

# Research on oil palm biotechnology and breeding - an introduction for chemical engineers

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Monash University



# PRESENTATION OUTLINE

Oil Palm Processing

Oil Palm Germplasm

Oil Palm Breeding

Biotechnology - Clonal propagation

Biotechnology – Genetic Modification

Conclusions

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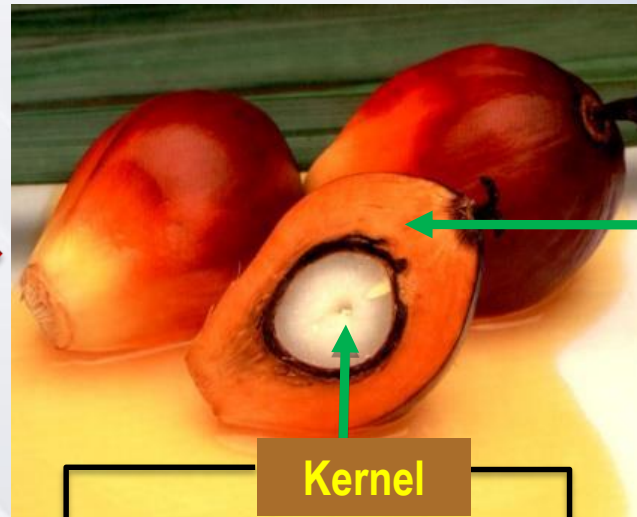
Biotechnology – Genetic Modification

Conclusions

### Fresh Fruit Bunch (FFB)



### Oil Palm Fruits



**Mesocarp**

Crude Palm Oil (CPO)  
**4 t/ha/yr**

**Kernel**

Palm Kernel Oil (PKO)  
**0.5 t/ha/yr**

Palm Kernel Cake (PKC)  
**0.5 t/ha/yr**



# Physical Refining Process



**Crude Palm Oil**



80°C – 90°C

**Degumming**



90°C – 120°C

**Bleaching**



**Filtration**



**RBD Palm Oil**



180°C – 260°C under vacuum

**Deacidification & deodorization**



**Bleached Palm Oil**



# Fractionation Process



RBD Palm Oil



Fractionation Process (physical process)



RBD Palm Kernel Oil



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- ◆ Starting from 4 seedlings from Deli Dura
- ◆ To broader genetic based - collect palms: many sites & wider range of environments

# Seed Producers in Malaysia

Seed Producers	<i>Dura</i> parent	<i>Pisifera</i> parent
1.	Deli <i>dura</i>	Yangambi <b>Congo</b>
2.	Deli <i>dura</i>	URT
3.	Deli <i>dura</i>	AVROS
4.	Deli <i>dura</i>	Dumpy AVROS
5.	Deli <i>dura</i>	Dumpy AVROS-Yangambi
6.	Deli <i>dura</i>	Yangambi derived
7.	Deli <i>dura</i>	AVROS
8.	Deli <i>dura</i>	AVROS
9.	Deli <i>dura</i>	AVROS
10.	Deli <i>dura</i>	AVROS
11.	Deli <i>dura</i>	AVROS
12.	Deli <i>dura</i>	AVROS
13.	Deli <i>dura</i>	AVROS
14.	Deli <i>dura</i>	AVROS
15.	Deli <i>dura</i>	AVROS
16.	Deli <i>dura</i>	AVROS

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# MPOB STRATEGIES FOR CROP IMPROVEMENT

## STRATEGY 1:

Enhance Productivity Upstream

Producing High Yielding Planting Material

**Breeding**

Seed-derived  
Tissue-culture

Genome Programme (Non-GM)

