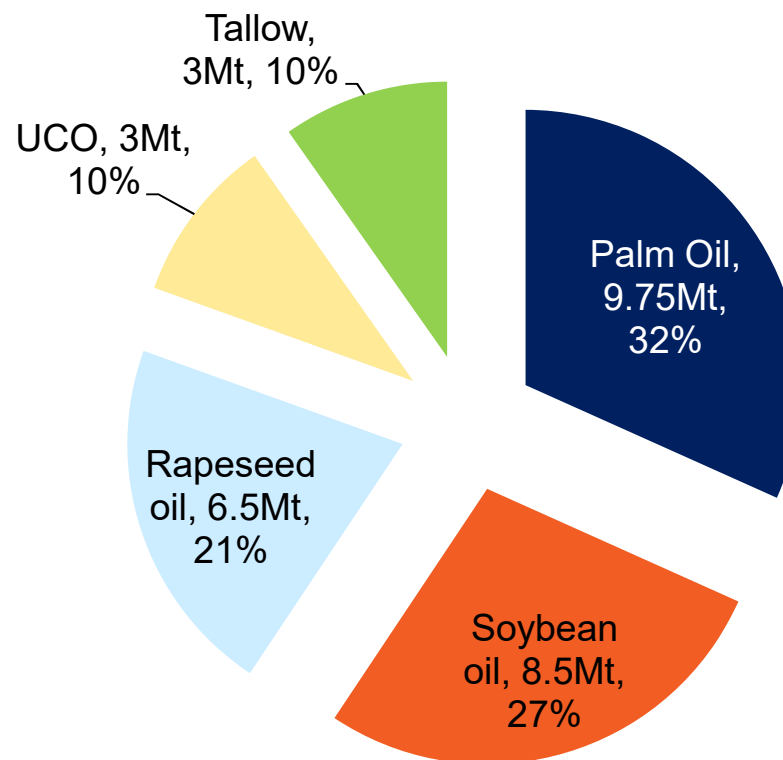
Global Biodiesel Market

Global Biodiesel Market

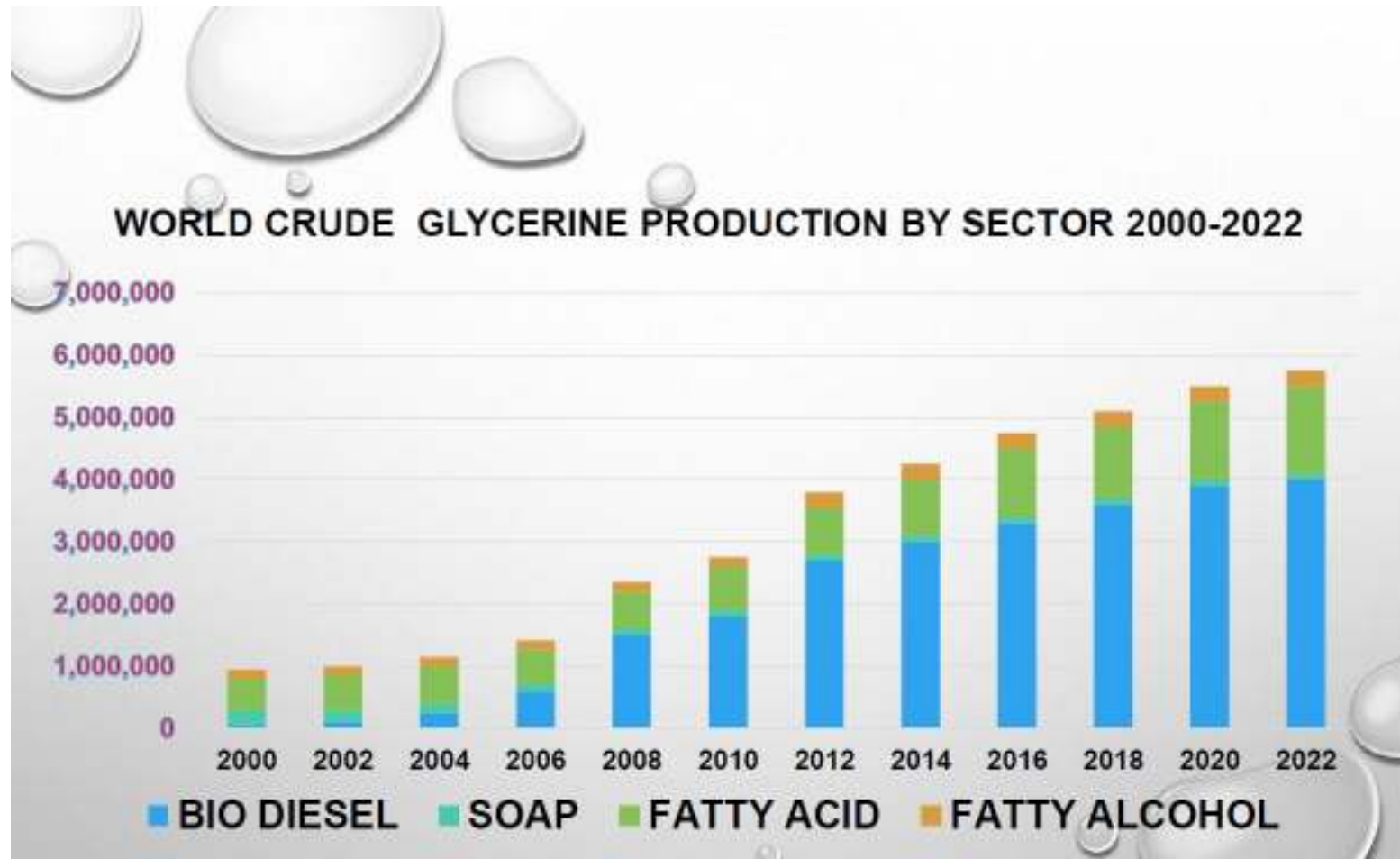


- **Market Size: 31 million mt, \$ 25 billion.**

Global Biodiesel Market by type of oil, 2016



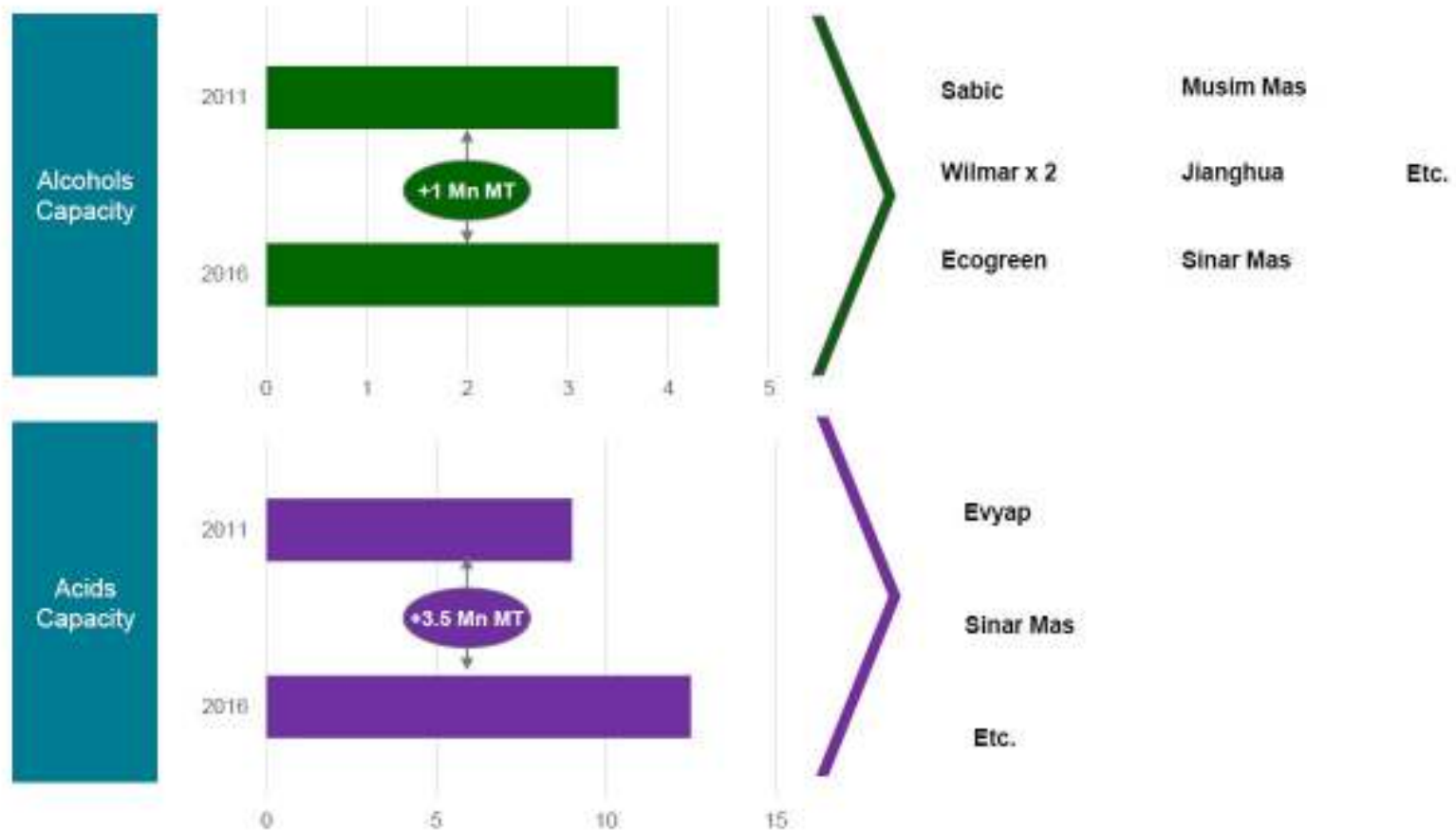
World crude glycerine production



The top 3 challenges



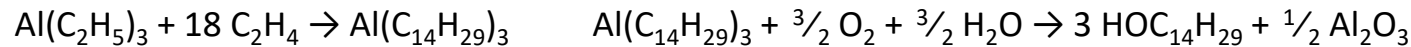
Biggest issue - overcapacity



Synthetic process for fatty alcohols

- Ethylene or natural gas feedstock

1. Ziegler process



2. Oligomerized, hydroformylation, hydrogenation



3. Shell higher olefin process

- No glycerine is produced

Moving forward

likely outcomes for oleochemicals

- More capacity to absorb vegetable oil supply
- Consolidation, weaker players drop out
- Synthetics on the rise, tough for alcohols
