Mitigation of 3-MCPDE & GE Precursors in Palm Oil Mill

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Presentation Outline

Sime Darby Plantation

1. **COMPANY PROFILE**
   - An Integrated Plantation Company

2. **PALM OIL MILLING PROCESS & CRUDE PALM OIL QUALITY**
   - Palm Oil Processing
   - Crude Palm Oil Composition
   - Crude Palm Oil Specification

3. **3-MCPDE & GE FORMATION & FACTORS**
   - Formation
   - Factors

4. **MITIGATION STRATEGIES**
   - Reduction of 3-MCPDE Precursor
   - Improvement of Oil Quality

5. **CONCLUSION**

Sime Darby Plantation

COMPANY PROFILE

- SIME DARBY PLANTATION
  An Integrated Plantation Company

Company Profile

Integrated Plantation Company

Upstream

Oil palm estate

Mill

Oil palm, rubber & sugarcane estates

- Developing, cultivating and managing oil palm, rubber and sugarcane plantation estates

Milling of FFB and processing & sales

- Milling of FFB into CPO and PK
- Processing and sales of rubber and sugarcane

Others

- Cattle rearing and beef production

Downstream

Refinery

Food application

Bulk and refined oils & fats

- Production and sales of refined oils and fats (which includes specialty and end-user oils and fats)

Oleochemicals, biodiesel products & derivatives

- Production and sales of oleochemicals, biodiesel products and derivatives

Others

High-yielding genome seeds

Renewables

R&D

- Focused on yield and productivity improvements, increasing revenue streams and developing sustainable practices while pursuing innovative strategies

Renewables business

- Development of green technology and renewable energy which includes bio-based chemicals, biogas and composting

Agribusiness

- Provision of agriculture products and services

Sime Darby Plantation

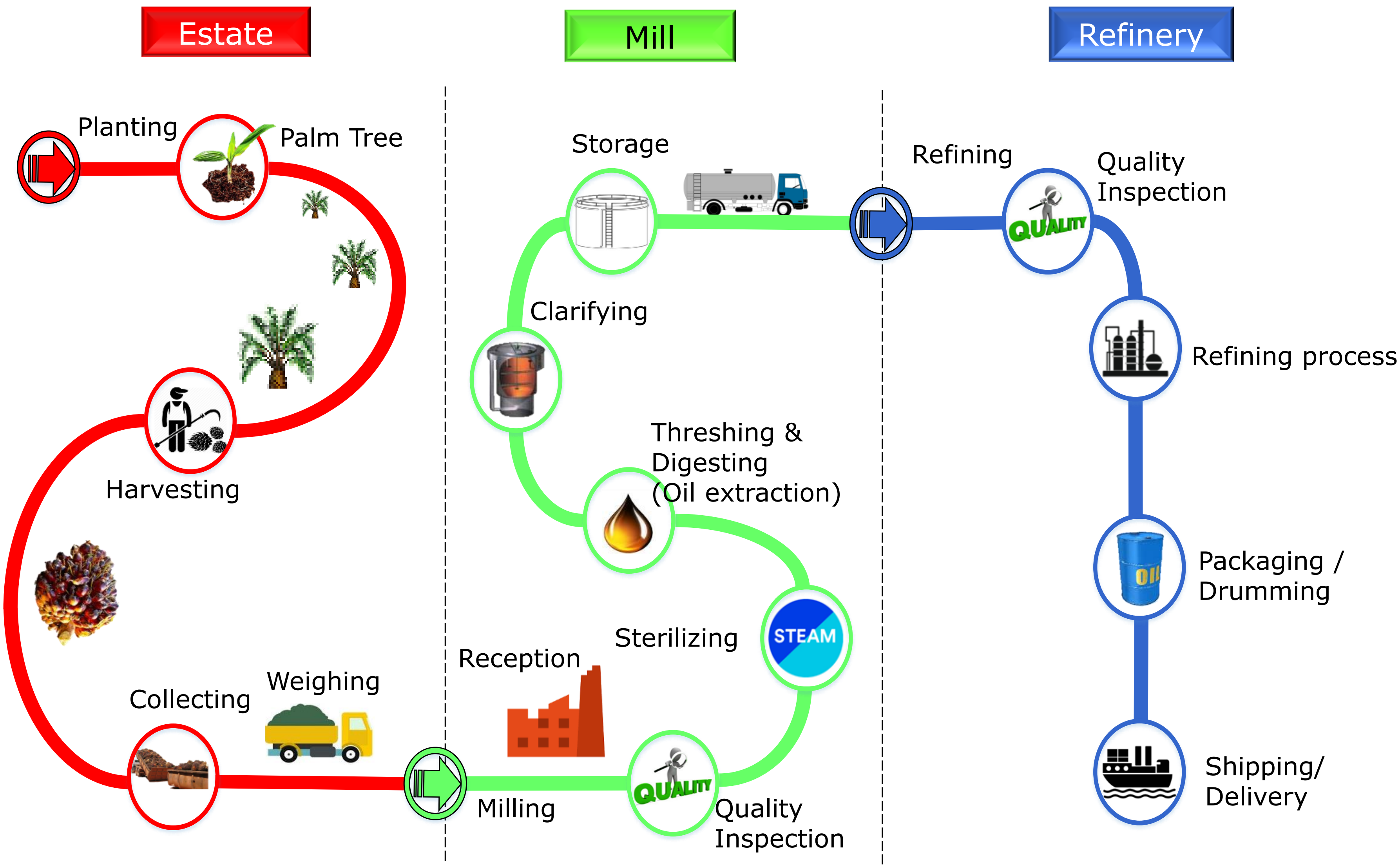
2

PALM OIL MILLING PROCESS & CRUDE PALM OIL QUALITY

- Palm Oil Processing
- Crude Palm Oil Composition
- Crude Palm Oil Specification

