MENINGKATKAN NILAI TAMBAH MINYAK SAWIT

Palm Fruit

PFAD

Crude Palm Oil

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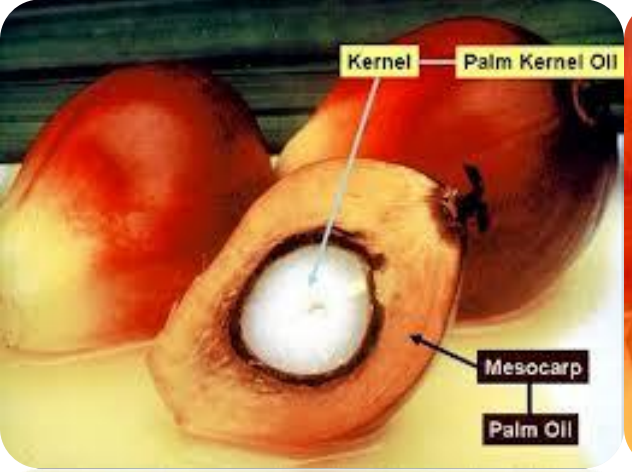

KULIAH TAMU

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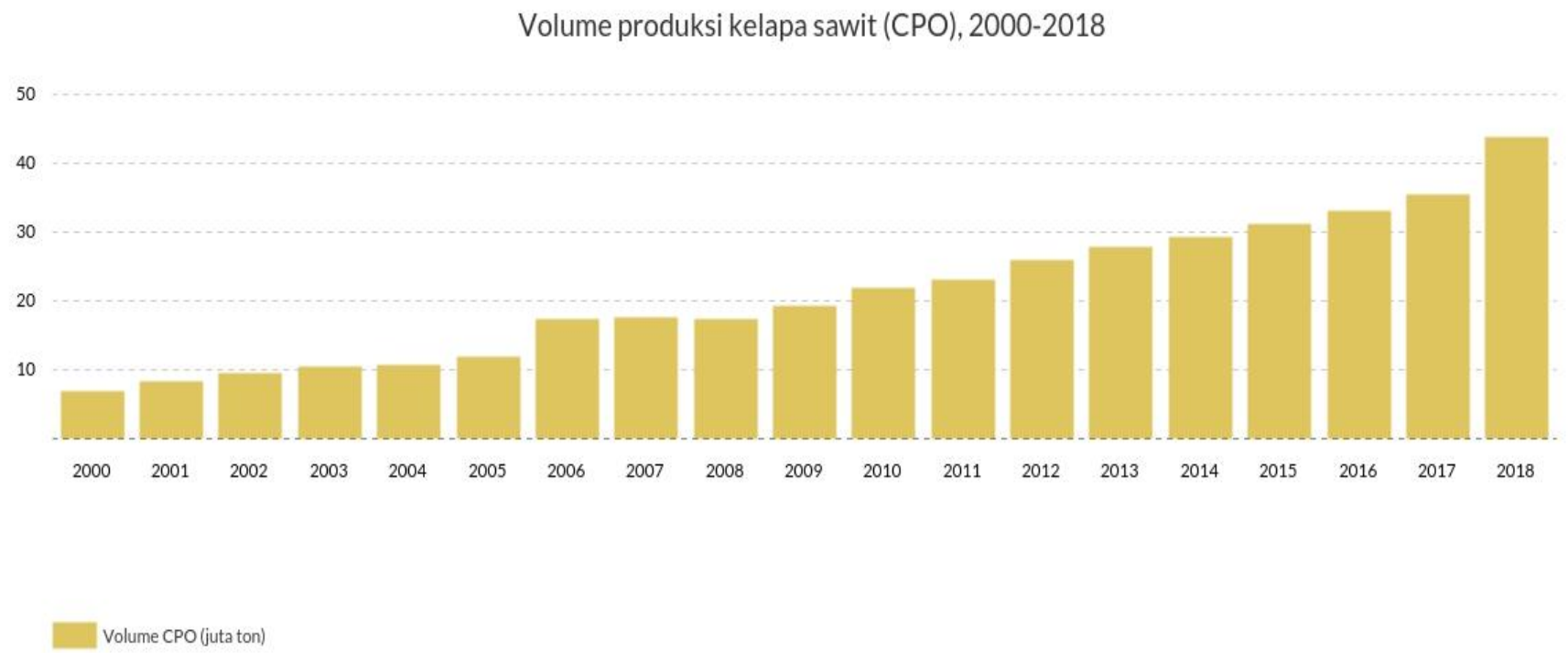
PRODUKSI CPO DI INDONESIA



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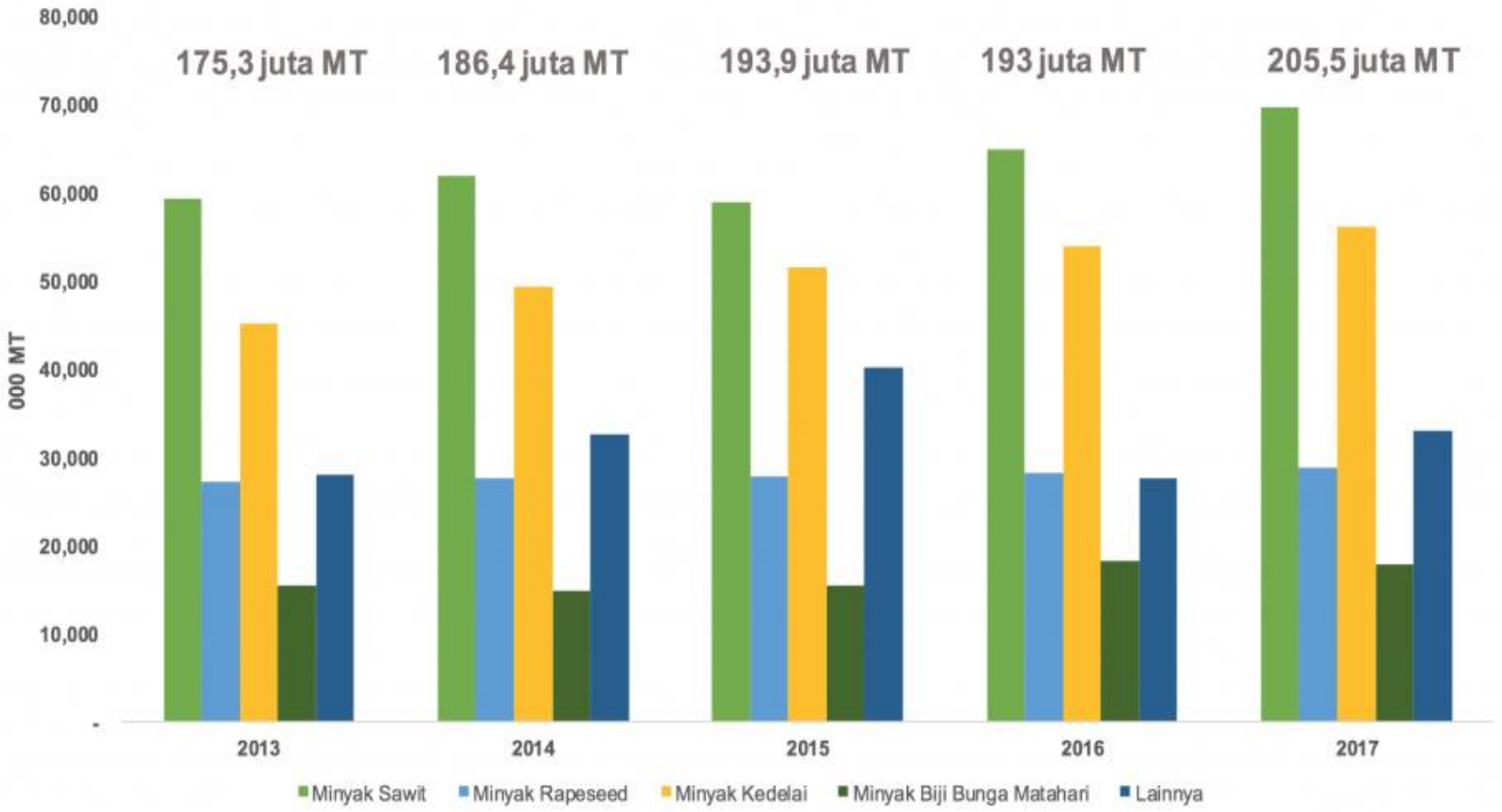
SUPLAI EDIBLE OILS DI DUNIA



Sumber: fas.USDA.gov.us

POHON SAWIT

Kelapa Sawit

DURA

Kelebaran cangkang:
2 - 8 mm (20-90%)

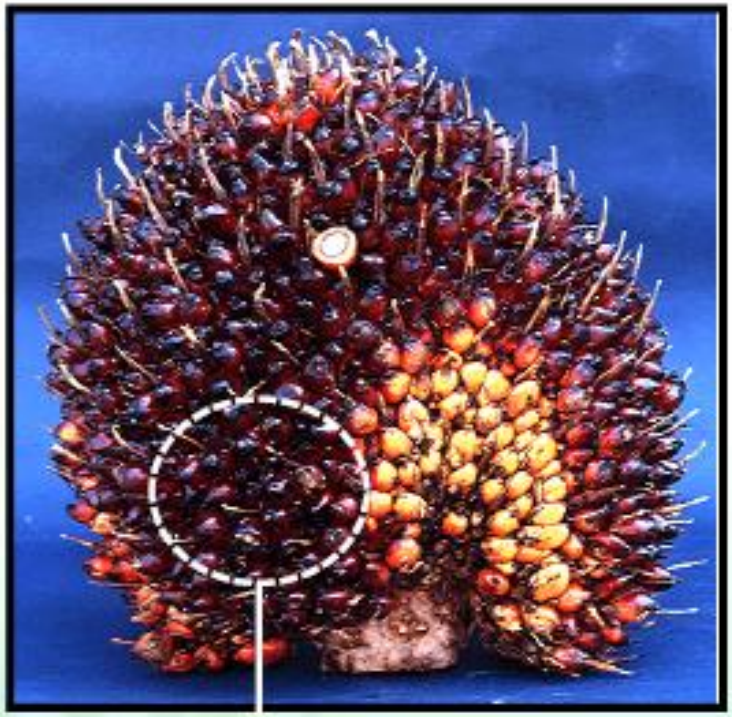
TENERA

Kelebaran cangkang:
1 - 2.8 mm(3-20%)

PISIFERA

Tidak memiliki
Cangkang (0%)
Female Fertile

THE OIL PALM FRUITS



Basic Information

- Fruits per bunch: 1000 to 3000
- Bunch Weight: 15-25kg
- Fruit size: 5 cm
- Fruit shape: Oval
- Fruit Color: Yellowish Red
- Fruitlet weight: 10 grams
- Oil per bunch: 23-25%

Mesocarp: crude palm oil

Palm kernel: crude palm kernel oil

Shell

PRODUKTIVITAS

- Kelapa sawit berbuah setelah 2-3 tahun dengan umur ekonomi 25-30 tahun
- Kelapa sawit menghasilkan 20-25 ton tandan per hektar per tahun
- Proporsi minyak per tandan adalah 25% tetapi setelah diolah skala pabrik 20-22%
- Produksi minyak per hektar adalah 4-5 ton per tahun


TANDAN KELAPA SAWIT

TANDAN DAN BUAH SAWIT

- Tandan sawit yang sudah matang mengandung ratusan sampai ribuan buah sawit dengan berat sekitar 40 kg
- Buah sawit berukuran 2-5 cm dengan bentuk oval dan berat 8-20 g
- Buah yang belum matang berwarna violet sampai hitam, jika sudah matang berubah warna menjadi oranye tua atau merah cerah
- Buah sawit terdiri dari mesokarp (pulp) dan biji yang terdiri dari kulit (endokarp) dan daging buah (kernel)

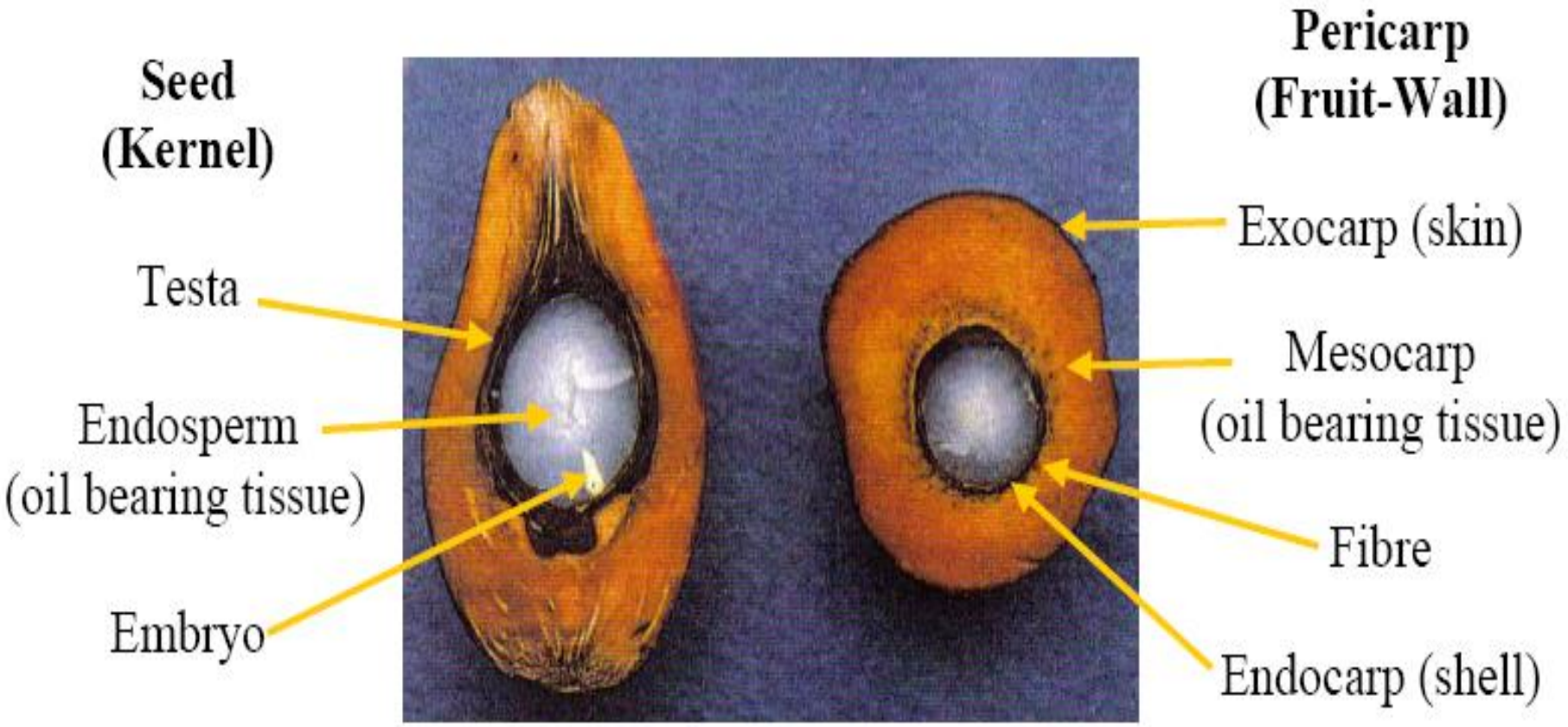
TANDAN BUAH SAWIT SEGAR (FFB=FRESH FRUIT BUNCH)

BUAH SAWIT

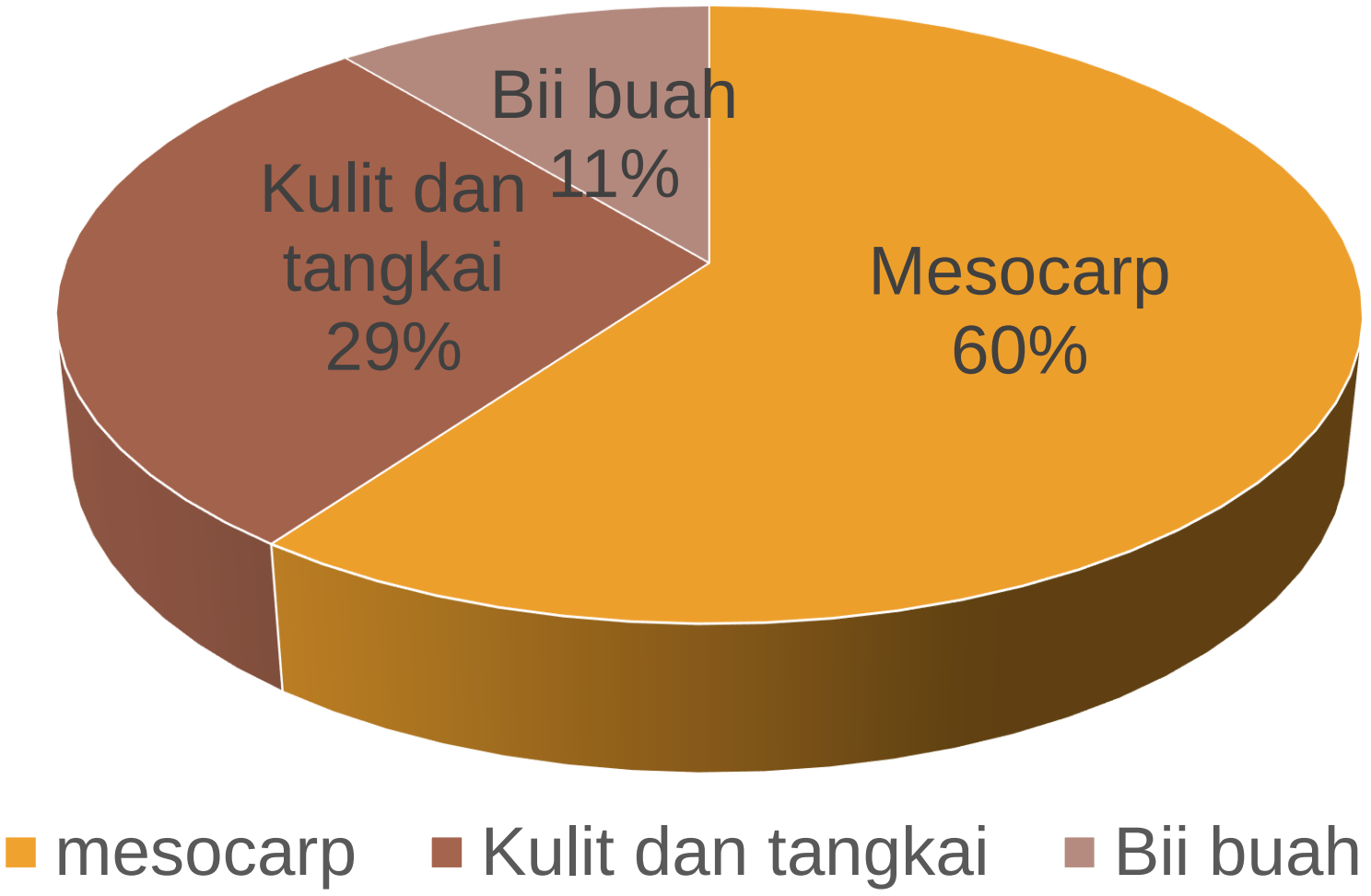
Key Raw Materials

- Palm Oil to Carbon chain length: C_{16}, C_{18}
- Palm kernel oil to: C_6 , C_8 , C_{10}, C_{12}, C_{14}