**Biotechnology** (Vir)

Fatty Acid Composition

TC Conformity

Plant Height

Ganoderma Tolerance

## STRATEGY 9:

Enhance Value Downstream:  
Food, Phytonutrients & Oleochemicals

GM-OP

**Biotechnology**

Fatty Acid Composition

Nutra/Pharmaceutical

# BREEDING STRATEGIES

**Germplasm Collection**



**Oleifera/  
hybrid &  
backcross**

**Broaden the  
Genetic base**

**Introgress**



**Improved  
Planting  
Materials**



**Tissue  
Culture**

**Production/imp  
rovement in  
solid culture**

**Fast track  
breeding  
programme**

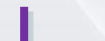
**Innovative  
technologies**

**Quality Control  
(Biomarker discovery)**

- ◆ Epigenome
- ◆ Organellar (mtDNA)
- ◆ Proteomics/Metabolomics

**MAS**

**Molecular breeding:  
Genomics-based breeding**



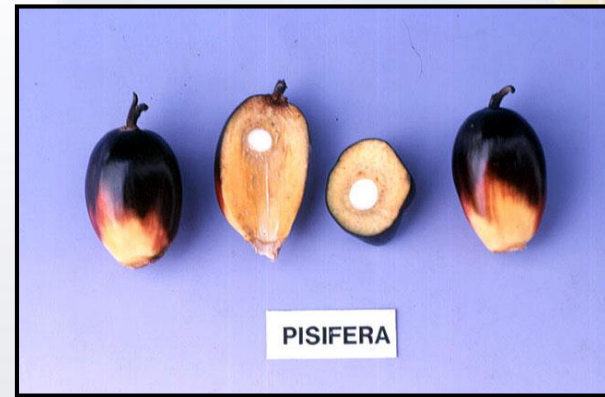
# Genetics of Oil Palm (DxP) Seed Production



***Dura***  
**(SH<sup>+</sup> SH<sup>+</sup>)**

Homozygous wild type

**X**



***Pisifera***  
**(Sh<sup>-</sup>Sh<sup>-</sup>)**

Homozygous mutant



***Tenera*** (SH<sup>+</sup>Sh<sup>-</sup>)  
Heterozygous co-dominant





# Deli *Dura* Improvement Programme



# AVROS *Pisifera* Improvement Programme





# D x P Progeny Test Result

## PS 1: SHORT PALM - NGA

- **Slow height increment**

**PS1: 20 – 45 cm/yr**

**Current DxP: 40-75 cm**

- **High FFB yield**

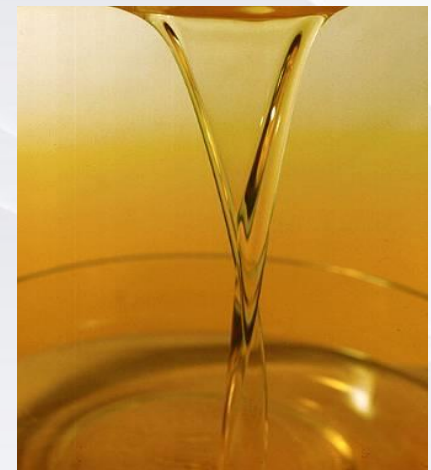
**30 – 33t/ha/yr**



- **O/B >25%**

# PS 2: HIGH IODINE VALUE

- For a more unsaturated and liquid palm oil
- Iodine value  
**PS2: > 60**  
**Current DxP: 50-53**