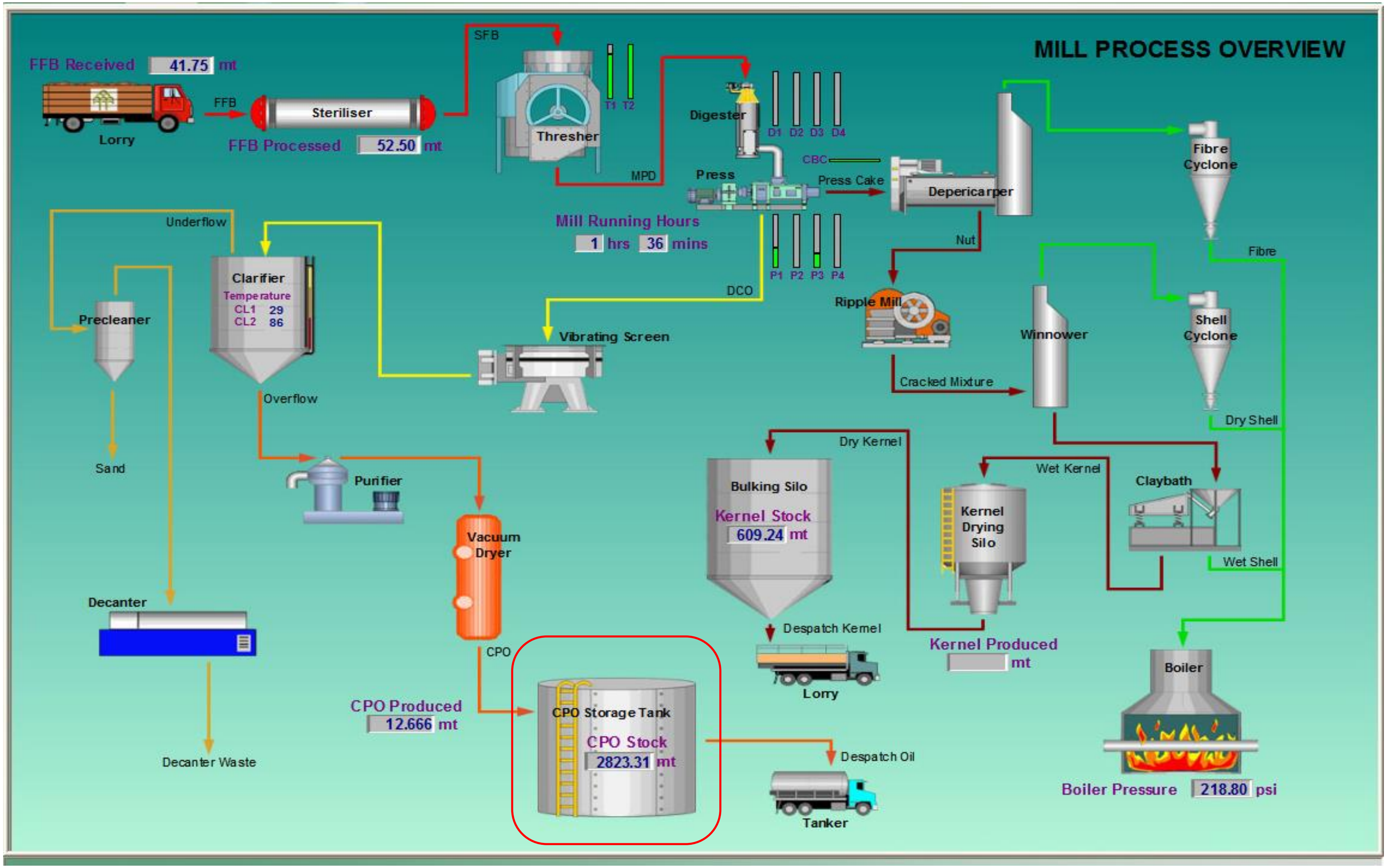
Palm Oil Milling Process & Crude Palm Oil Quality

Palm Oil Processing



Palm Oil Milling Process & Crude Palm Oil Quality

Palm Oil Processing



***Oil Extraction Rate (OER)** = 20-22%*

***Oil Losses** = 1.40-1.60%*

Palm Oil Milling Process & Crude Palm Oil Quality

Crude Palm Oil Composition

RISE APEX Sime Darby Plantation

01 **Tocopherols and tocotrienols, ppm**
500 - 1100

02 **Triacyclglycerol (TAG), %**
88 – 97

03 **Carotenoids, ppm**
400 - 800

04 **Diacyclglycerol (DAG), %**
3 – 7

05 **Phytosterols, ppm**
300 - 600

06 **Monoacyclglycerol (MAG), %**
0 – 1

07 **Squalene, ppm**
200 - 500

08 **Free fatty acid (FFA), %**
1 – 5

09 **Phospholipids, ppm**
3 - 140

10 **Moistures Solid & Impurities, %**
0.08 – 0.24

11 **Metals, Copper and Iron, ppm**
1 – 10

Palm Oil Milling Process & Crude Palm Oil Quality

Crude Palm Oil Specification

PORAM Specifications

Characteristics,
Quality Guideline

	Characteristic	Quality Guideline
01	Free fatty acid (as palmitic), % max	5.0
02	Moisture & impurities, % max	0.25
03	Degree of Bleachability Index (DOBI), min	2.3
04	*Chlorine, ppm max	2.0
05	**Phosphorus, ppm max	10.0

* *Additional quality requirement for CPO by January 2020 but was* ***deferred until further notice****.*

** *Proposed as guideline.*

Palm Oil Milling Process & Crude Palm Oil Quality

Crude Palm Oil Specification

Rising concern by the food safety authority on the presence of common probable carcinogenic food contaminants in edible oil.

Joint FAO/WHO Expert Committee on Food Additives (JECFA) proposed Provisional Maximum Tolerable Daily Intake (PMTDI) of 4 µg/kg body weight for 3-MCPDEs, either single or in combination with the GEs[2,3].

Studies found that refined palm oil contains the highest amount of 3-MCPDEs and GEs[17].

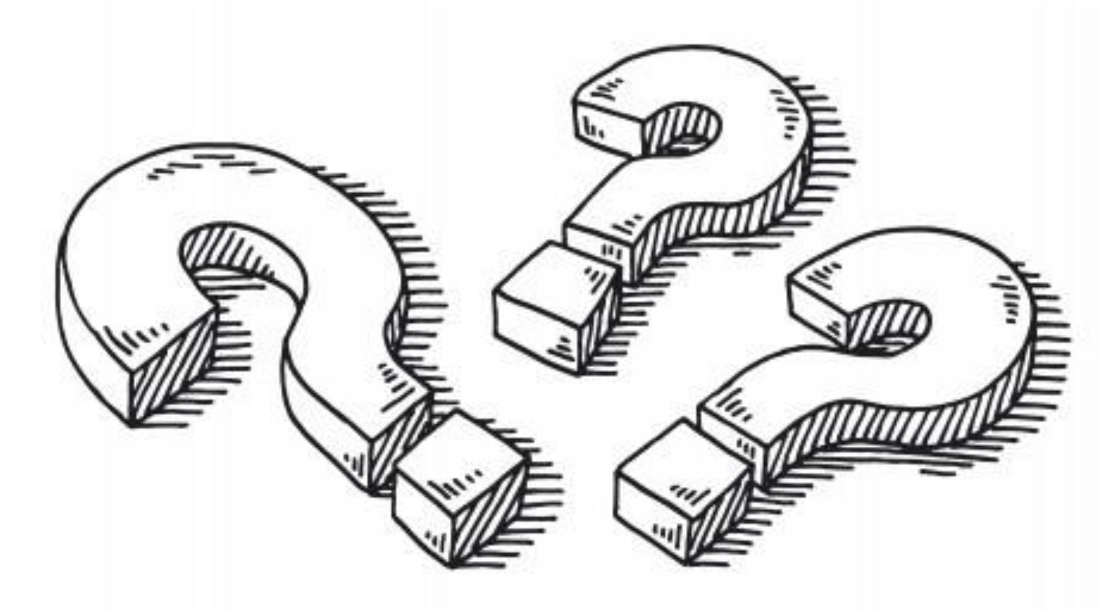
European Food Safety Authority (EFSA) proposed Tolerable Daily Intake (TDI) limit of 0.8 µg/kg body weight for 3-MCPDE[1].