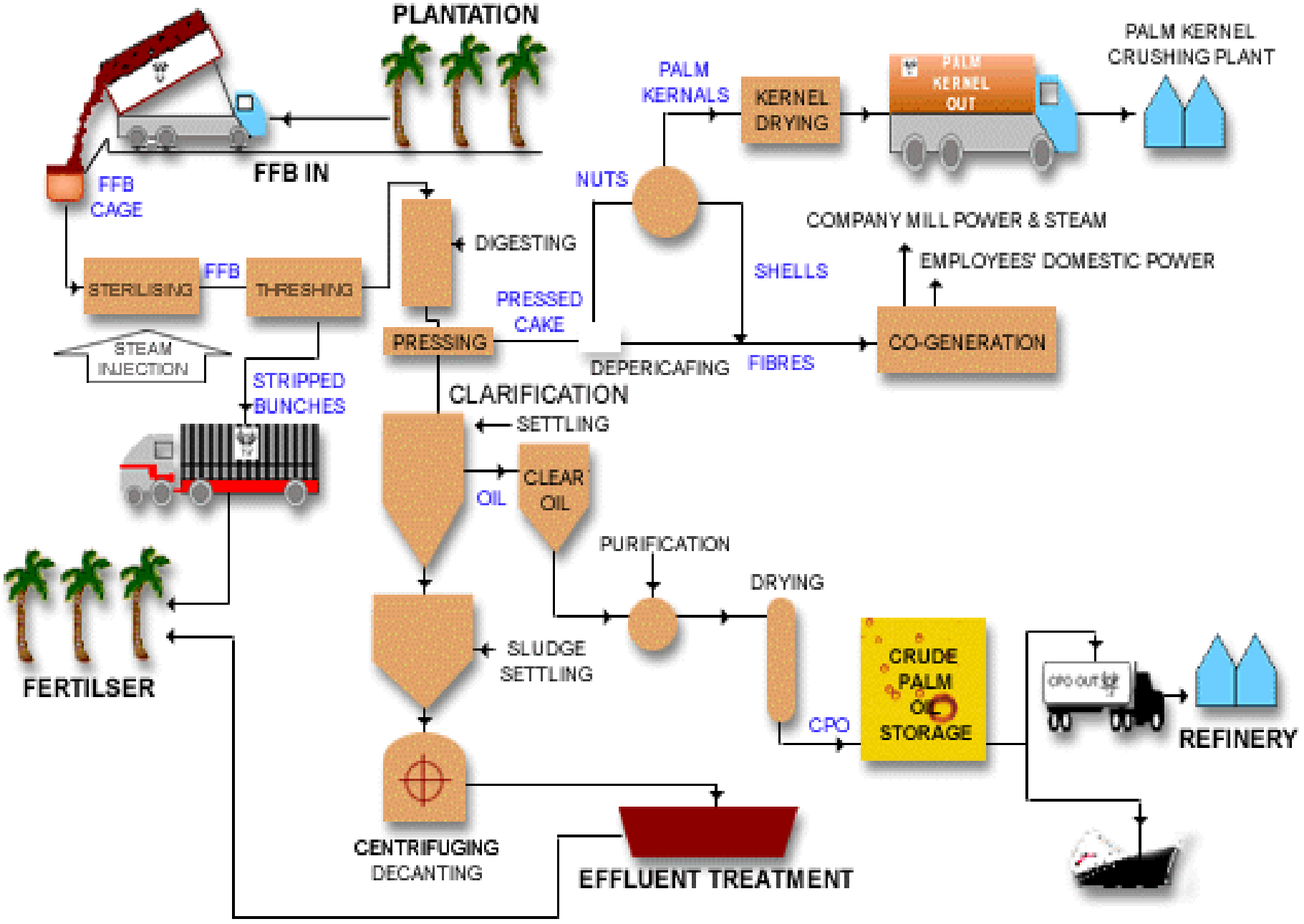
BAGIAN BUAH SAWIT



KOMPOSISI BUAH SAWIT



Crude Palm Oil Milling Process



EKSTRAKSI MINYAK SAWIT KASAR (CPO, CRUDE PALM OIL)

Beberapa tahapan ekstraksi minyak dari tandan sawit adalah:

1. Sterilisasi
2. Pelepasan buah (*bunch stripping*) (treshing)
3. Digesti
4. Ekstraksi minyak
5. Klarifikasi dan Purifikasi

EKSTRAKSI MINYAK SAWIT


1 Fibre
2 Shell
Used as boiler fuel in the mills
3 Palm Oil Mill Effluent (POME)
the wastewater derived from processing the fruit
After treatment
used as organic fertiliser
After processing
used as energy (biogas)
8 Pruned midrib
used as organic fertiliser
7 Leaves
used as organic fertiliser
6 Trees
used as basic material for furniture
4 Flesh & Kernel
of the oil palm fruit is converted into palm oil and palm kernel oil respectively
5 Empty Fruit Bunches (EFB)
composted and reused as organic fertiliser in the plantations

POHON INDUSTRI KELAPA SAWIT







PUSAT PENELITIAN KELAPA SAWIT
Jl. Brigjen Katamso No. 51, Medan 20158, Indonesia
Telp. 061-7862477, Fax. 061-7862488
e-mail : admin@iopri.org, http://www.iopri.org












TANDAN BUAH SEGAR

PELEPAH DAN BATANG SAWIT

- Pulp & Paper
- Animal Feed

Furniture

TANDAN KOSONG SAWIT

INTI SAWIT

BUAH SAWIT

MESOCARP

Pulp & Paper | Compost | Carbon | Rayon

MINYAK SAWIT MENTAH (CPO)

SERAT

Medium density fibre-board

Bahan Bakar

CANGKANG

- Bahak Bakar
- Karbon

AMPAS SAWIT

Pakan Ternak

MINYAK INTI SAWIT

PRODUK PANGAN

- Confectioneries
- Ice Cream
- Yoghurt

Emulsifier | Margarin | Minyak Goreng | Minyak Makan Merah | Shortening | Susu Kental Manis | Vanaspati

PRODUK NON PANGAN /OLEOKIMIA

- Asam lemak sawit
- Fatty alkohol
- Fatty amina
- Senyawa epoksi
- Senyawa hidroksi

Pelumas | Biodiesel | Senyawa Ester | Lilin | Kosmetik | Farmasi

SETRILISASI

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TRESHING ATAU BUNCH STRIPPING

Palm Fruit Bunches in Stripping Machine

Empty Bunch after Threshing/Stripping

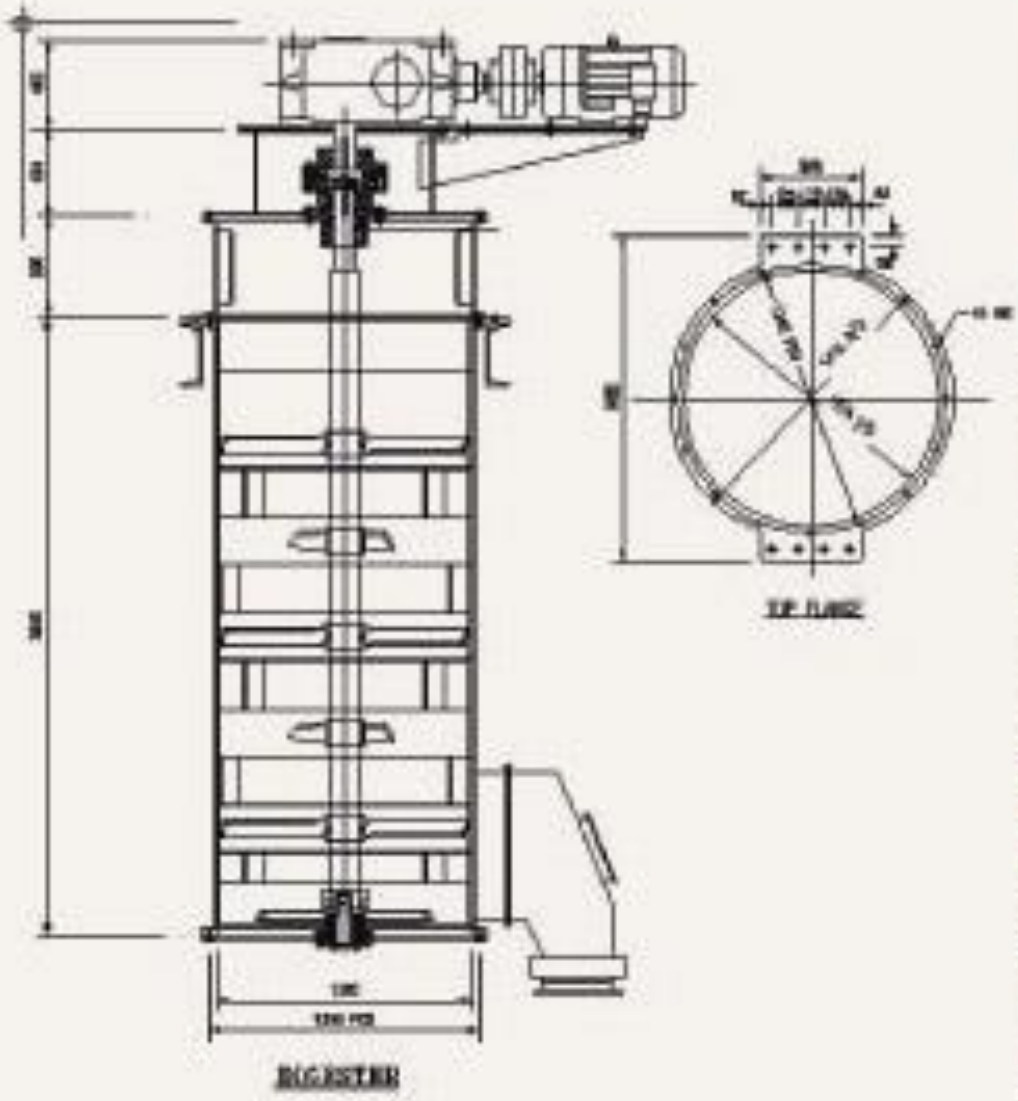
Palm Fruits

Trimming Station in Palm Oil Mill

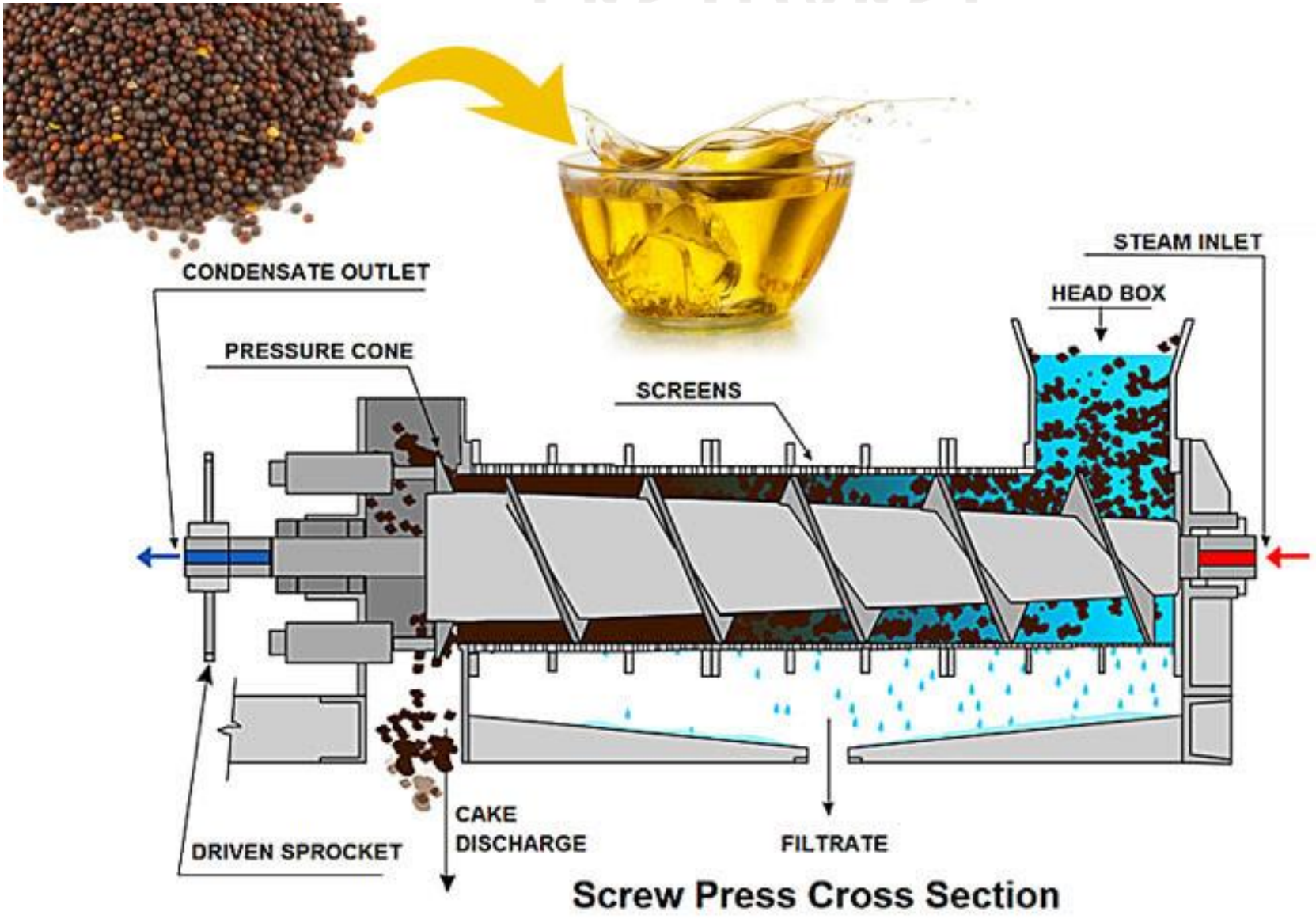
Palm Oil Mill Threshing Section

Palm Fruit Threshing Machine / Thresher

DIGESTI



EKSTRAKSI


CONDENSATE OUTLET
PRESSURE CONE
SCREENS
STEAM INLET
HEAD BOX
DRIVEN SPROCKET
CAKE
DISCHARGE
FILTRATE
Screw Press Cross Section

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CRUDE PALM OIL

BIJI SAWIT/KERNEL

SERAT SAWIT

LUMPUR SAWIT (SLUDGE)

DOING

Palm Oil Refining line

Crude Palm Oil

Filtration → Granular Impurities

Phosphoric Acid → Degumming → Gums

Floridin → Decolorization → Pigment

Direct Stream → Deodorization → Odour (refined oil)

Temperature → Fractionation

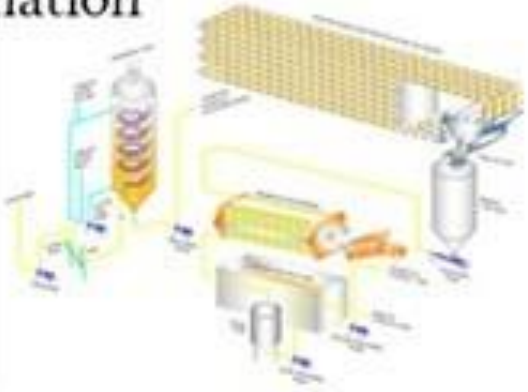
20°C | 30°C | 40°C

Filtration

Deugmming
Decolorization

Fractionation

Dedorization



REFINING PROCESS

CRUDE PALM OIL

80°C - 90°C

Degumming

90°C - 120°C

Bleaching

Filtration

Bleached Palm Oil

180°C - 260°C under vacuum

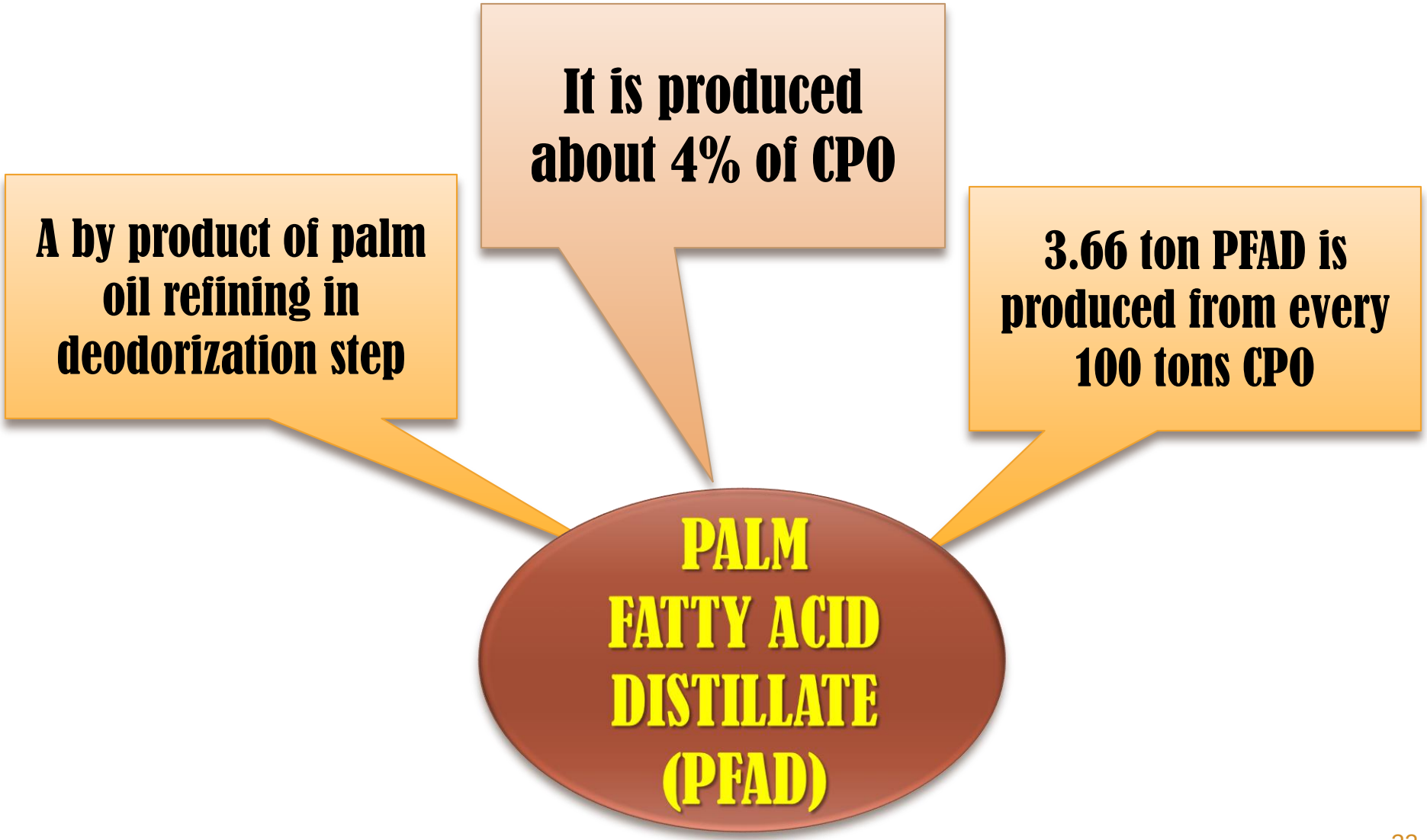
Deacidification and deodorization

Palm Fatty Acid Distillate

RBD Palm Oil

PALM FATTY ACID DISTILLATE

PALM FATTY ACID DISTILLATE



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MINOR AND VALUABLE COMPONENTS OF PALM OIL