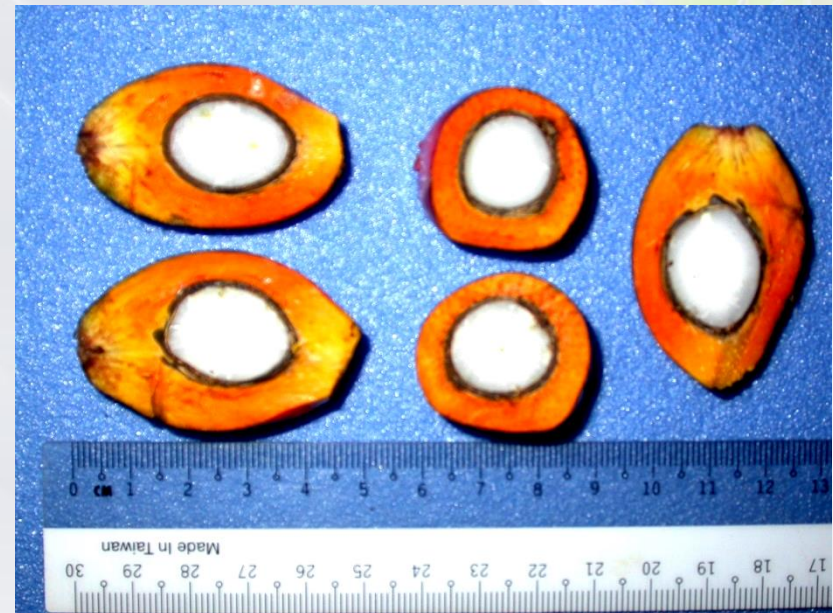


- important for lauric acid
- K/B

**PS3: 2.6-15.3%**

**Current DxP:5-7%**

- Individual performance  
K/F>16%, FFB>160,  
OY>20kg



# PS4 & 11 HIGH CAROTENE *E. oleifera* & *E. guineensis*



- Important source of Vitamin A

- Carotene content - *oleifera*

**PS4: > 3000 ppm, IV-80**

**Current DxP: 500 – 700 ppm, IV- 50-53**

- Carotene content - *guineensis*

**PS11: > 2000ppm**

**Commercial DxP : 500 – 700ppm**

**FFB >28t/ha/yr**





•S/F

**PS5: 2.80-7.40%**

**Current DxP: 12%**

•Individual performance – M/F>80%, O/B- 26-29%, F/B-60-65%

- Criteria - **MFW (24g – 34g)**
- **FFB > 100kg/p/yr**
- **M/F (50% – 60%)**
- **F/B (60%– 77%)**
- **O/B (16%– 22%)**

•Commercial DxP: MFW (10g)



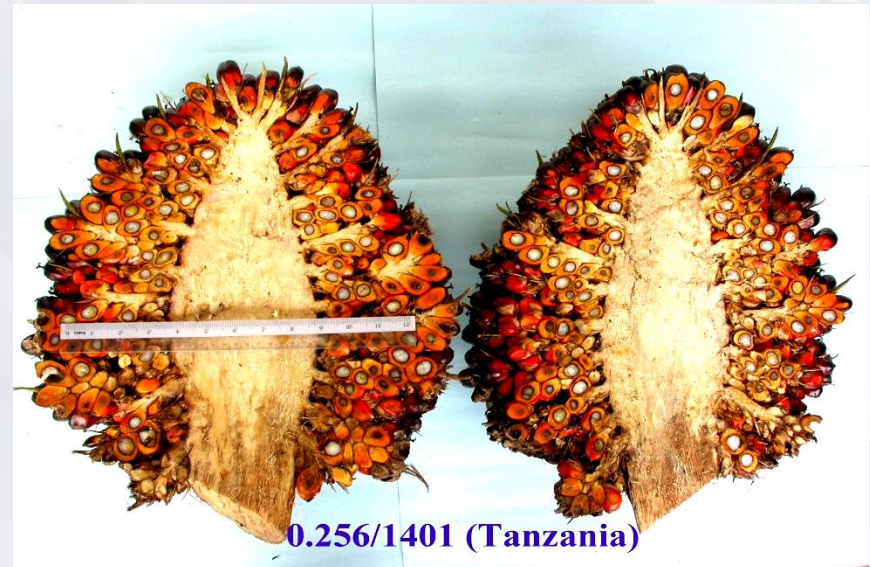


- $BI = \frac{BDM}{TDM}$

**PS7: 0.6**

**Commercial DxP: 0.3**

- **High FFB Yield :**  
**27 – 40 t/ha/yr**





**Several material – NGA, TZA, ZAR, AGO, CMR**

**PS8 : 1300 – 2500 ppm**

**Commercial DxP :600 – 1000 ppm**

**•150/500- 2496.7ppm; dwarf; BI-0.68; yield-8.32t/ha/yr**

- Stalk length  
**PS10: 20cm – 30 cm**  
**Commercial DxP: 10cm – 15 cm**
- FFB > 170kg/p/yr (dura), > 200kg/p/yr (tenera)





- High oleic acid has higher iodine value > liquidity
- Oleic Acid (C18:1)

**PS12: > 48%**

**Commercial DxP : 37% - 40%**



- Low lipase > low FFA > good quality palm oil
- Lipase content  
**PS13: <10% at 5°C**  
**Commercial DxP: 22% - 73%**
- 4 *teneras* and 4 *duras*, FFB > 144.08 kg/p/year O/B > 11.57%

## PS 14 : HIGH PROTEIN KERNEL

- Palm kernel cake (PKC)
  - Solid residue from extraction of oil
  - Important in formulation of animal feed
- Crude protein
  - PS14: 21.09% - 24.04%**
  - Commercial DxP: 16.67%**



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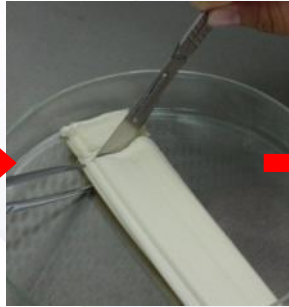