From 2021, EFSA proposed to limit the presence this food contaminants in edible oil[1]:-

- 3-MCPDEs (< 1.25 ppm for soft oil and 2.5 ppm for palm oil)
- GEs (< 1 ppm)

Palm Oil Milling Process & Crude Palm Oil Quality

Crude Palm Oil Composition



How can we mitigate this issue at palm oil mill?

3-MCPDE & GE
FORMATION & FACTORS

a macroscopic perspective

- Formation
- Factors

3-MCPDE & GE Formation & Factors

Formation

- Only presence in refined oil and **not presence** in CPO[4].
- Formed during the CPO refining process at temperature of more than 200°C - deodorisation process[5].
- 3-MCPDE & GE formation – through oils as DAG or MAG via acyloxonium ions as intermediates in presence of heat[6,7].
- 3-MCPDE formation– **with** present of chlorine.
- GE formation – **without** present of chlorine

3-MCPDE & GE Formation & Factors

Factors

3-MCPDE [6,8,9,10]

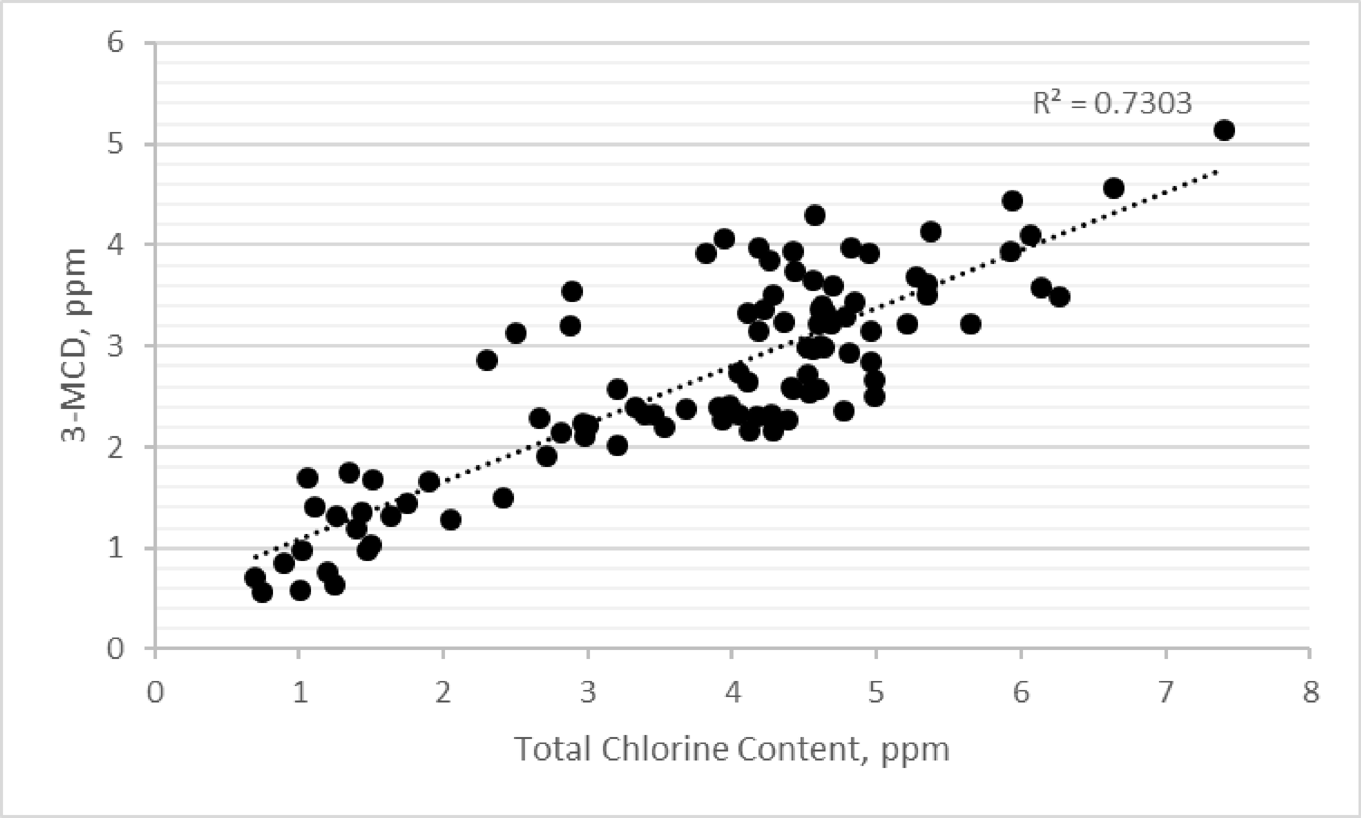
- Precursor :
  Chlorine, TAG, DAG, MAG
- Temperature
- Heating Time
- FFA, pH?