Bioactive Compounds

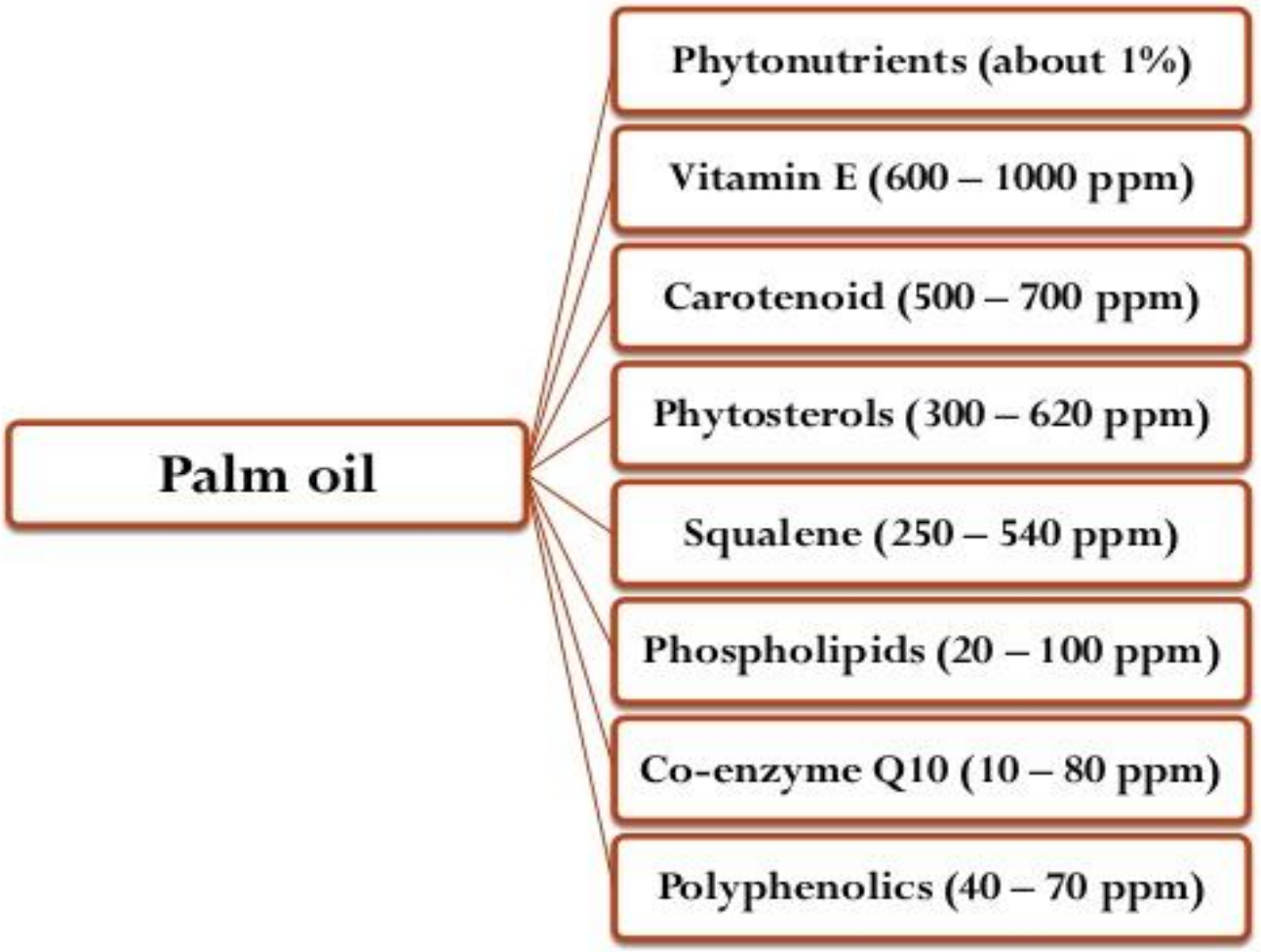
- Phytonutrients, phytochemicals
- Ingredients for functional foods
- Compounds that have positive physiological effects on health more than essential nutrition
- A broad diversity of structures and functionalities

Composition of

Component	Percentage
Triglyceride	>90
Diglyceride	2-7
Monoglyceride	<1
Free Fatty Acid	3-5
Phytonutrients	1

Loganathan *et al*. (2009)

Bioactive Compounds of



Hassanein, www.slideshare.net

Bioactive Compounds of CPO

- Vitamin E 222 ppm
- Phytosterols 17,322 ppm
- Squalene 535 ppm
- β carotene 643 ppm

PFAD Utilization

Currently used for non food industries

- Oleochemicals
- Soap
- Feed

Ignoring bioactive compounds

PFAD could be used integratively as a source of bioactive compounds and free fatty acids

The Occurance of Bioactive Compounds of palm oil

- **A**ccumulated in PFAD and unsaponifiable fraction of CPO
- **T**ocotrienols and tocopherols 0.7-1.0% (Liu *et al.* (2008)
- **S**qualene 1.03% (Posada *et al*., 2007)
- **P**hytosterols 0.37% (Gapoor *et a*
- **B**ioactive compounds of PFAD is unsaponifiable matters

PFAD COMPOSITION (*Gapoor *et al.*, 2002; ** Lewis,2001)

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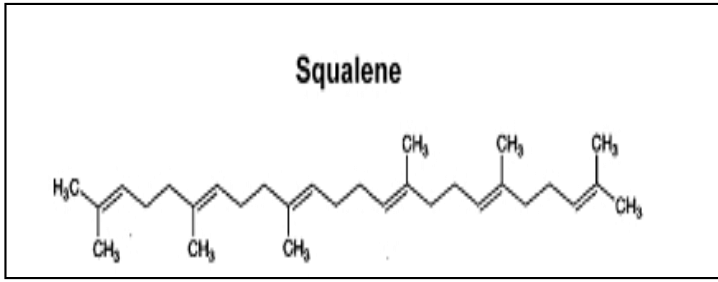
Component	Concentration (%)*	Concentration (%)**
Free fatty acid	81.7	40
Glyceride	14.4	
• Triglyceride	4.1	28.5
• Diglyceride	7.1	13.2
• Monoglyceride	2.7	10.5
Sterols	0.37	0.3
• Stigmasterol	0.004	
• Campesterol	0.092	
• β Sitosterol	0.212	
Steryl ester		0.5
Hydrocarbon	1.47	
• Squalene	0.76	
• Others	0.71	6.0
Tocopherol + tocotrienol	0.48	1.0
Others	1.60	

Bioactive Compounds in Palm Oil

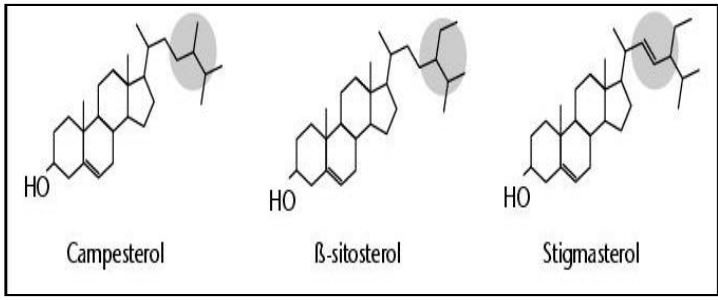
Squalene

- Major hydrocarbon in PFAD
- Concentration reaches 0.76%



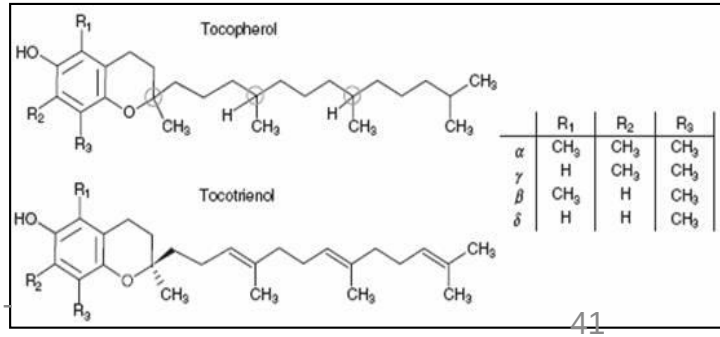
Phytosterols

- Campesterol (13%), β sitosterol (60%), stigmasterol (24%)
- Concentration 0.37%



Vitamin E

- Rich in tocotrienols
- Concentration 0.48%

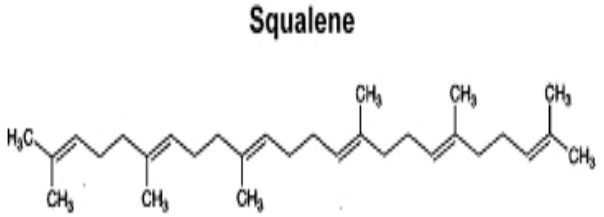


The Role of Bioactive Compounds of Palm Oil

Squalene	• Hypocholesterolaemic property
Phytosterols	• Cholesterol lowering property • Lactogenic
Vitamin E	• Cholesterol lowering property • Antioxidant/Hepatoprotector

$C_{30}H_{62}$

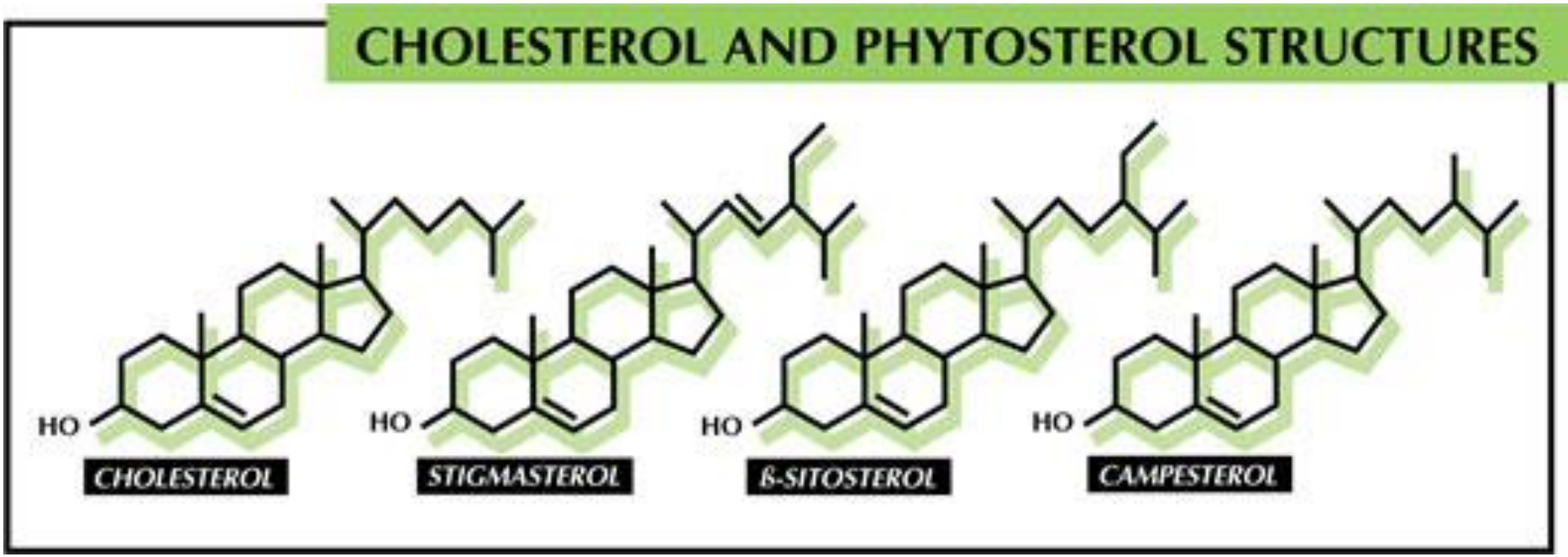
Squalane



- Has anti cancer and cholesterol lowering properties (Loganathan *et al*., 2009).
- Has the ability to increase fecal excretion of bile acid that leads to reduce blood cholesterol level (Qureshi *et al*., 1996; Shin *et al*., 2004; de Costa *et al*., 2013).
- Increase cholesterol level (Zesheng *et al*., 2002), due to incresing extent of cholesterol synthesis (Coskun *et al*., 2013).
- Increased the excretion of bile acids

  (de Castro *et al*., 2013)

Phytosterols



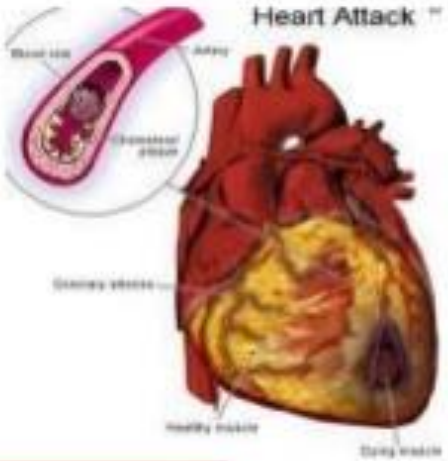
Phytosterols

- Phytosterols lower blood cholesterol level by inhibiting cholesterol absorption
- Phytosterols also have the ability to increase breast milk production (Freitsche and Steinhart, 1999),
- Anti inflammation, anti cancer, immunomodulatory (Carr *et al*., 2010), antithrombotic, and hypocholesterolaemic properties (Awad and Fink, 2000; Piiron *et al*., 2000; Ostlund *et al*., 2002).

Mechanism of action

1)Reduces the absorption of cholesterol by competing with cholesterol for incorporation into the bile salts micelles or for uptaking of cholesterol by enterocytes.

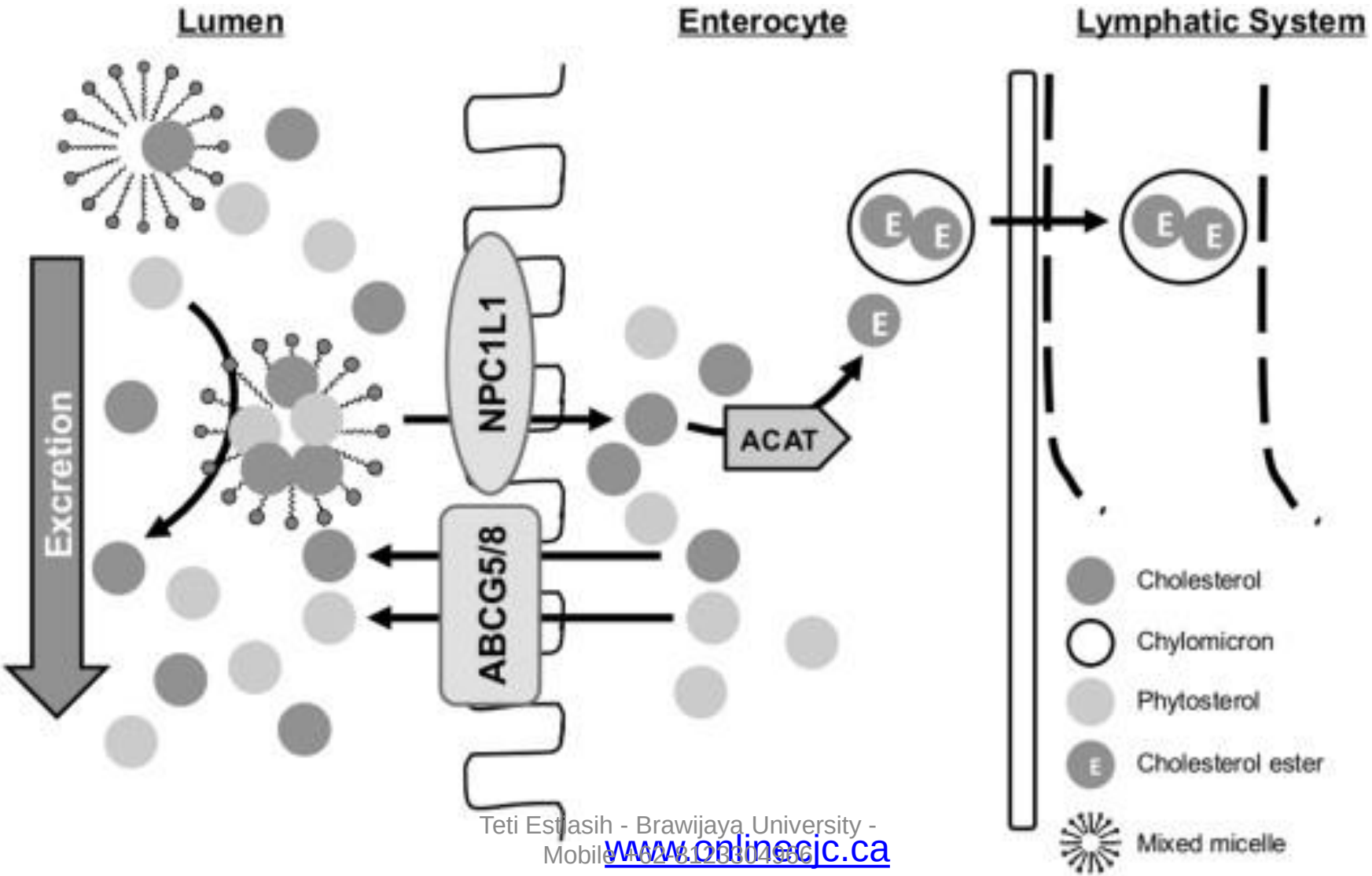
2) Phytosterol precipitates marginally soluble cholesterol into non absorbable form in the intestine.