# OIL PALM TISSUE CULTURE

Sampling leaf cabbage/palm crown



Cutting of young leaves



6 months

Leaf explant culture



9 months

Callus formation

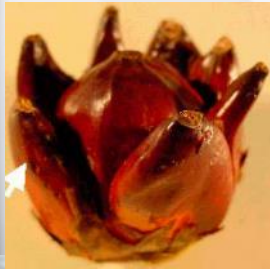


24 months

Embryoid formation



Abnormal



Normal



Boost yields  
20% - 30%



Polyembryoid multiplication stage

2 months



Shoot dev stage

4 months



Rooting stage

3 months



Acclimatization stage

3 - 4 months



In field nursery

8-9 months

(Field planting - 1 yr old)



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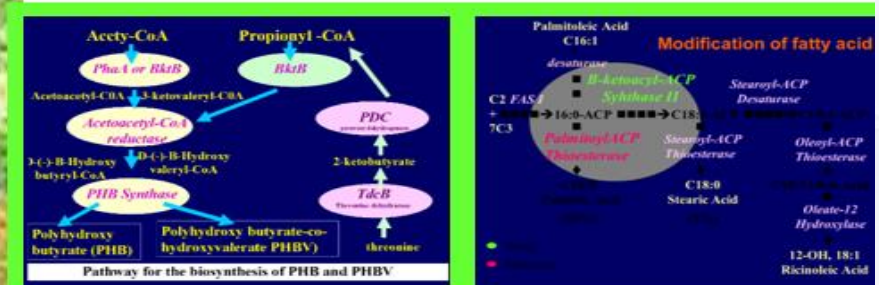
# Biotechnology of Oil Palm

Inherent high productivity of the oil palm to be channeled towards the production of high value specialty oils and industrial feedstock



## TARGETED PRODUCTS

- High oleic acid oil
- High stearic acid oil
- Biodegradable plastics
- Lycopene-enriched oil
- High palmitoleic acid oil
- High ricinoleic acid oil





# **Genetic engineering approaches**

- 1. Method to regenerate plants (TC)**
- 2. Isolation of Target Genes and Tissue-specific Promoters**
- 3. Gene Constructs for Transformation**
- 4. Introduction into Oil Palm Tissues**
- 5. Selection and Regeneration**
- 6. Molecular & biochemical analyses**



# Transformation

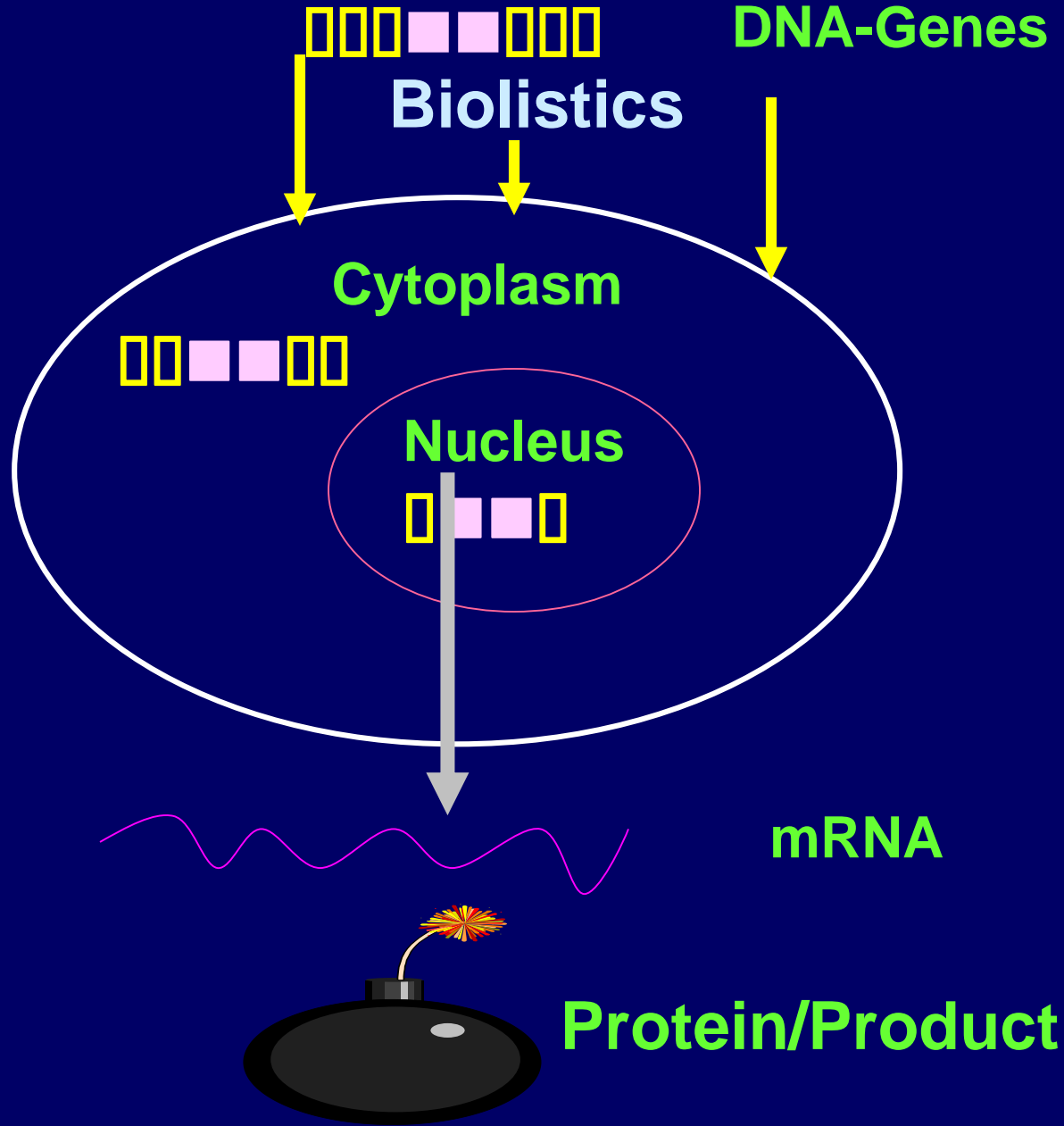
Process to **transfer foreign genes** (DNA) from one organism into the same or different organism - transgenic