GE [5,11,12,13]

- Precursor : **DAG**, MAG
- Temperature
- Heating Time

3-MCPDE & GE Formation & Factors

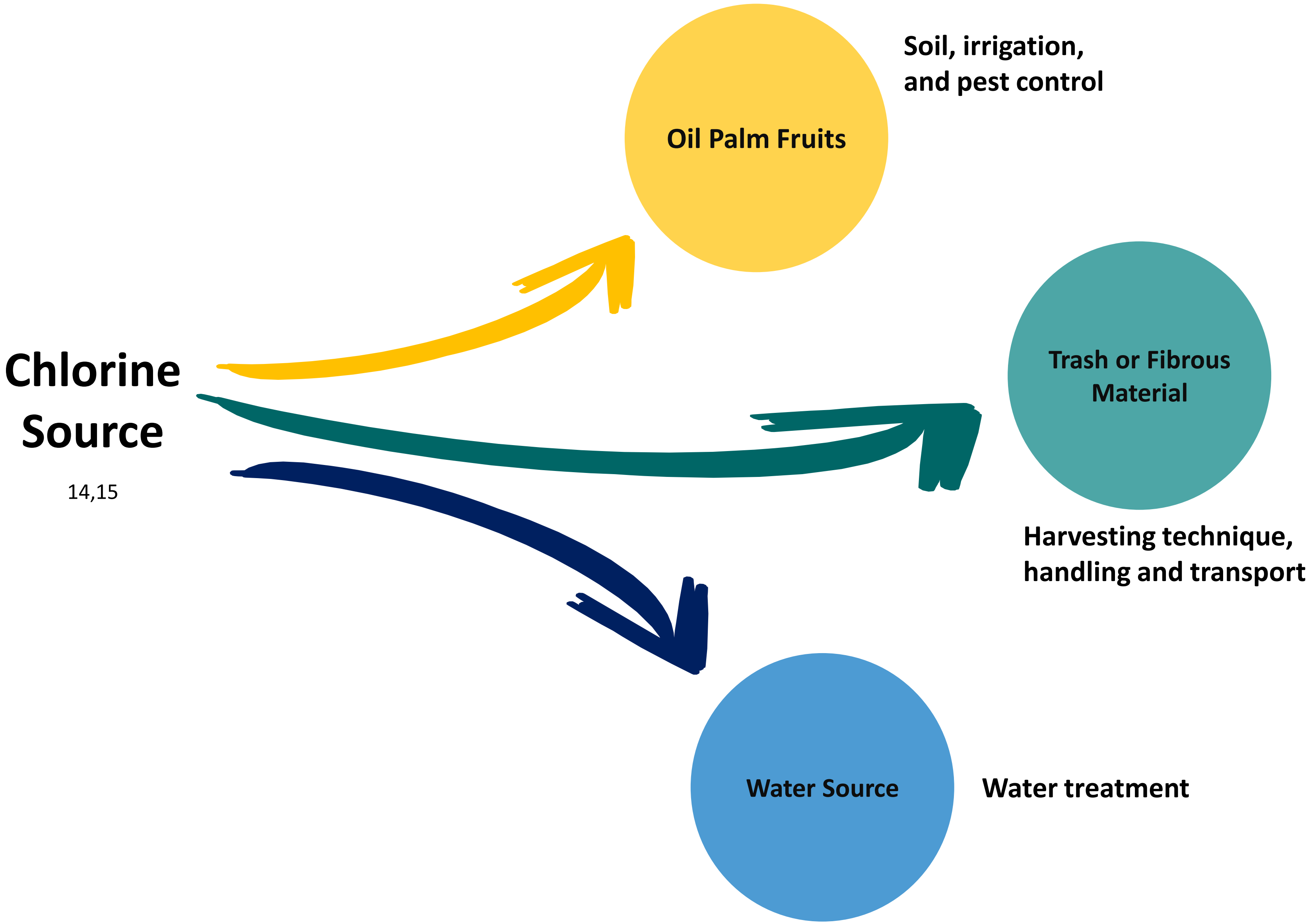
3-MCPDE Factors



Correlation of 3-MCPDE and Chlorine content[14]