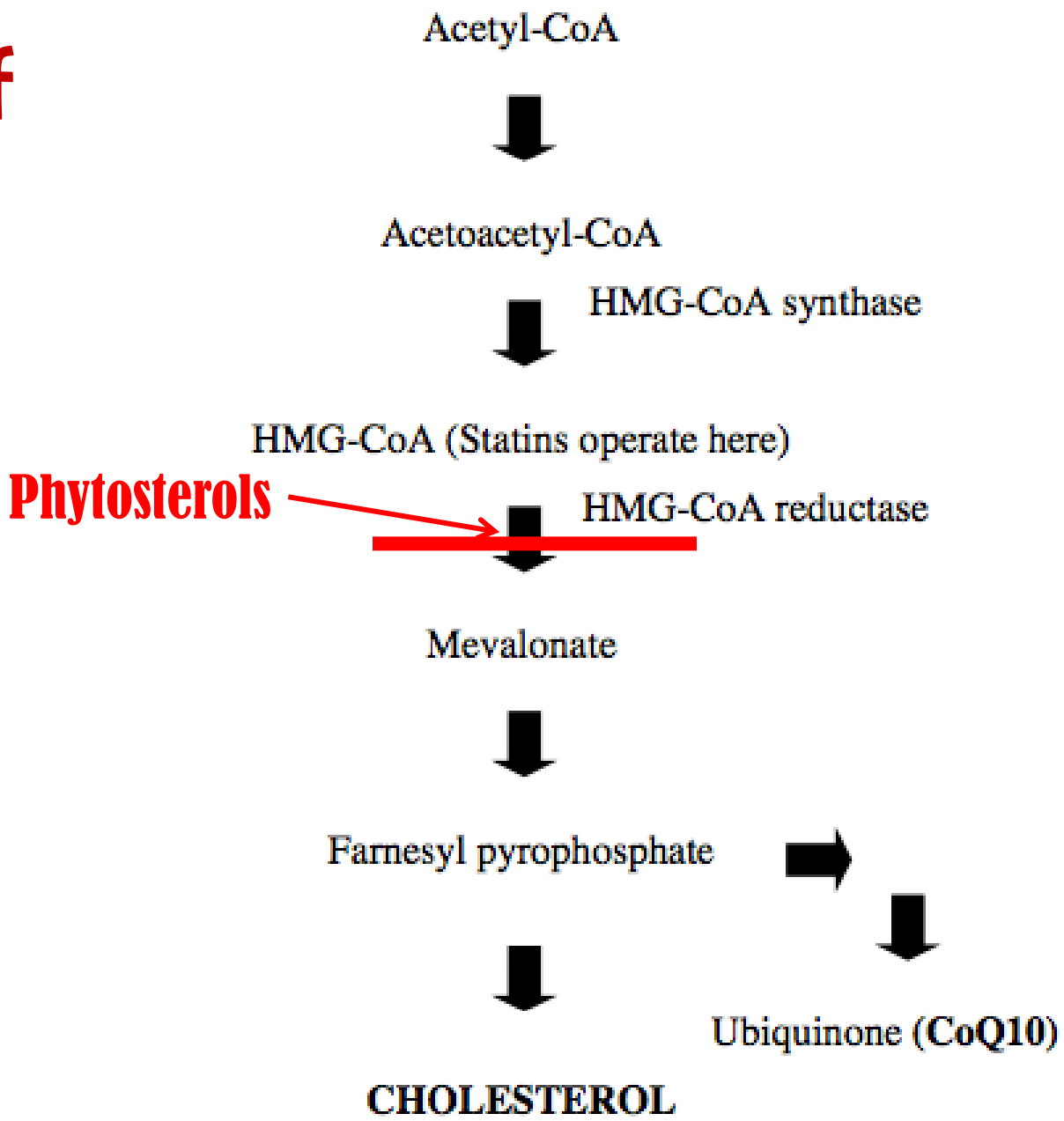
3) Phytosterols enhance cholesterol excretion back into the intestinal lumen through the ABC G5/G8 transporters

4)They could also prevent esterification of free cholesterol.

Inhibition of Cholesterol Absorption



Inhibition of Cholesterol Synthesis



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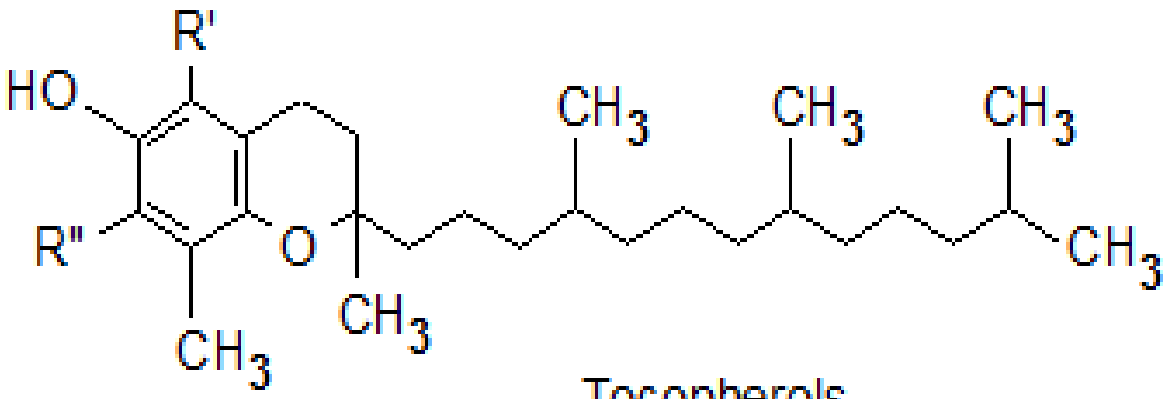
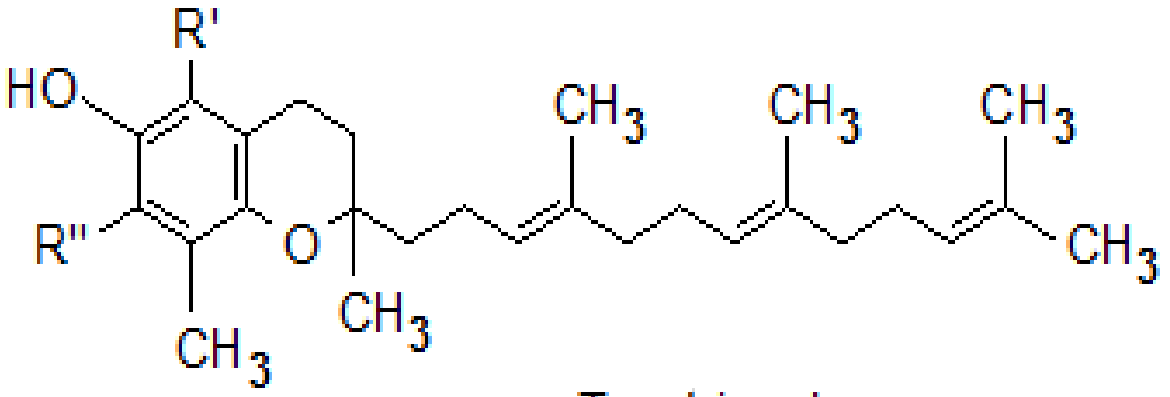
Vitamin E