The foreign gene can be from **plant, animal, human, bacteria, fungal or virus.**





# Transformation Process



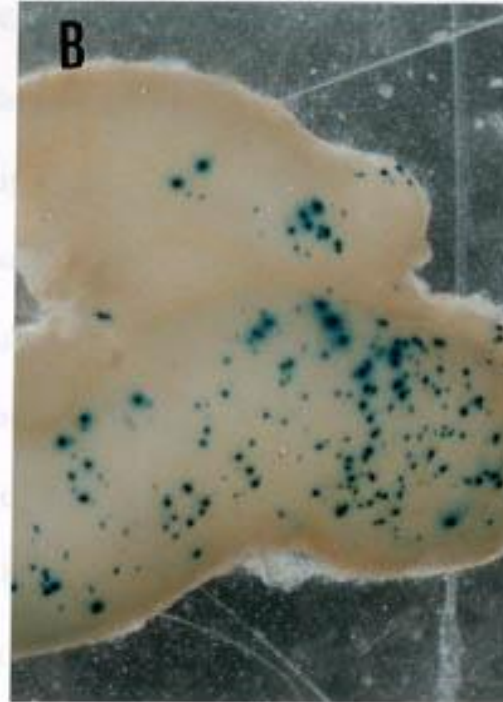


# Steps to produce transgenic plants

1. Optimize transformation method
2. Transformation of target tissue
3. Selection of transformants
4. Proliferation and regeneration
5. Confirmation of transgenic status –  
molecular and biochemical analyses