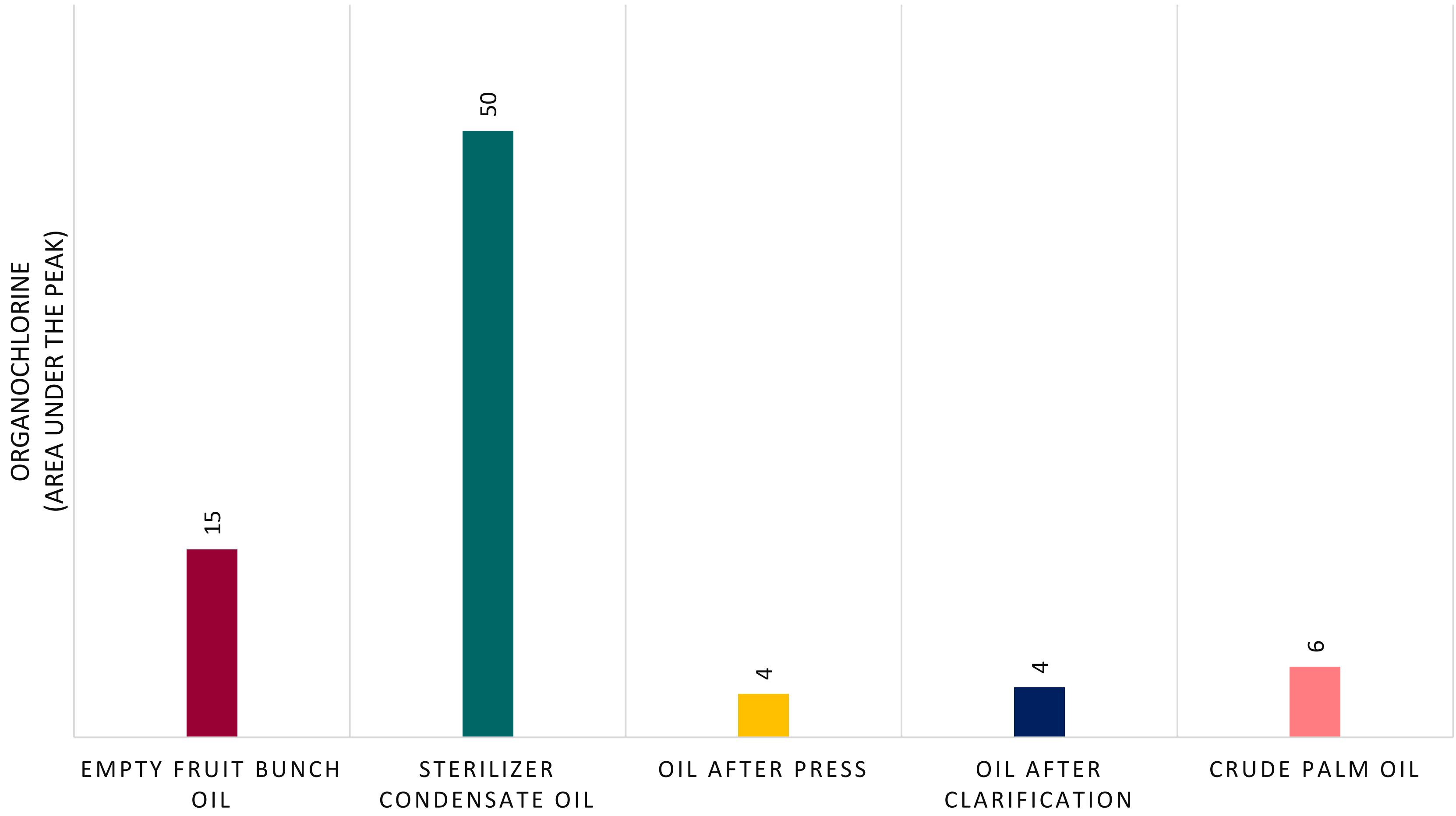
3-MCPDE & GE Formation & Factors

3-MCPDE Factors



3-MCPDE & GE Formation & Factors

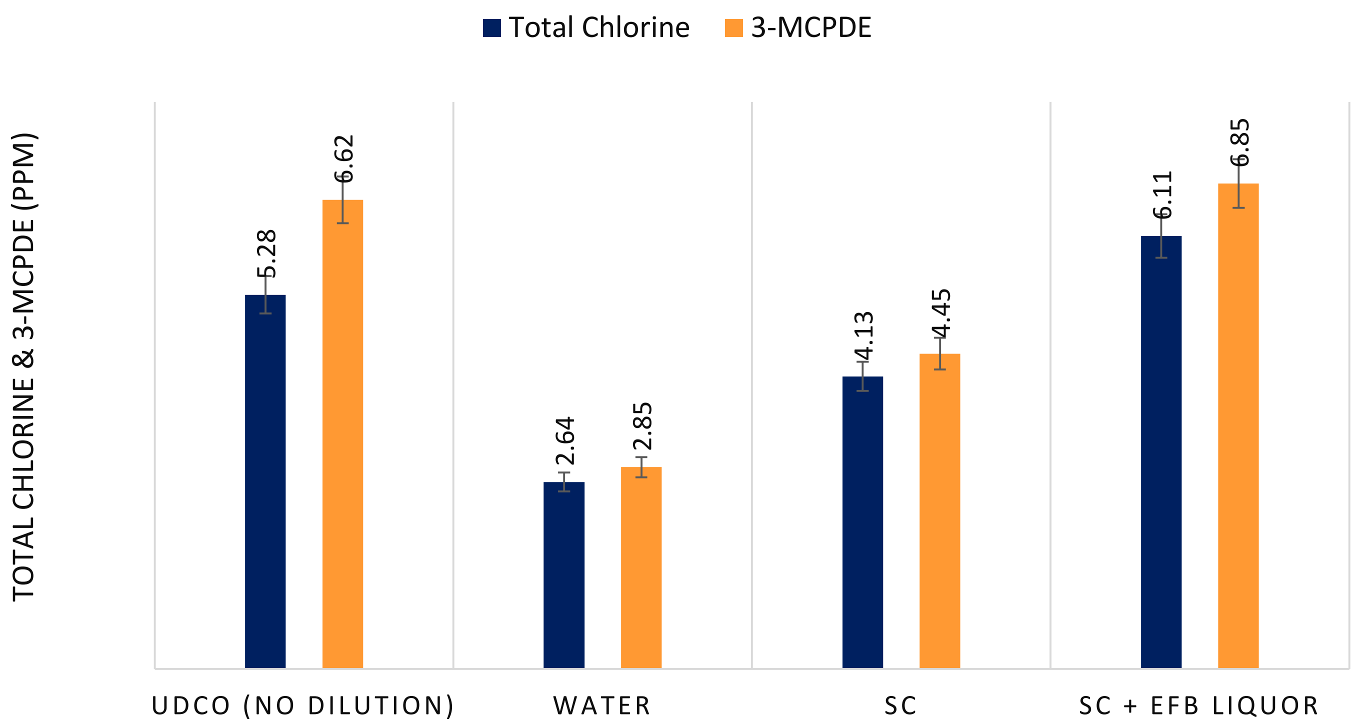
3-MCDPE Factors



- Sphingolipid organochlorine content in palm oil during palm oil milling process

3-MCPDE & GE Formation & Factors

3-MCDPE Factors

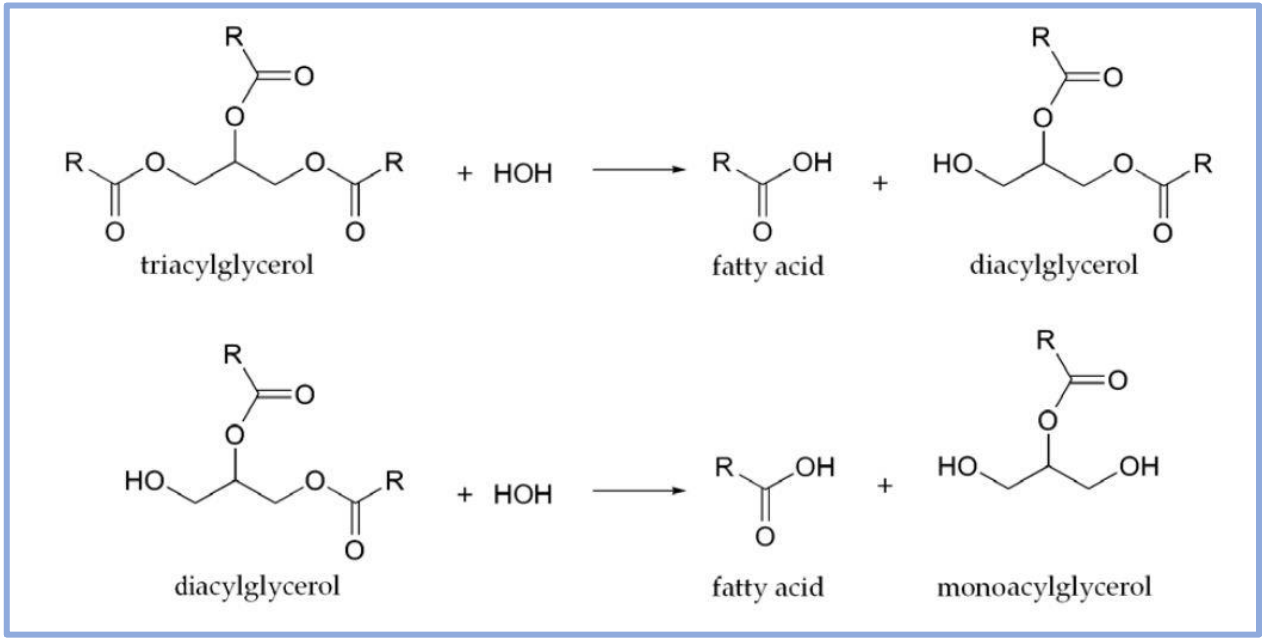


- Total Chlorine and 3-MCPD content in CPO and its refined oil respectively for types of dilution water used

3-MCPDE & GE Formation & Factors

GE Factors

DAG formed during oil hydrolysis releasing FFA with the presence of water.