Vitamin E: Tocopherols & Tocotrienols



Tocopherols



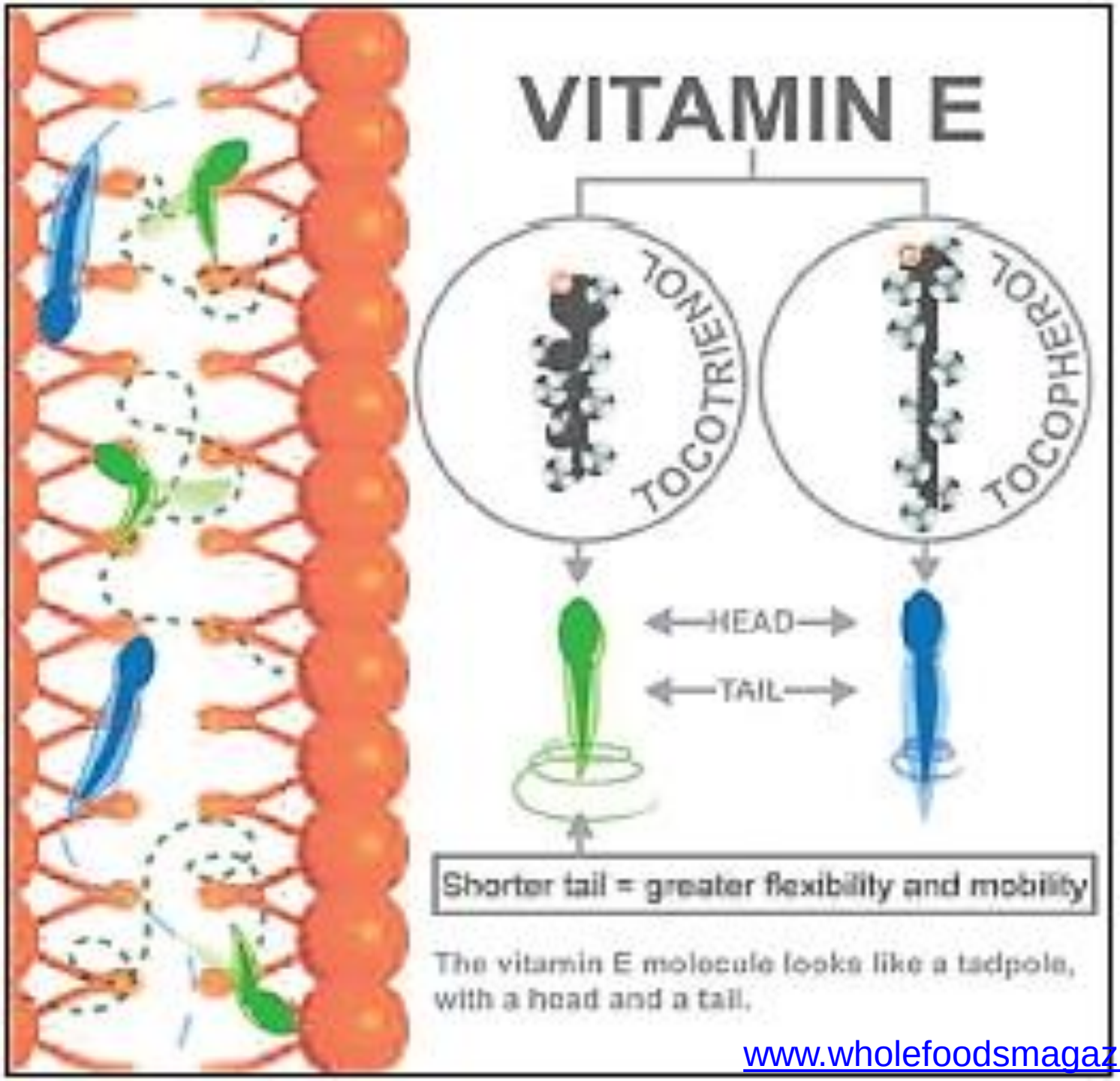
Tocotrienols

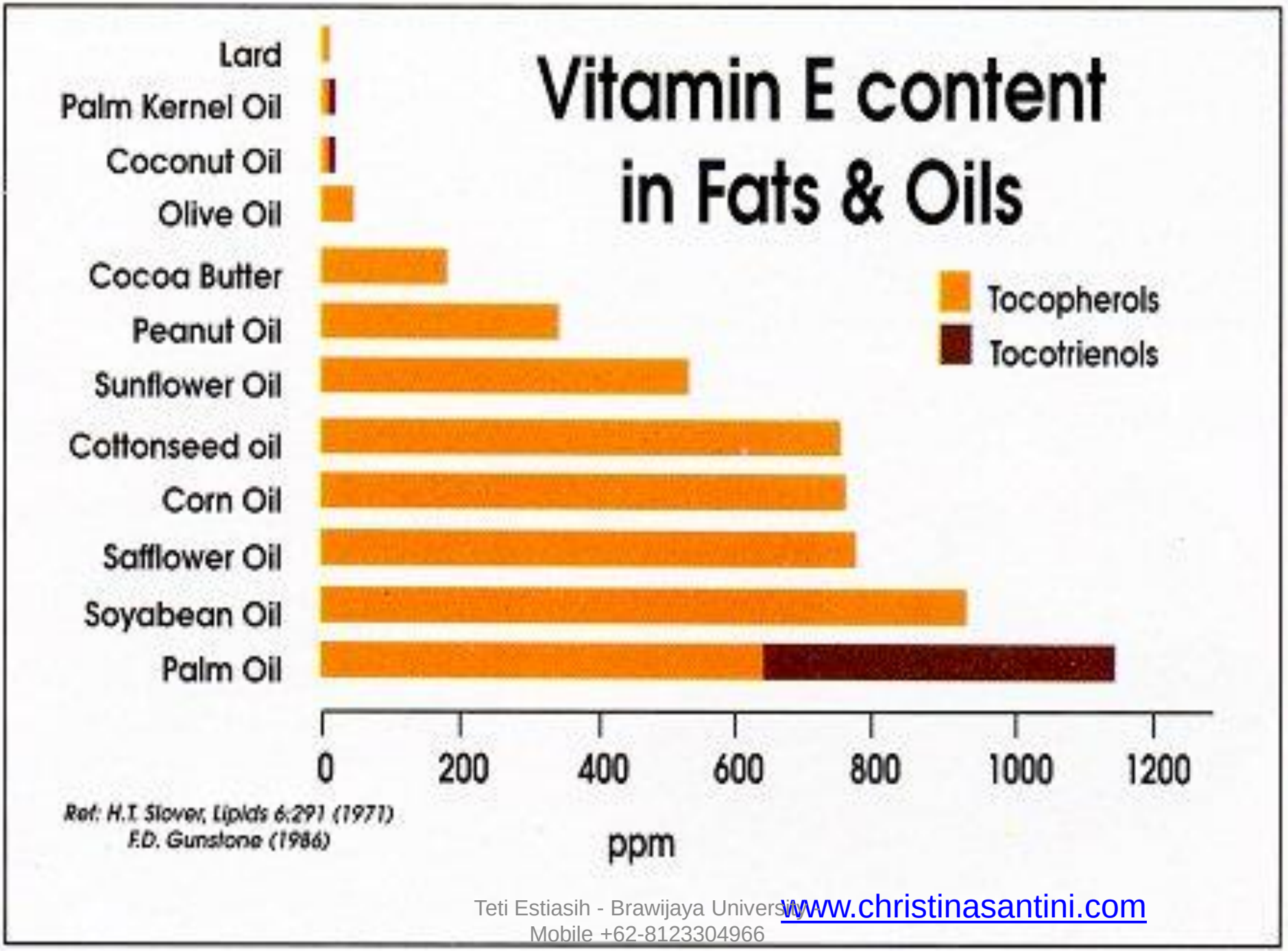
α: R' = CH_3, R" = CH_3

β: R' = CH_3, R" = H

γ: R' = H, R" = CH_3

δ: R' = H, R" = H





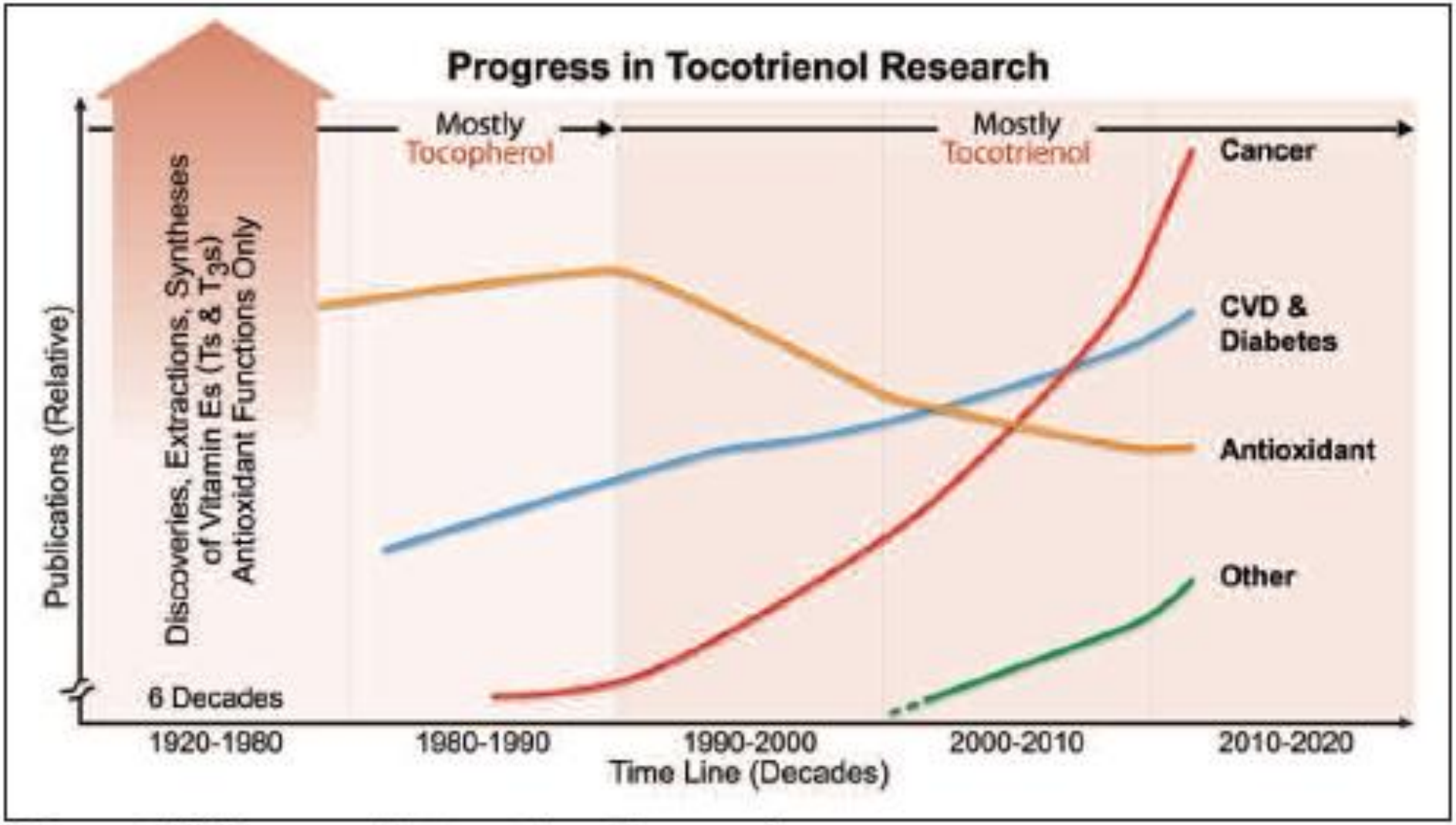
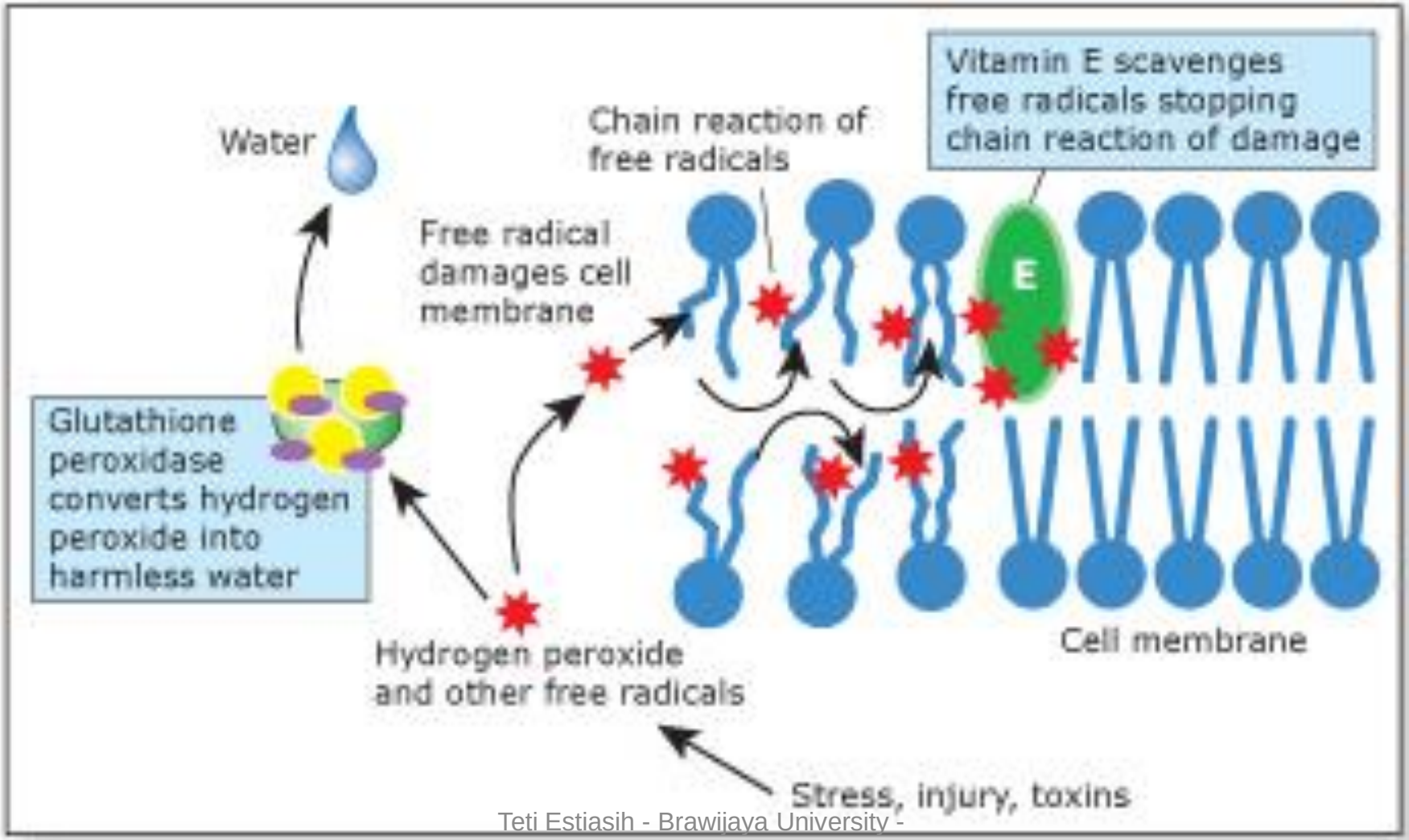
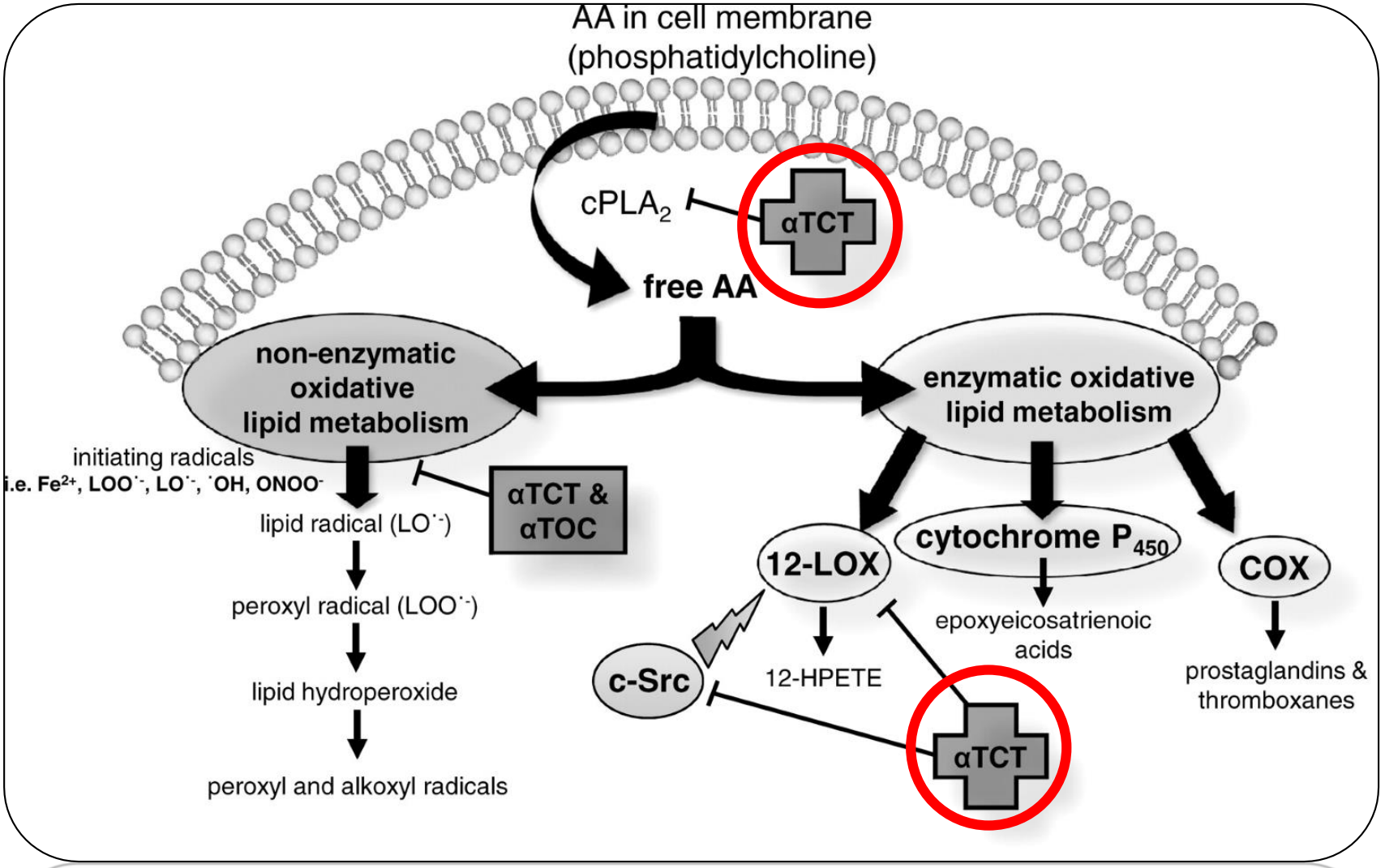


Figure 10: Progress in tocotrienol research.

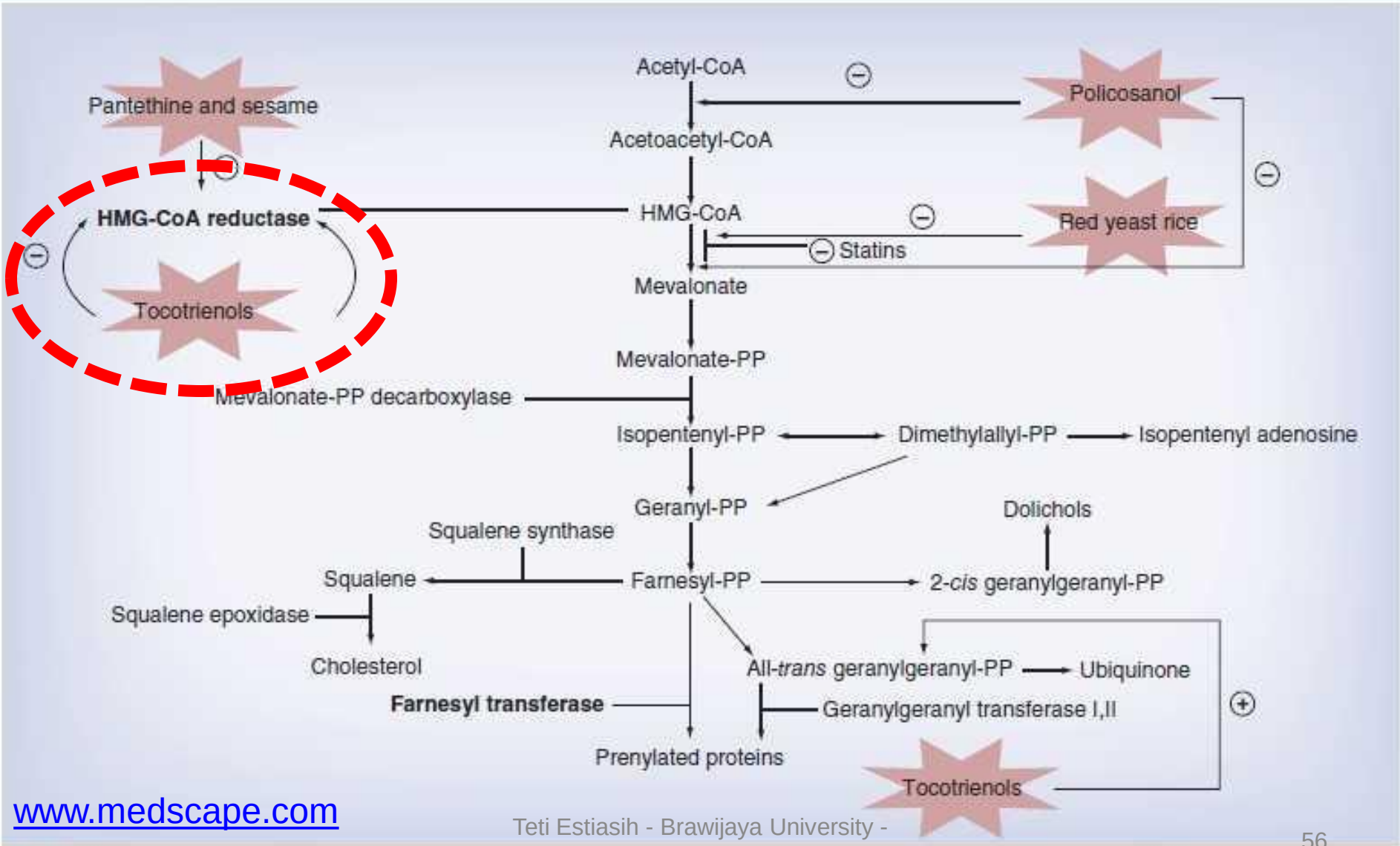
Incorporation of Vitamin E into Lipid Membrane Bilayer



Role of Vitamin E as Antioxidant



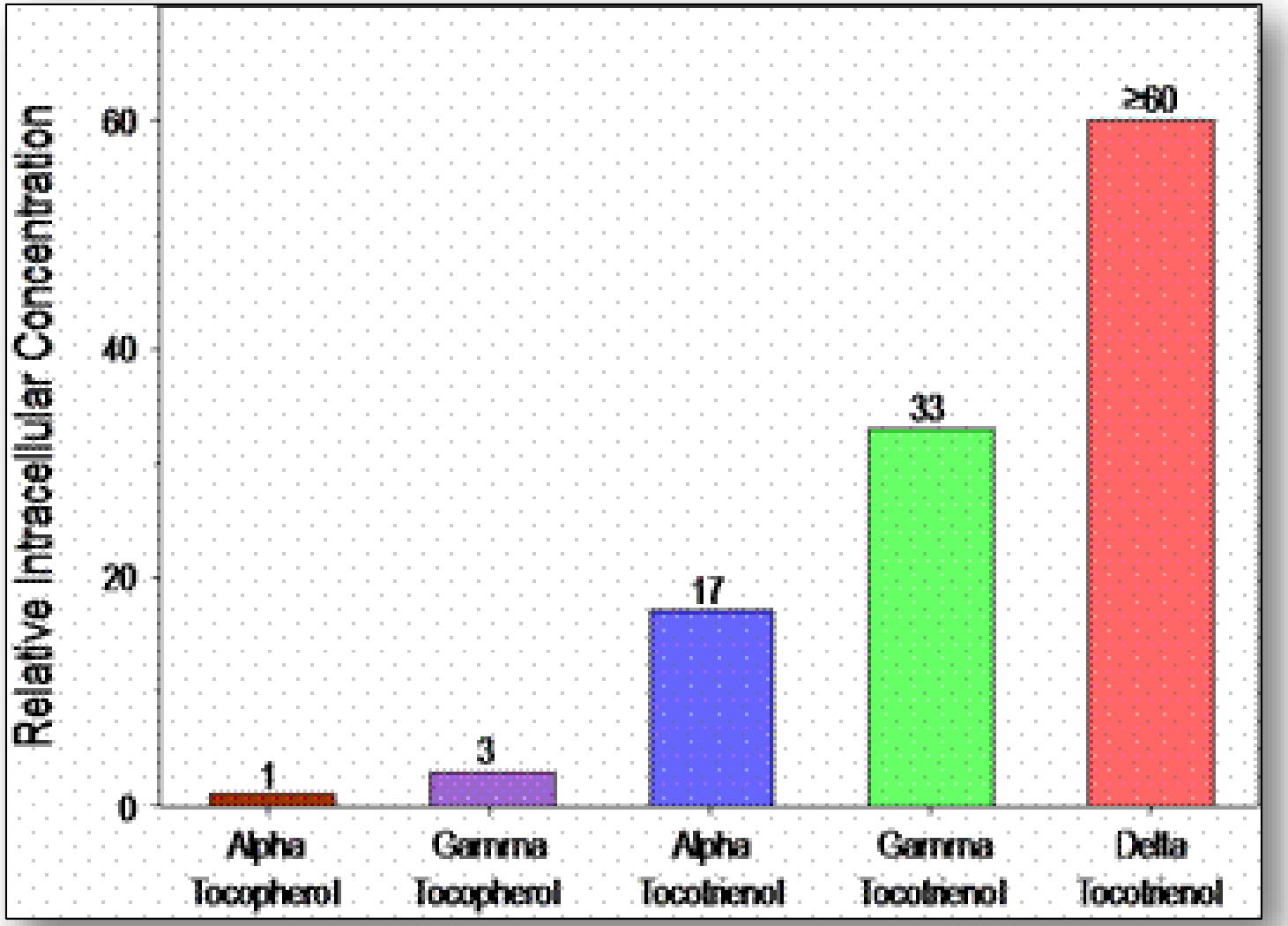
Mechanism of Tocotrienols in Reducing Cholesterol



www.medscape.com

Bioavailability of Tocotrienols

www.drpasswater.com



Bioactive Compounds of PFADs from Several Palm Oil Refineries in Indonesia

Palm Oil Refinery	Vitamin E (ppm)	Phytosterol (ppm)	Squalene (ppm)	Polycosanol (ppm)	Co-enzyme Q10 (ppm)
1	195.60	7476.56	2373.27	nd	nd
2	64.70	407.00	462.87	nd	nd
3	280.63	6011.72	2767.08	nd	nd
4	200.76	2310.52	1380.16	nd	nd
5	172.47	1956.15	2222.41	nd	nd
6	208.82	3915.22	nd	nd	nd

nd = not detectable

Reference: Estiasih *et al*. (2013)

Unsaponifiable Fraction (USF) of PFAD

Bioactive components of PFAD were accumulated in (USF)

USF could be separated from SF by simple saponification

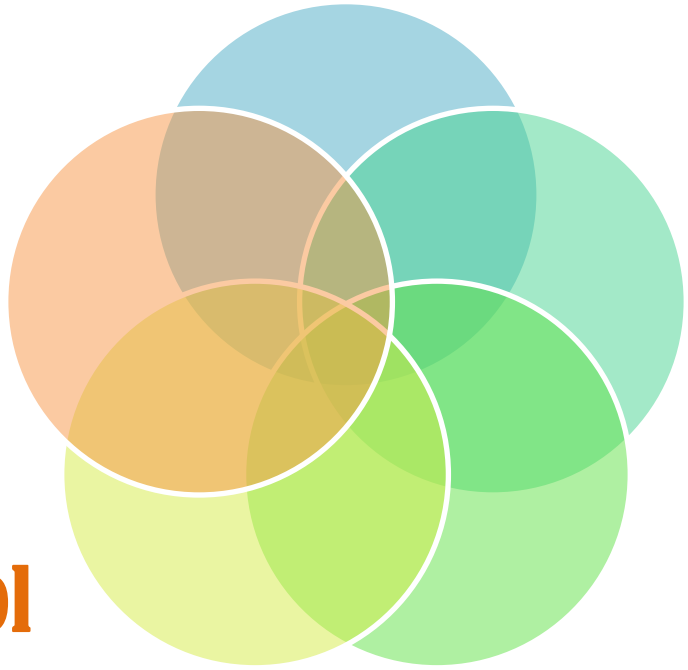
Two fractions are formed during saponification

- USF contains bioactive compounds
- Saponification fraction that rich in FFA or soap

Bioactive Compounds of USF from PFAD (Estiasih *et al.*, 2012)

Vitamin E
0.80%

Co-enzyme
Q10 n.d.