- Move toward specialities, margins erode?
- M&A and partnerships will increase
- Rise of biochemicals for margins & differentiation
- Innovation in feedstock, chemistry and processes
- Investment in infrastructure

Conclusion

- Oleochemicals is versatile
- Appreciate fatty acids in our lives
- New processes are streaming in
- There is overcapacity
- Low crude oil prices impacts some sector
- The glycerine glut poses new opportunities

Q&A

Back up slides

FAC of selected oils/fats

TABLE 41. Fatty Acids Compositions of Selected Oils/Fats.

Fatty Acids	Weight Percentage							
	Palm Oil	Palm Stearin	Tallow	Palm Kernel Oil	Palm Kernel Olein	Coconut	Palm Olein	Soybean Oil
C6	—	—	—	0.3	0.4	0.2	—	—
C8	—	—	—	4.4	5.4	8.0	—	—
C10	—	—	—	3.7	3.9	7.0	—	—
C12	0.2	0.3	—	48.3	41.5	48.2	0.2	—
C14	1.1	1.3	2.5	15.6	11.8	18.0	1.0	—
C16	44.0	55.0	26.6	7.8	8.4	8.5	39.8	6.5
C18	4.5	5.1	21.8	2.0	2.4	2.3	4.4	4.2
C18:1	39.2	29.5	42.8	15.1	22.8	5.7	42.5	28.0
C18:2	10.1	7.4	2.3	2.7	3.3	2.1	11.2	52.6
Other	0.8	0.7	4.0	0.1	0.1	—	0.9	8.0
IV	53.3	35.5	35–48	17.8	25.5	9.5	58.4	133
SAP. V	196	199	195	245	—	256	198	192

Bodywash, shampoo, dog shampoo and soap

Attributes	Bodywash	Shampoo	Dog shampoo	Soap
pH	5 to 6.5	4 to 6	6.5 to 7.5	10
Matter	Living skin	Hair is dead		
Surfactant	Mild	More, hair is dirty		
Foam	More	Less		Poor in hard water
Residues	None	None		Scum
Skin	10-15 layers		3-5 cell layers	Damage hair

Cat's skin pH in the range of 7.0 to 7.2. Cats don't usually need a bath. Make sure no tea tree oil or flea control products if you use dog shampoo.