Hydrolysis reaction of vegetable oil[16]

3-MCPDE & GE Formation & Factors

GE Factors

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Enzymatic Hydrolysis

Due to:

- Presence of **lipase enzymes on fruit surface.**
  - Release when the fruits are **bruised.**
- Presence of **lipolytic micro-organism.**
- **Need Moisture** and **Temperature**
  - Lipase enzymes are inactivated at **temperature** of above 50°C.

Before heat treatment (sterilisation)

Autocatalytic Hydrolysis

Depends on:

- **Moisture Content.**
  - VM high-FFA high.
- **Initial FFA.**
  - High FFA content-Faster FFA formation.
- **Temperature.**
  - Storage Tank , Temp high-FFA high.
- **Time/Period of Oil Storage.**
  - Long time-FFA high.

Before & after heat treatment (sterilisation)

- Controlling the CPO FFA, controls the level of DAG

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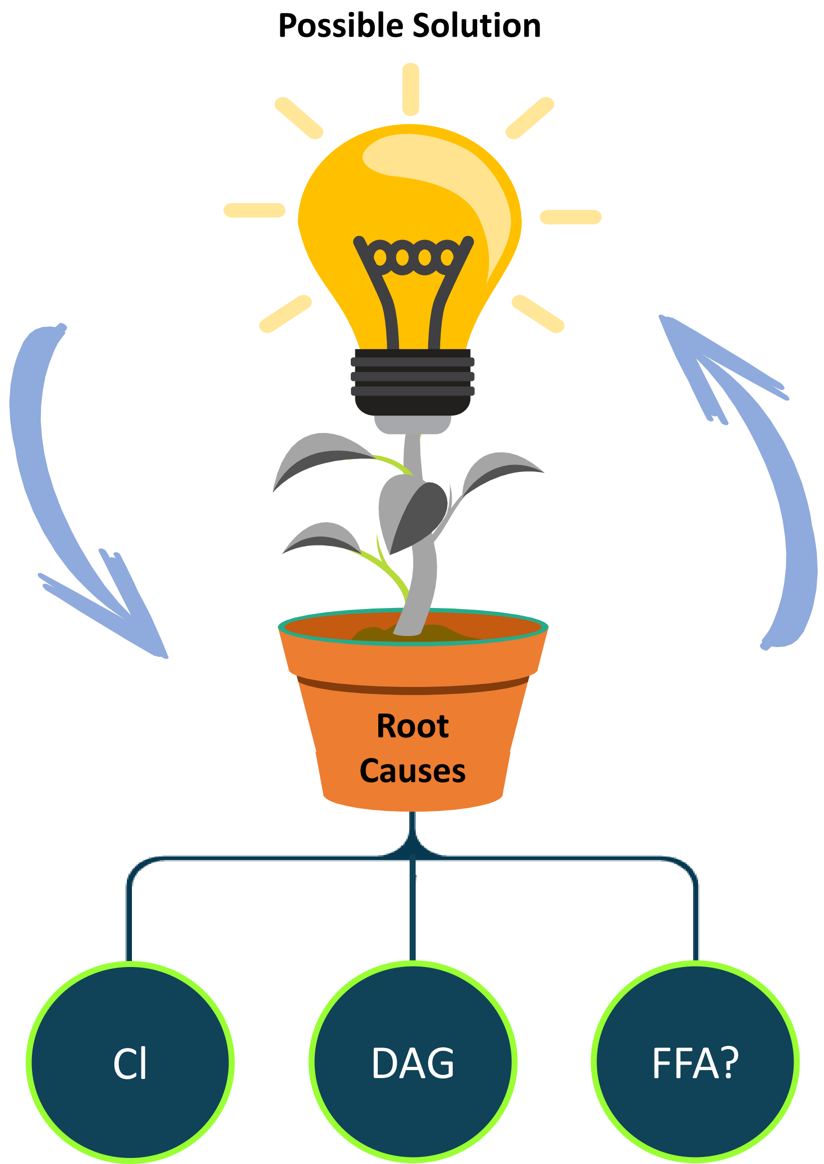
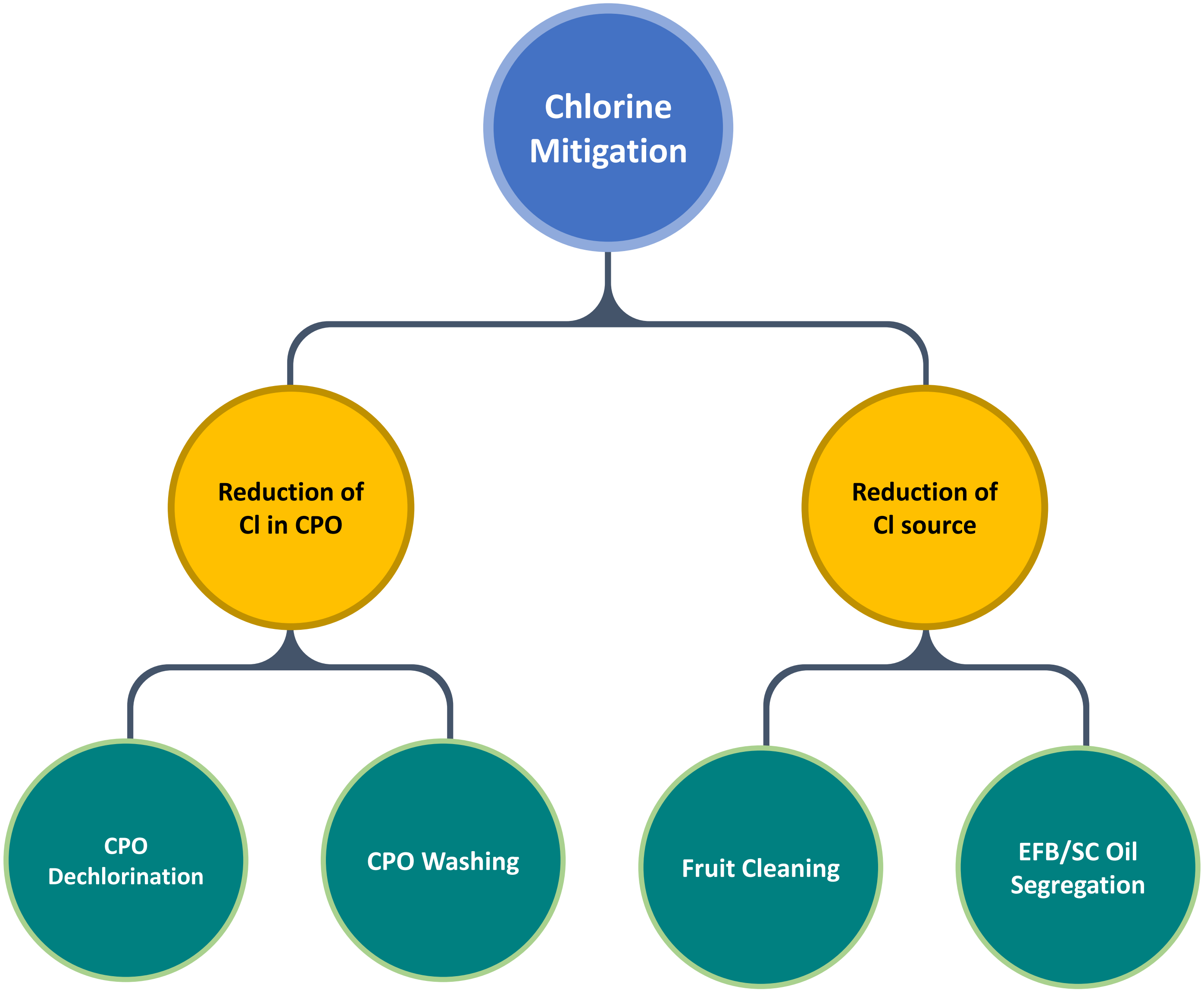
MITIGATION STRATEGIES