Phytosterols
9.16%

Polycosanol
n.d.

Squalene
1.14%

Bioactive Compounds of USF from PFAD (Estiasih et al., 2012)

Bioactive Compounds	Concentration	
	ppm	%
Vitamin E	**7,968.04**	**0.80**
• α tocopherol	644.11	0.06
• α tocotrienol	1,860.54	0.19
• δ tocotrienol	4,853.78	0.49
• γ tocotrienol	609.61	0.06
• Total tocotrienol	7,323.93	0.73
Phytosterol	**91,846.30**	**9.18**
• Beta sitosterol	81,932.59	8.19
• Campesterol	61.87	0.01
• Stigmasterol	9,851.83	0.99
Polycosanol	**nd**	**nd**
Squalene	**11,436.66**	**1.14**
Co-enzyme Q10	**nd**	**nd**

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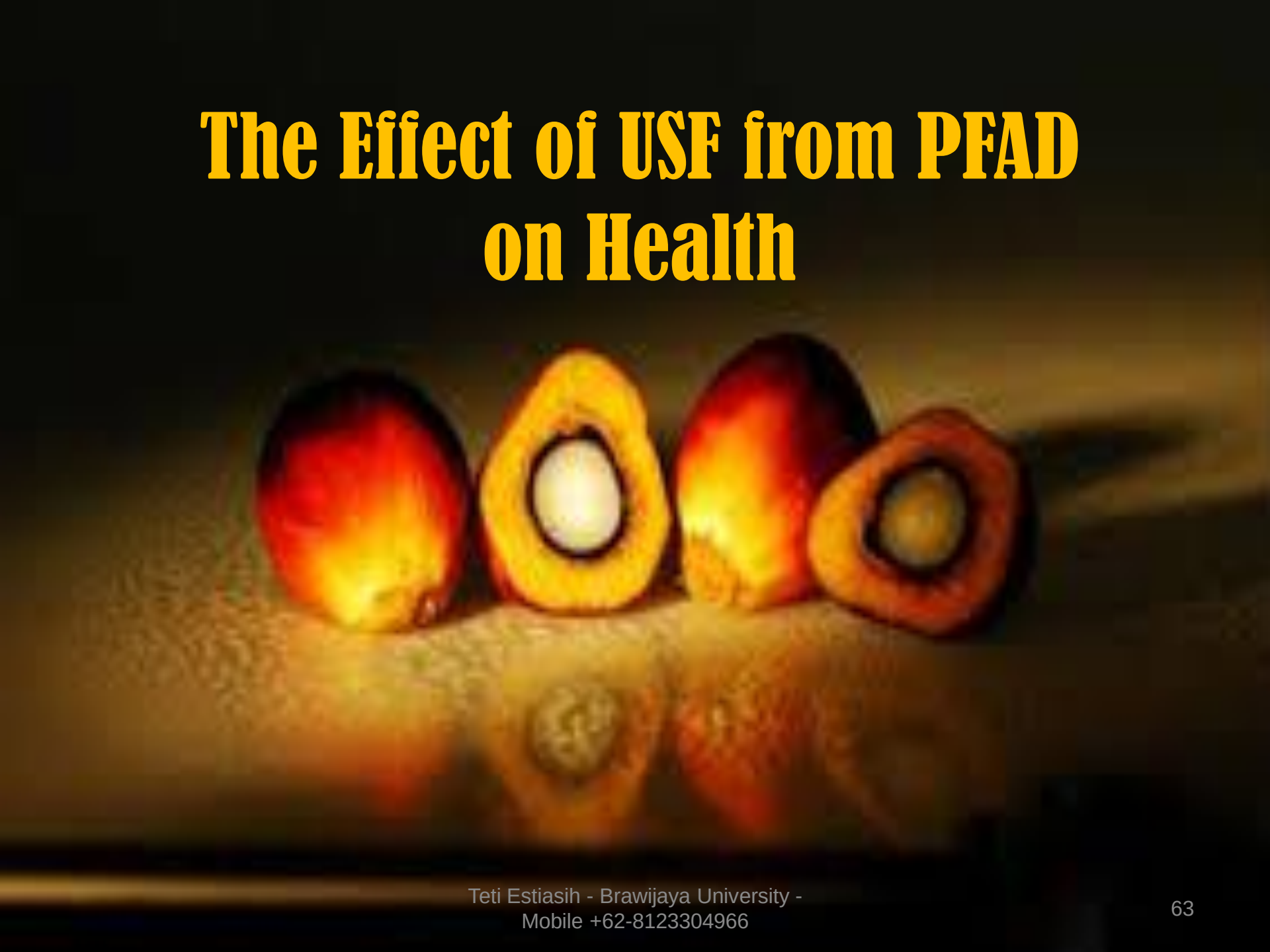
Yield of Unsaponifiable Fraction (USF)

2-3%

The Effect of USF from PFAD on Health



Total Cholesterol Lowering Properties (Estiasih et al., 2014)

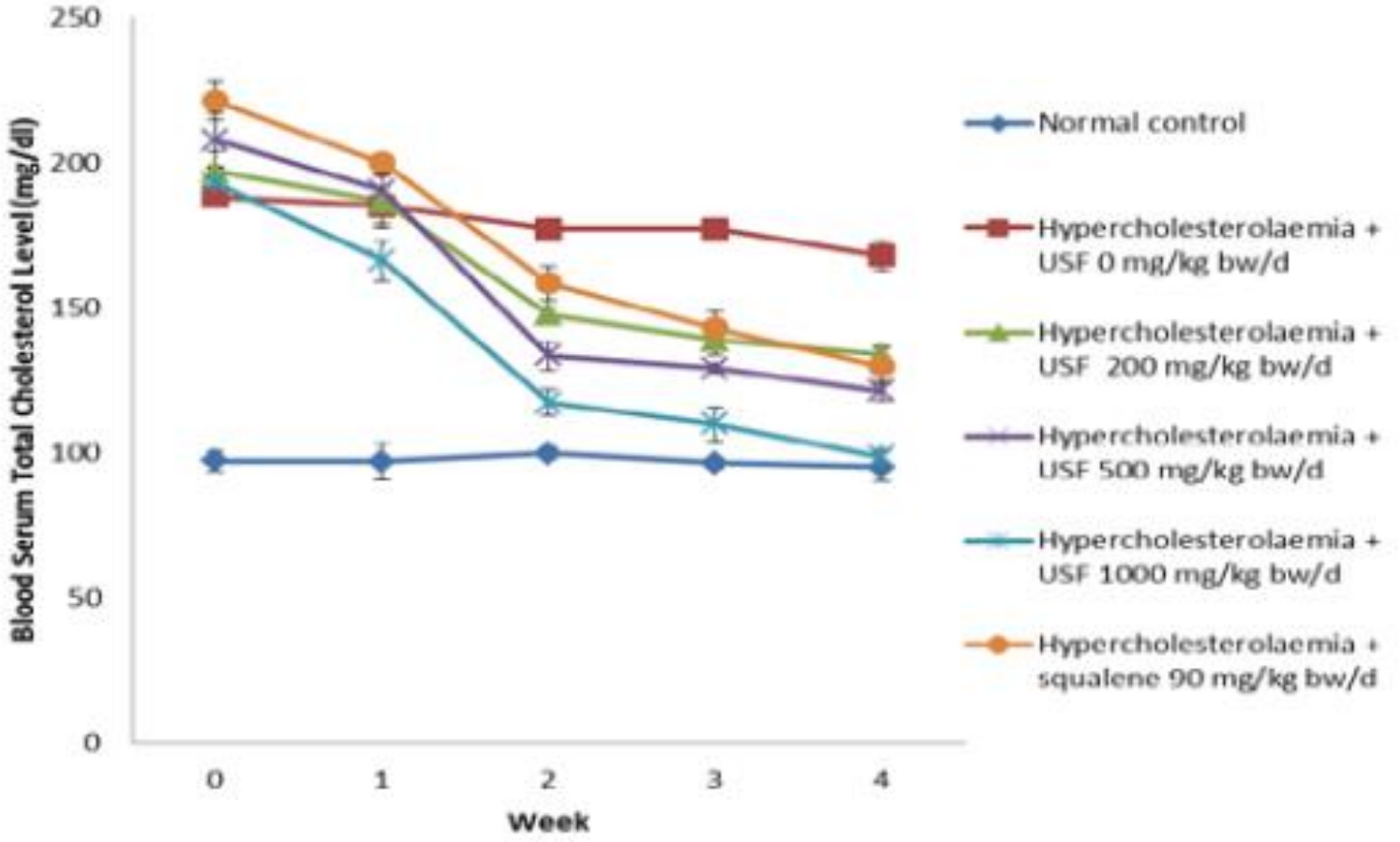


Figure 1. Blood serum total cholesterol level after USF administration at various doses

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Triglyceride Lowering Properties (Estiasih et al., 2014)

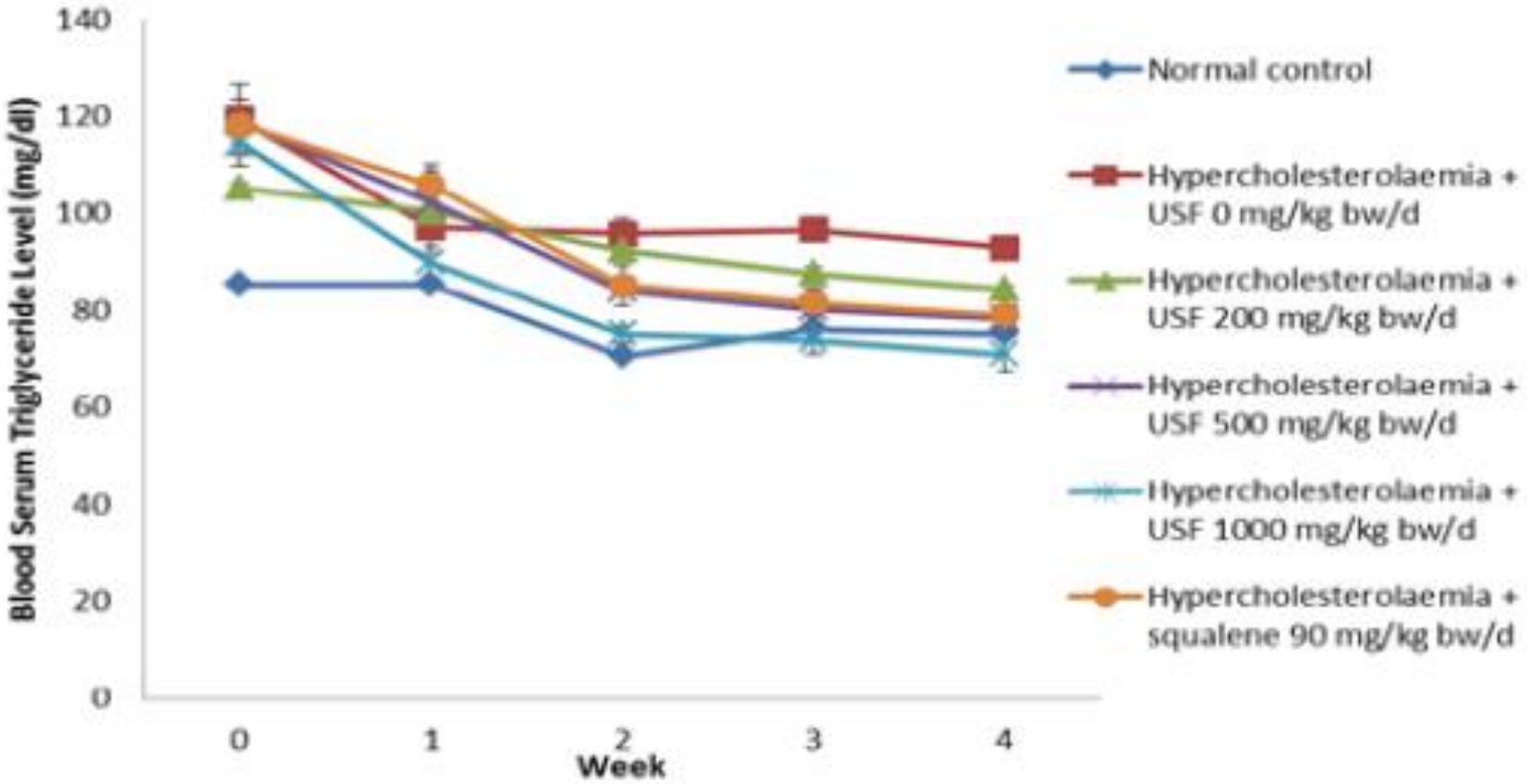


Figure 2. Blood serum triglyceride level after USF administration at various doses

LDL Cholesterol Lowering Properties (Estiasih et al., 2014)

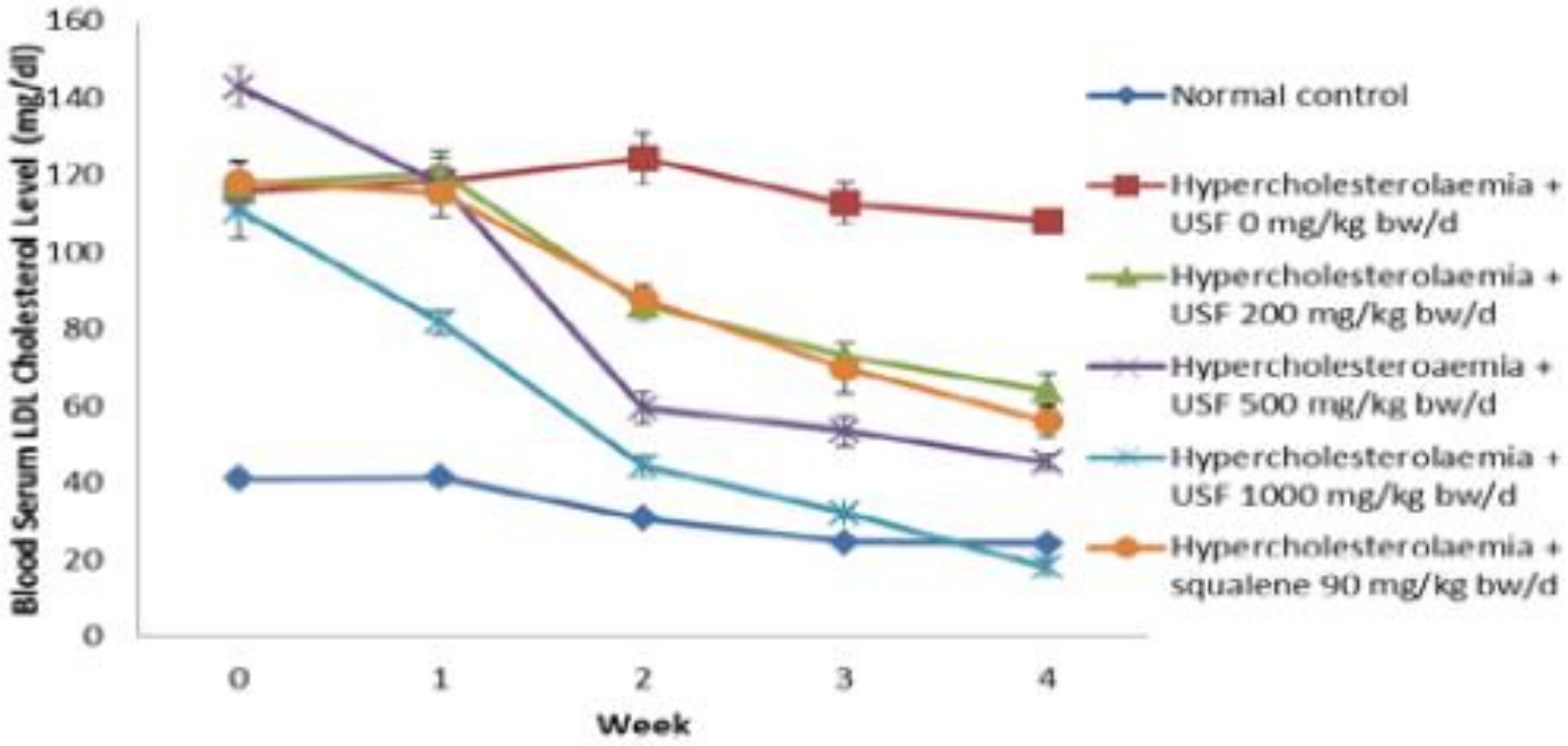


Figure 3. Blood serum LDL cholesterol level after USF administration at various doses

HDL Cholesterol Rising Properties (Estiasih et al., 2014)

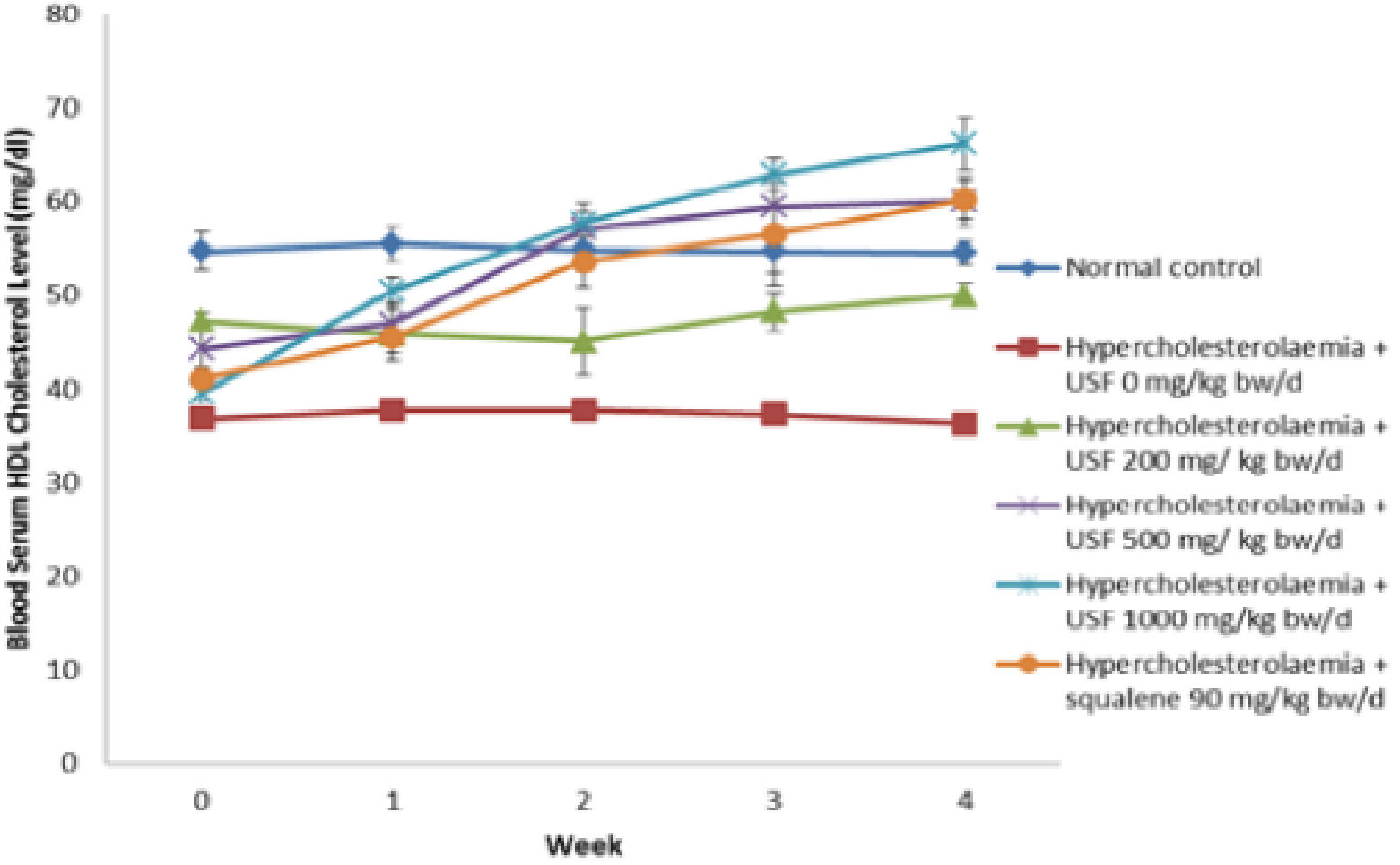


Figure 4. Blood serum HDL cholesterol level after USF administration at various doses

Immunomodulator Effects

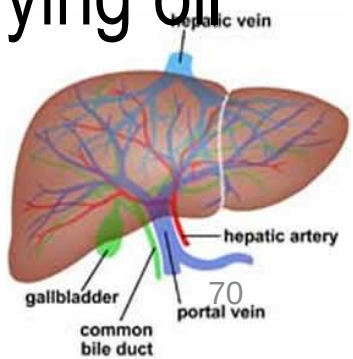
- **USF** acted as immunomodulator
- USF increased **immune system** by increasing limphocytes proliferation as well as increasing IgG and interferon γ production

Lactogenic Effect

- USF from PFAD increased the production of breast milk
  - USF increased baby's weight of rats treated by USF better than untreated rats.
    - The best dose to increase breast milk production was 500 mg/kg bw/day.
      - The ability of USF to increase breast milk production also proved by the dilatation and the increase of alveoli cells of mammary gland.
        - The higher the dose of USF, the more abundant milk production.

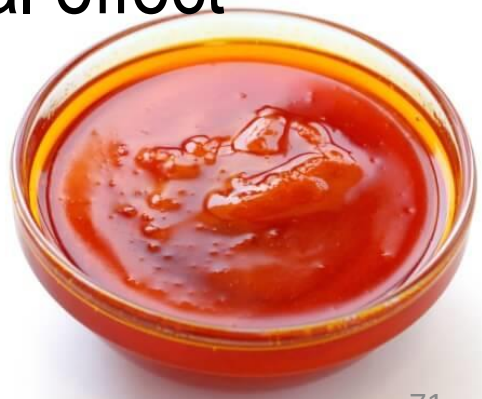
Hepatoprotective Effect

- **USF** had a role as hepatoprotector from liver peroxidation that indicated by its ability to reduce liver MDA level as well as increase liver SOD activity.
    - **No significant damage** was found in rats treated by USF compared to untreated rats when administered by highly oxidized frying oil

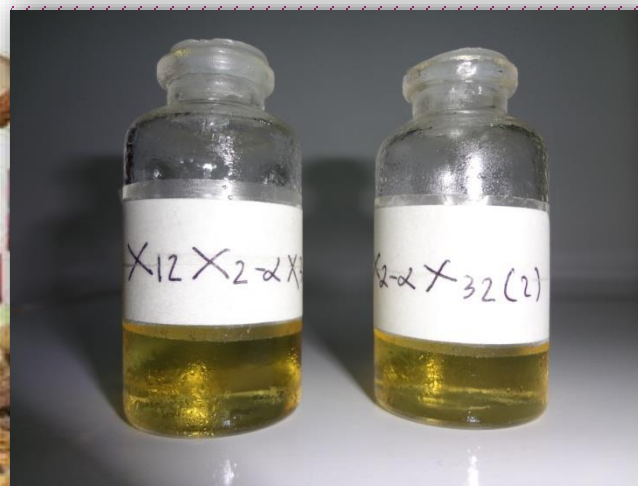


Antioxidant

- USF had antioxidant activity that indicated by its ability to reduce blood MDA level and increase blood SOD activity in peroxidation or oxidative stress condition.
- The ability of USF as antioxidant increased with increasing USF dose untill 500 mg/kg bw/day.
- Further dose did not show any beneficial effect




USF from PFAD as Fortificant

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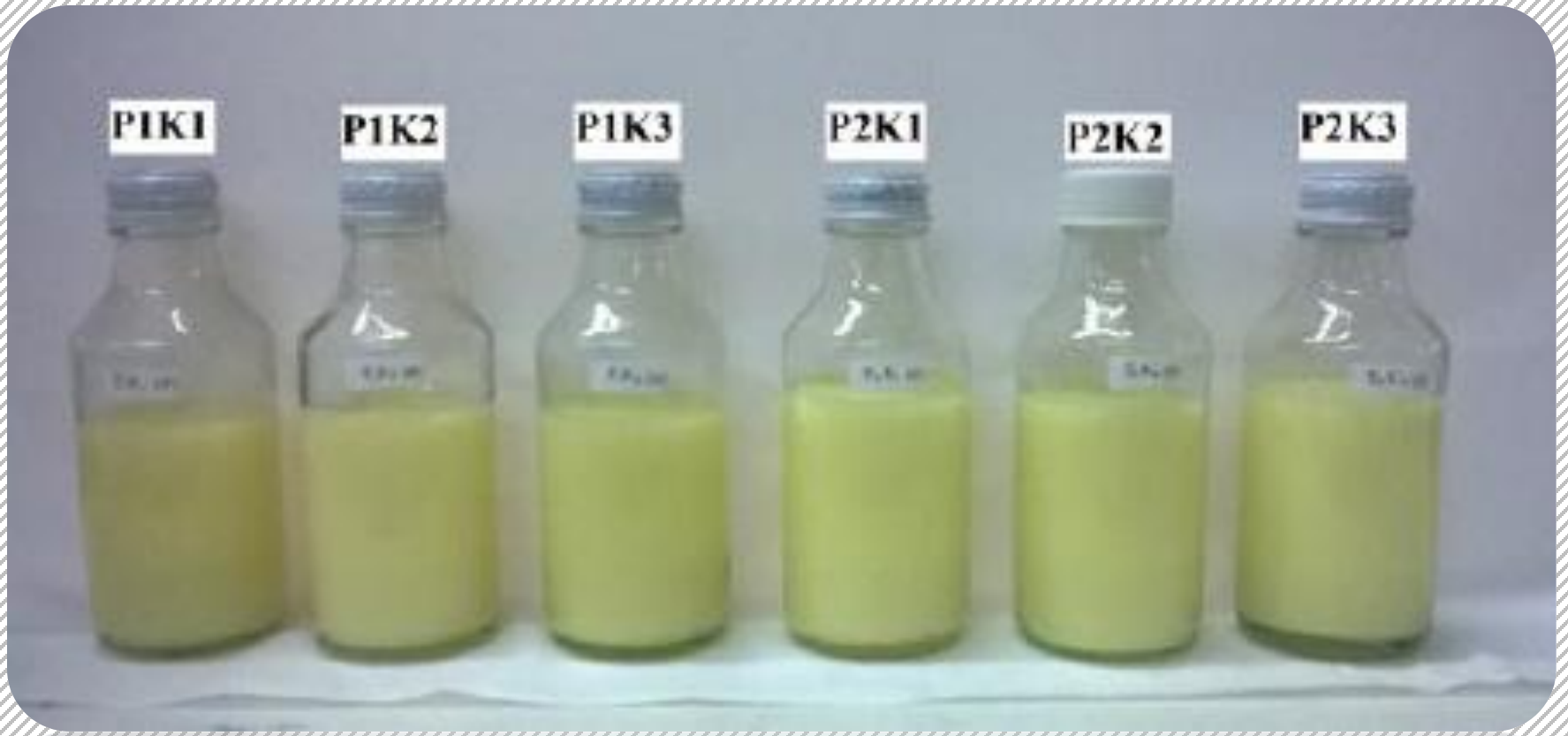
Microemulsion

Nanoemulsion



Microcapsule

Fortification USF Micremulsion into Instant Noodle

Fortification USF Micremulsion into Bread

Fortification of USF Microemulsion into Crackers

Fortification USF Microcapsule into Milk Powder

Direct USF Fortification into Bread

Direct USF Fortification into Biscuits

Direct Fortication of USF into Instant Noodles

0%

0.5%

1.0%

1.5%

2.0%

2.5%

Process Improvement

- **D**eodorization
  - Evication of health functions of USF fortified food products
    - Human studies on the effects of USF and USF fortified food products

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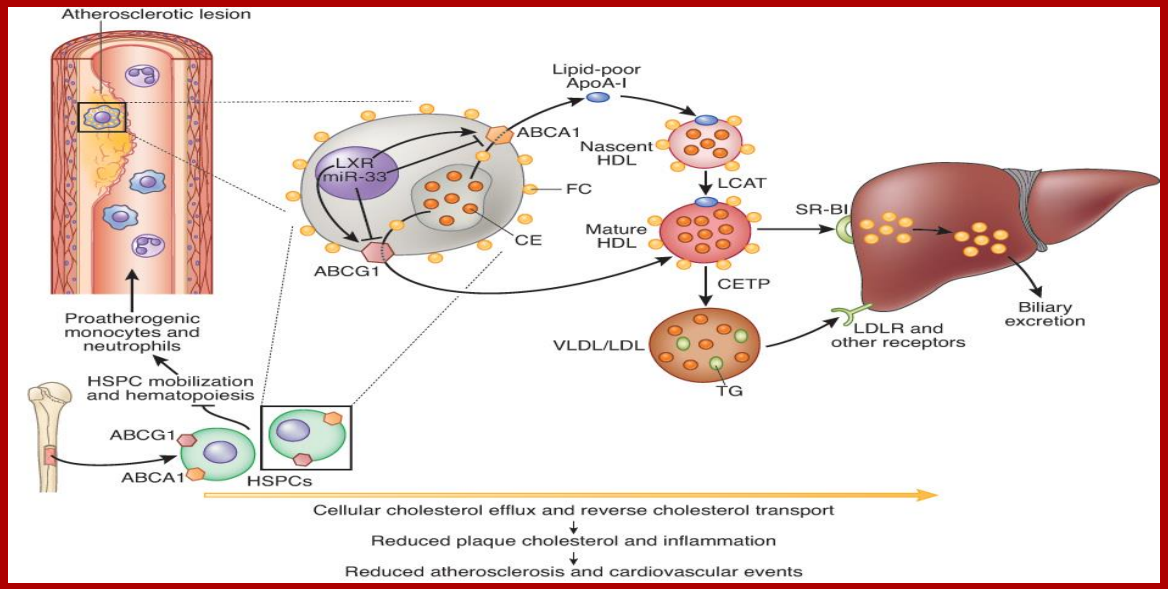

Developing of USF from PFAD as Supplement

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Tocotrienols Supplement Products

USD 29.95

USD 10.49

USD 43.000

USD 41.63

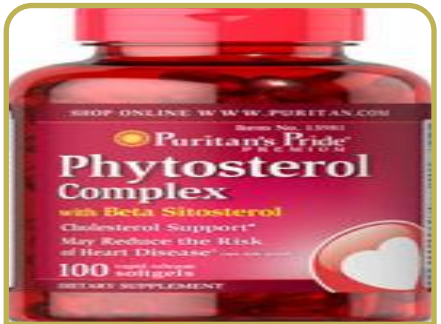
USD 45.00

USD 42.00

Phytosterols Supplement Products

$ 10.29

$ 19.99



$ 19.59

$ 20.00

Squalene Supplement Products

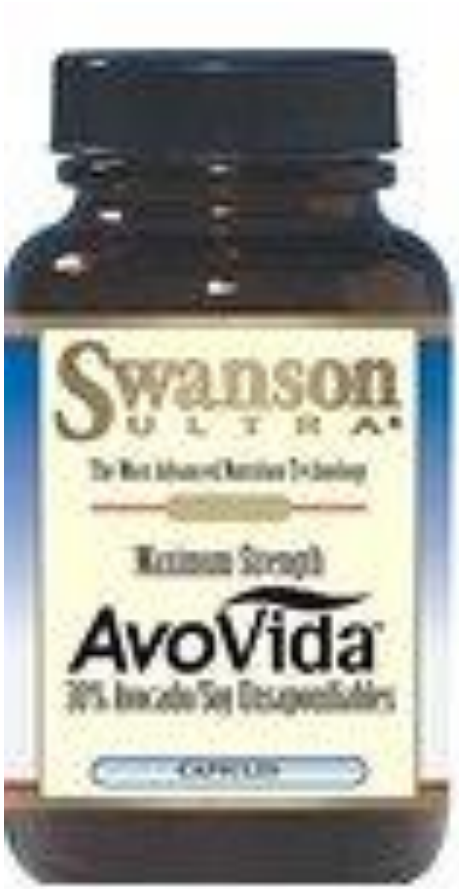
Rp. 170.000

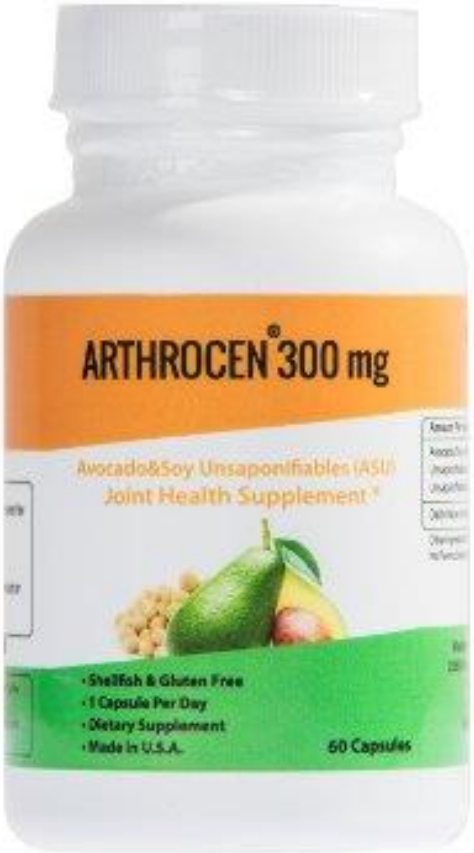
$ 44

NZ$ 43.39

$

Supplements Based Unsaponifiable Bioactive Compounds

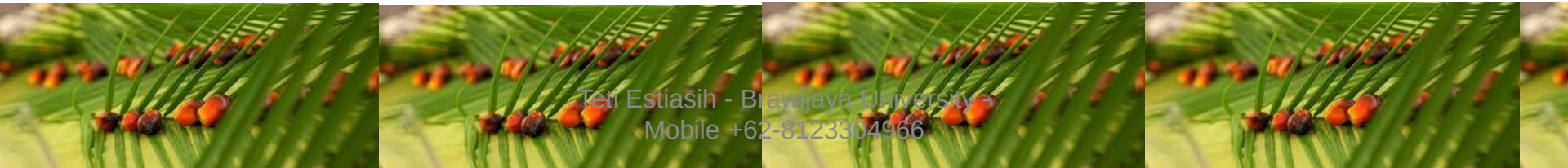




Tocotrienols Rich Fraction (Ahmadi *et al.*, 2012)

Table 1. Characteristics of palm fatty acid distillate (PFAD)and tocotrienol rich fraction (TRF)

Characteristics	PFAD	TRF
Free fatty acid (%)	85.10	not analyzed
Peroxide value (meq/kg)	0.27	not analyzed
Vitamin E concentration (ppm)	1313	230100
δtocotrienol (ppm)	84	312500
γtocotrienol (ppm)	505	206700
αtocotrienol (ppm)	279	107300
αtocopherol (ppm)	444	373800
Totaltocotrienol (ppm)	868	626500
Antioxidant activity (%)	22.83	81.51



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In Vivo Antioxidant Actvity of Tocotrienols Rich Fraction (Ahmadi *et al.*, 2012)