- Reduction of 3-MCPDE Precursor
- Improvement of Oil Quality

Mitigation Strategies



Mitigation Strategies



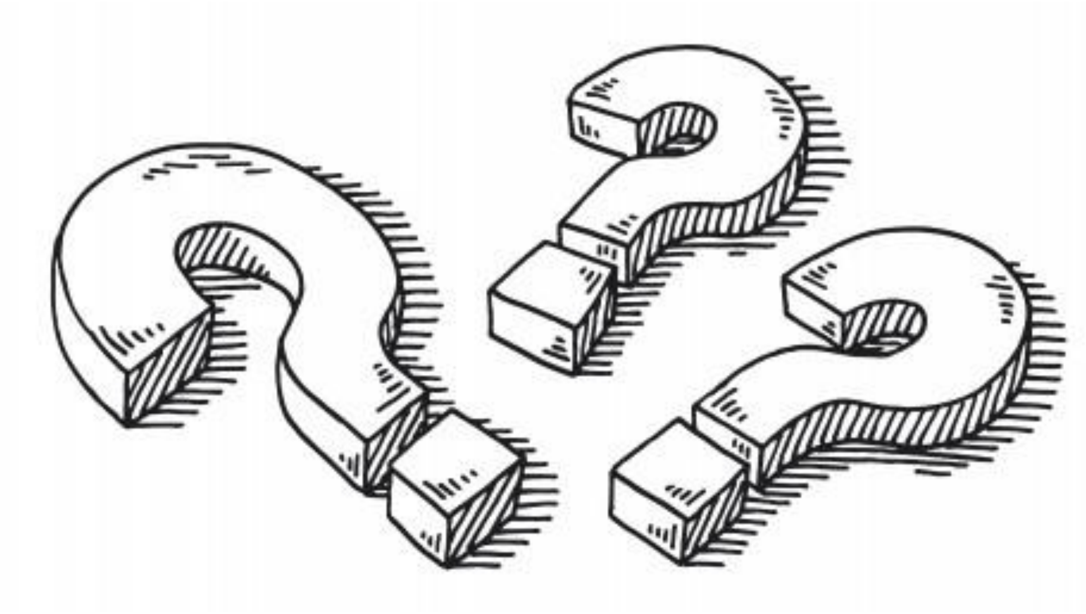
Mitigation Strategies

Reduction of 3-MCPDE precursor, Chlorine

Initiatives	Description	Pros	Cons
Palm fruits cleaning	• Dry & wet cleaning system. • Removing the precursors sources of 3-MCPDE.	• High removal of trash content. • Reduction in TC up to 30%. • Reduction of FFA by 40%	• High CAPEX. • High maintenance cost. • High water usage.
Secondary oil segregation	• No restreaming of SC and EFB oil. • Main product – Clean CPO • Secondary product - TGO	• Reduction of TC by 30%. • Clean CPO with better oil quality and stability	• High oil loss in waste stream.
CPO washing	• Water washing of CPO. • Before vacuum dryer. • Pilot/ commercial scale	• Reduction in TC up to 80%.	• High CAPEX. • Additional wastewater.
CPO Dechlorination	• Application of sodium metabisulfite (SMBS). • Followed by filtration.	• Reduction in TC up to below 2 ppm.	• High SMBS cost • Oil loss in spent SMBS.