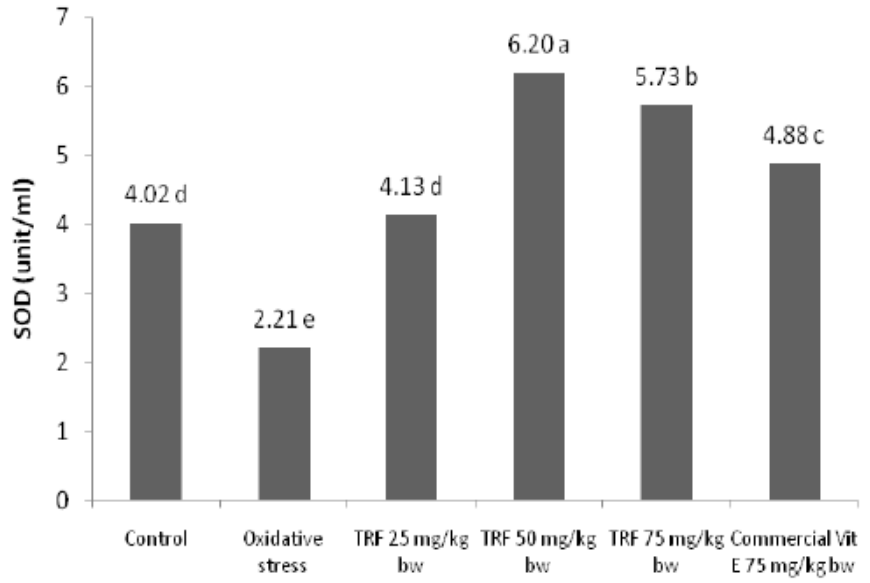


Figure 1. SOD activity of rat groups treated by TRF dose and commercial vitamin E

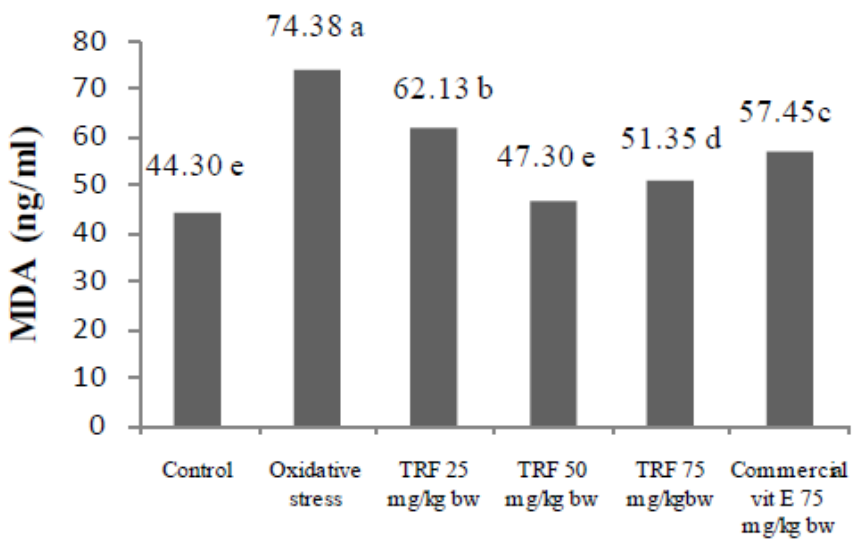
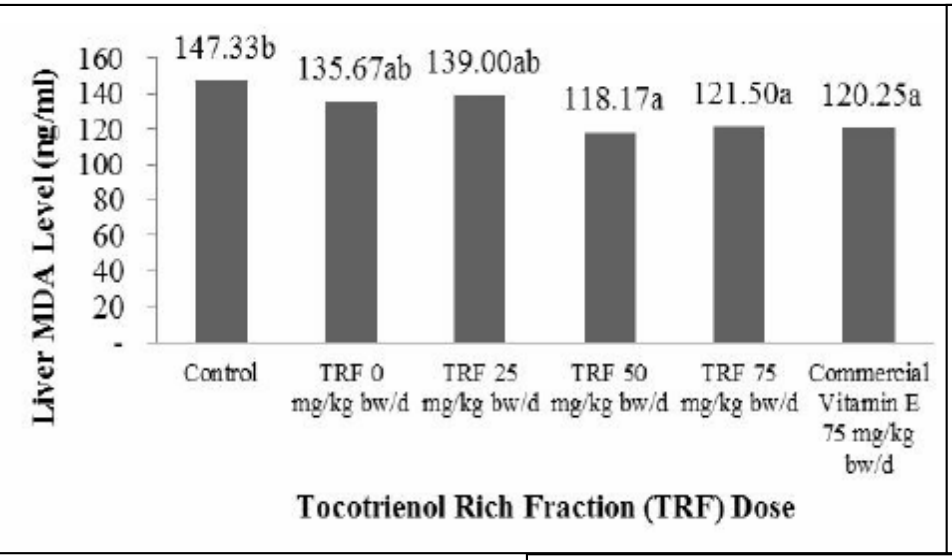
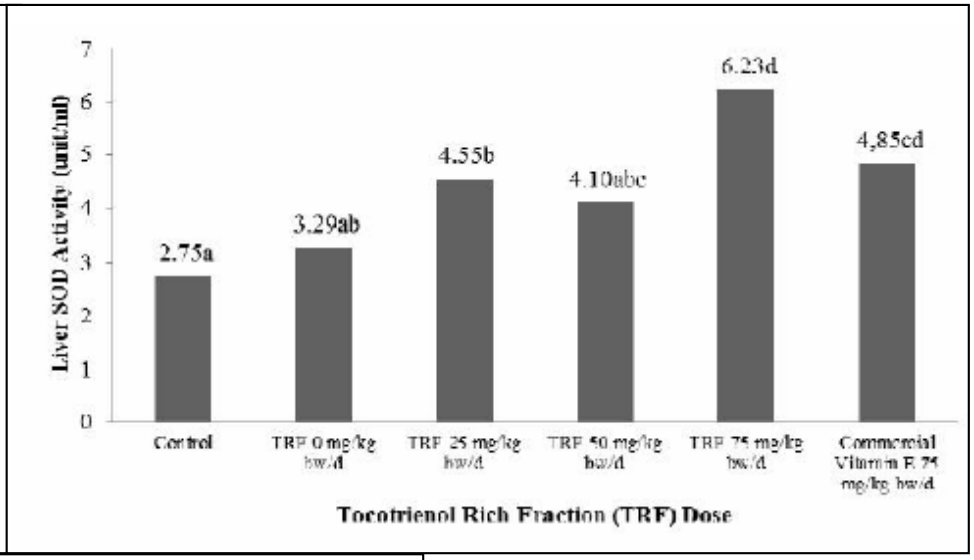
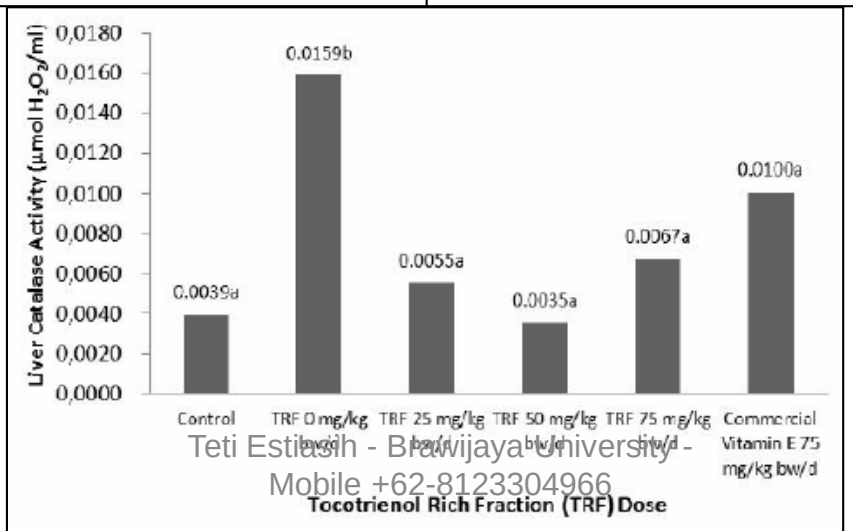


Figure 2. MDA level of groups of rats fed by various dose of TRF and commercial vitamin E

Hepatoprotective Effect of Tocotrienol Rich Fraction (Estiasih *et al.*, 2013)

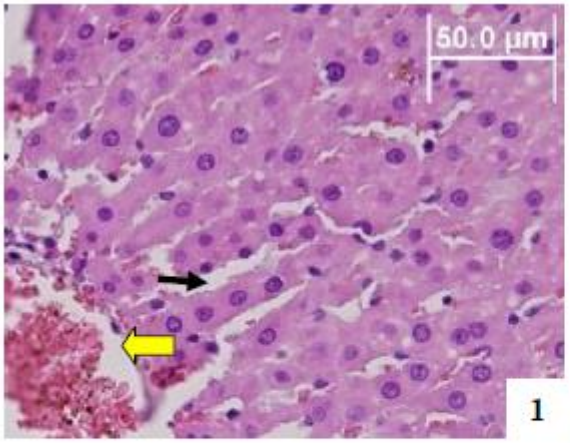


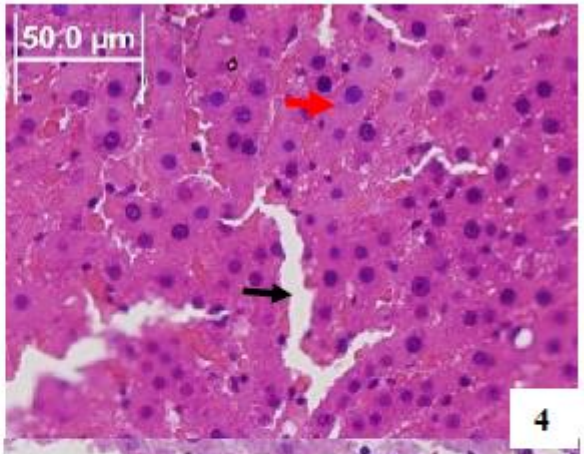


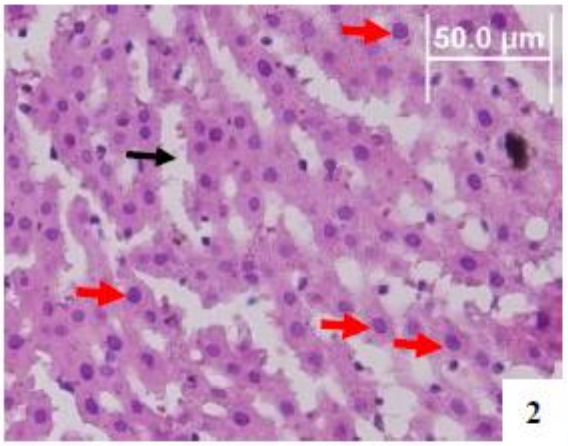


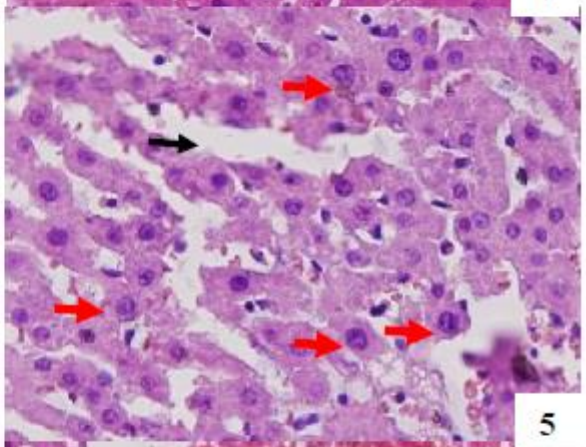
Histopathology of Liver

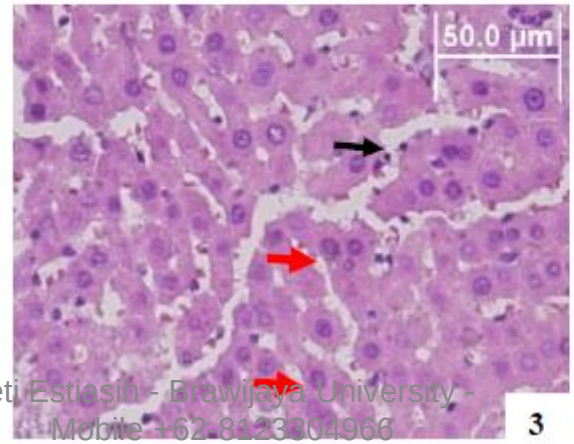
(Estiasih *et al*., 2013)











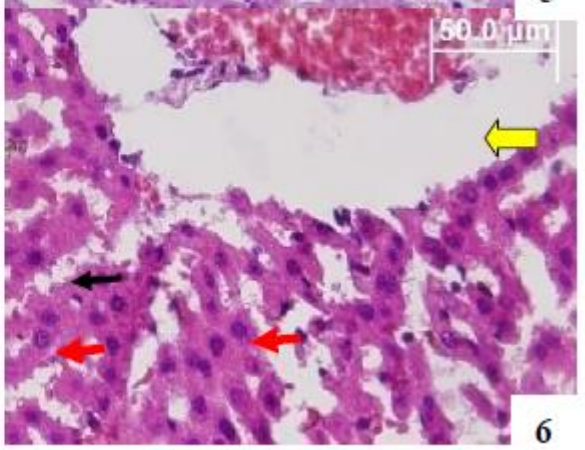
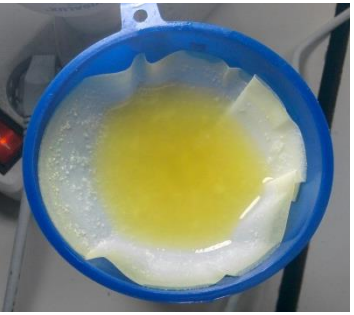
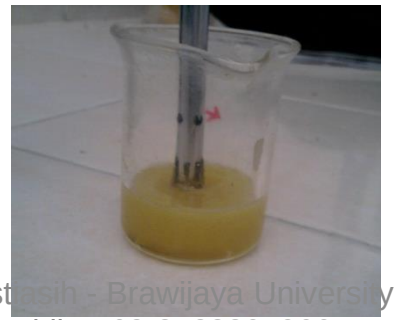


Figure 4. Histopathology of hepatic cells of rats treated by various doses of TRF and commercial vitamin E. Magnification of 400x and stained by hematoxyllin – (1) control, indicated normal cells; (2) TRF dose of 0 mg/kg bw/day, showed cell degeneration and dilated sinusoid in hepatic lobule; (3) TRF dose of 25 mg/kg bw/day showed normal cells arangement in hepatic lobule; (4) TRF dose of 50 mg/kg bw/day indicated normal cells but also contained cell degeneration; (5) TRF dose of 75 mg/kg bw/day showed dilated sinusoid at hepatic lobule and some cells were ballooning; (6) commercial vitamin E with dose of 75 mg/kg bw/day showed normal cells arrangement, but some cells were degeneration. = central vein; = sinusoid; = cell degeneration with ballooning nuclei and pale citoplasm (hydrophic degeneration).

Phytosterols Rich Fraction

- **P**repared from unsaponifiable fraction
  - **R**educe cholesterol level in hypercholesterolaemia condition





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PRODUK BERBASIS SAWIT

PALM OIL-BASED *TRANS*-FREE MARGARINE FORMULATIONS

Cake margarine

Filling with ease

Fluidized margarine

Soft margarine

Slab margarine

General purpose margarine

Pastry margarine

shortening

PALM OIL IN GHEE SUBSTITUTES (*TRANS*-FREE FAT VEGETABLE GHEE)

PALM OIL IN DAIRY PRODUCTS SUBSTITUTES

Evaporated Milk/Condensed Milk

Palm-based mozzarella analogue

Non-dairy Creamer/ Whiteners

PALM OIL IN DAIRY PRODUCTS SUBSTITUTES

Evaporated Milk/Condensed Milk

Palm-based mozzarella analogue

Non-dairy Creamer/ Whiteners

SPECIALTY FATS/CONFECTIONARY FATS

Penggunaan untuk Non Pangan

- Oleokimia (asam lemak, fatty alcohols, fatty amines, gliserol, dan metil ester)
- Deterjen dan surfaktan
- Sabun
- Lilin
- Pelumas
- Kosmetik
- Pelapis kaleng
- Bahan bakar diesel
- Plasticizer untuk plastik

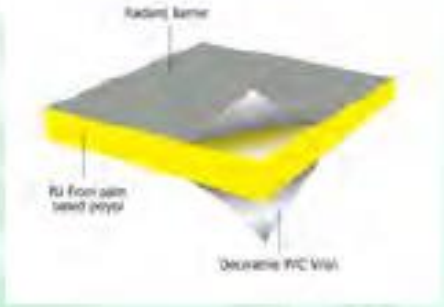
PALM OLEOCHEMICALS DOWNSTREAM PRODUCTS

MES-Based detergents/cleaning products

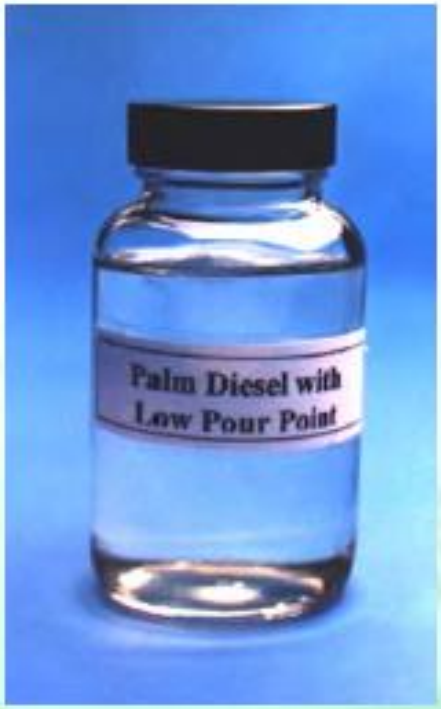
Transparent soap

Personal care products

POLYOLS – POLYURETHANES



PALM BIODIESEL



Summer-Grade Palm Biodiesel

Pour point +15° C

Winter-Grade Palm Biodiesel

Pour point –21° C

VALUE ADDITION THROUGH BIOMASS UTILIZATION

Abundance of Oil Palm Biomass

10% oil
90% biomass

OIL PALM FRONDS

FRESH FRUIT BUNCH

OIL PALM TRUNK

Crude Palm Oil

Biofuel / Biodiesel

Palm Biomass

Fuel for CHP

Palm oil mill effluent (POME)

Biogas

Thank You