Mitigation Strategies

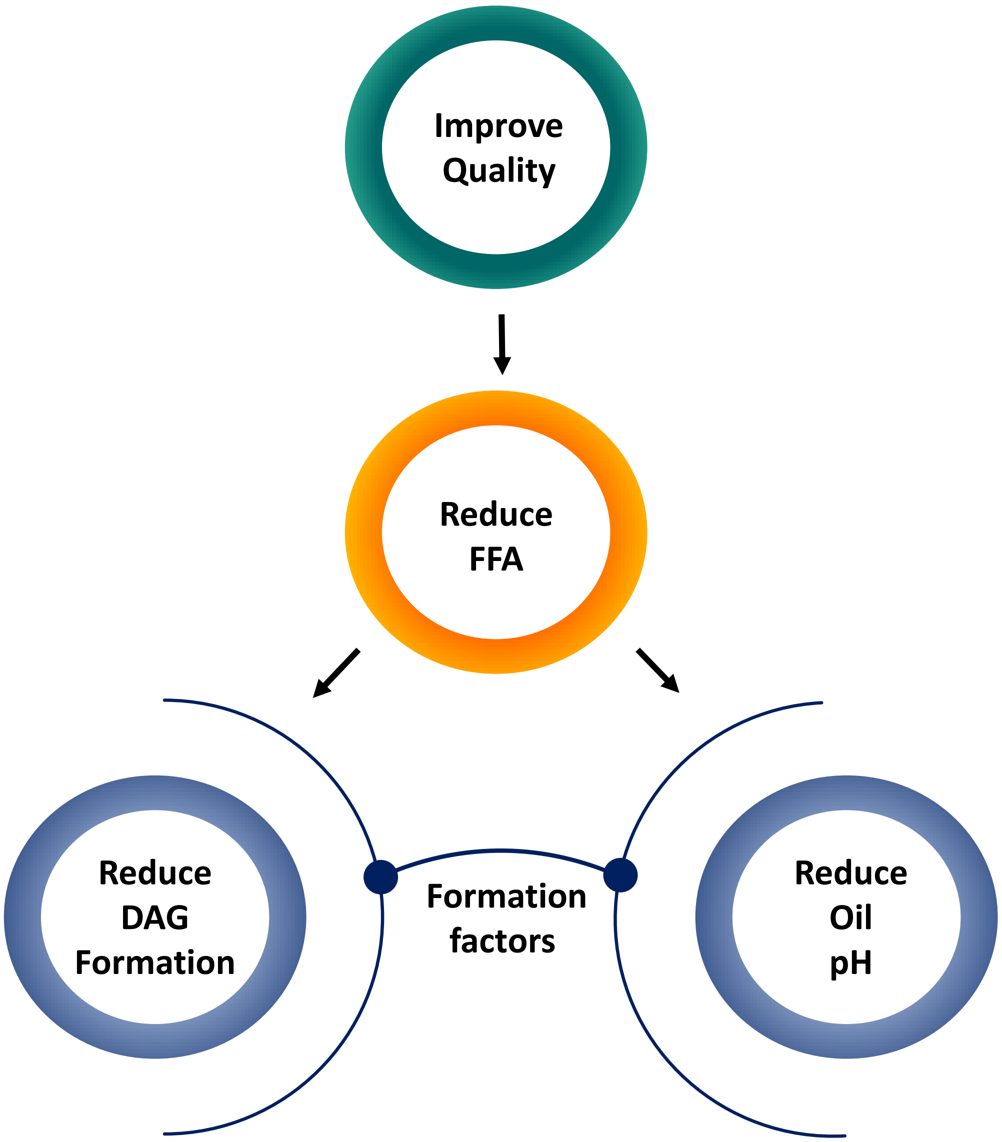
Improvement of Oil Quality



How does improving the oil quality helps to mitigate 3-MCPDE & GE?

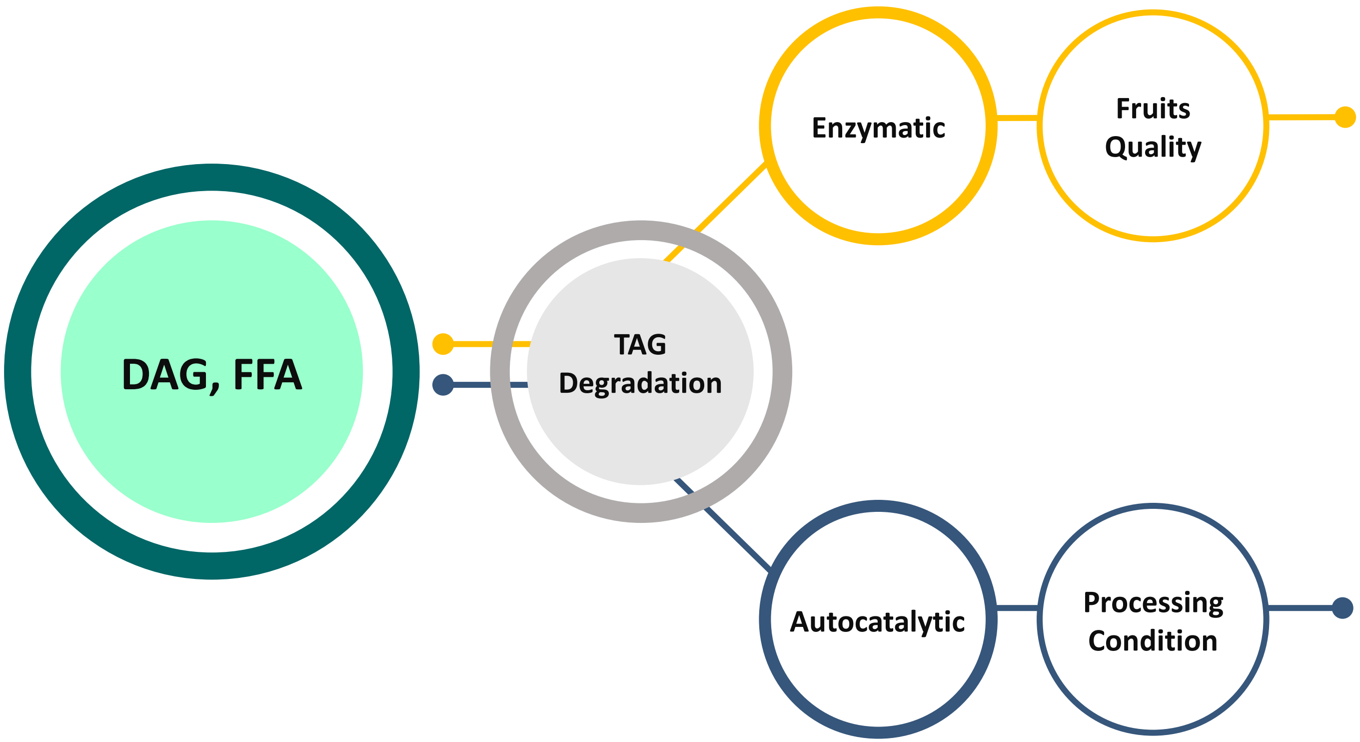
Mitigation Strategies

Improvement of Oil Quality



Mitigation Strategies

Improvement of Oil Quality



1. Fruits Handling
2. Harvesting Interval
3. Fruits Freshness

1. Processing Time
2. Oil Segregation
3. Moisture Content

Mitigation Strategies

Improvement of Oil Quality

Sample type	CPO (n =60)		RBDPO (n=30)	
	FFA	TC	3-MCPDE	GE
Standard CPO	<5%	4.06 (1.13-6.02)	3.03 (2.16-4.39)	4.56 (3.21-6.87)
Superior CPO	<1.5%	2.11 (0.99-2.72)	1.97 (1.05-2.84)	3.28 (2.51-3.88)
Premium CPO	<1.2%	1.77 (0.71-2.02)	1.25 (0.48-1.85)	1.61 (1.43-2.25)

- The above data was collected based on commercial physical refining route.
- Lower contaminants were observed through chemical refining route.

Mitigation Strategies

Improvement of Oil Quality

Plantation

1. Optimise HI
2. Reduce Handling
3. Minimise Trash content
4. Fast evacuation

Palm oil mill

1. No secondary oil recovery
2. Immediate processing
3. Minimise CPO in storage tank

Palm oil refinery

1. Refinery process modification

Conclusion

Sime Darby Plantation

01 — 3-MCPDE & GE only form in refinery at high heat. Not presence in CPO.

02 — Precursors for are 3-MCPDE Cl & DAG, while GE is DAG.

03 — Mitigation is proposed to start from estate an mill followed by refining process improvement.

04 — Collective effort from planter, miller and refiner to mitigate this process contamination issue.

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