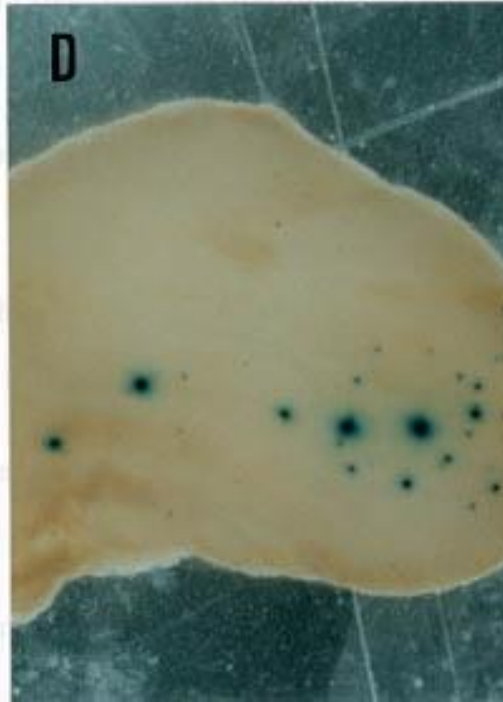
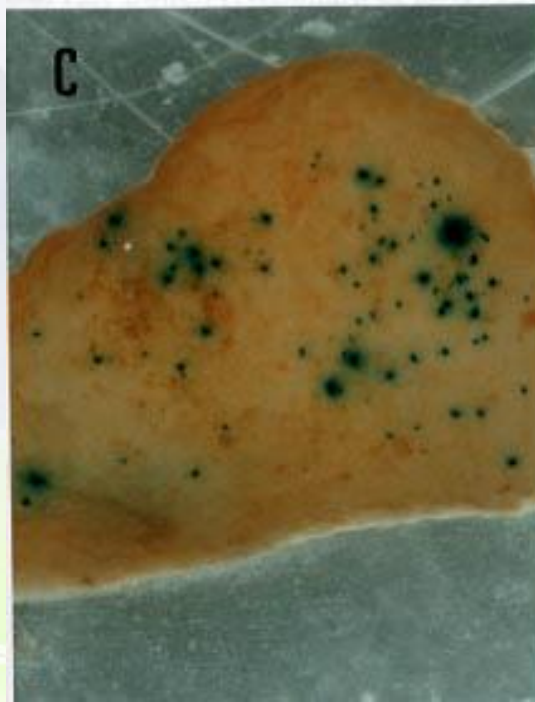


Control



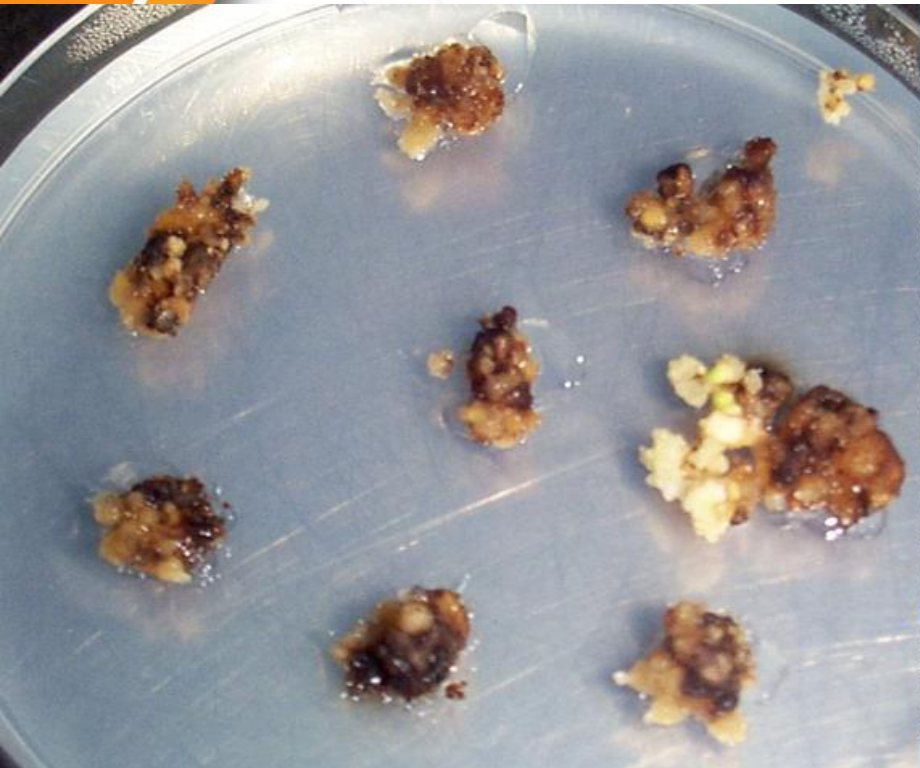
High

Medium



Low









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# CONCLUSION

- Large collection of oil palm germplasms - **broader gene pool**
- **14 PS Series** for oil palm industry
- Potential of **higher yield and novel metabolites** from germplasm collection
- **Tissue culture** to fast tract
- **Genetic manipulation** could produce oil palm with new characteristics not found in nature.





# See You at PIPOC 2019

**19 - 21 November 2019**  
**Kuala Lumpur Convention Centre,**  
**Kuala Lumpur, Malaysia**

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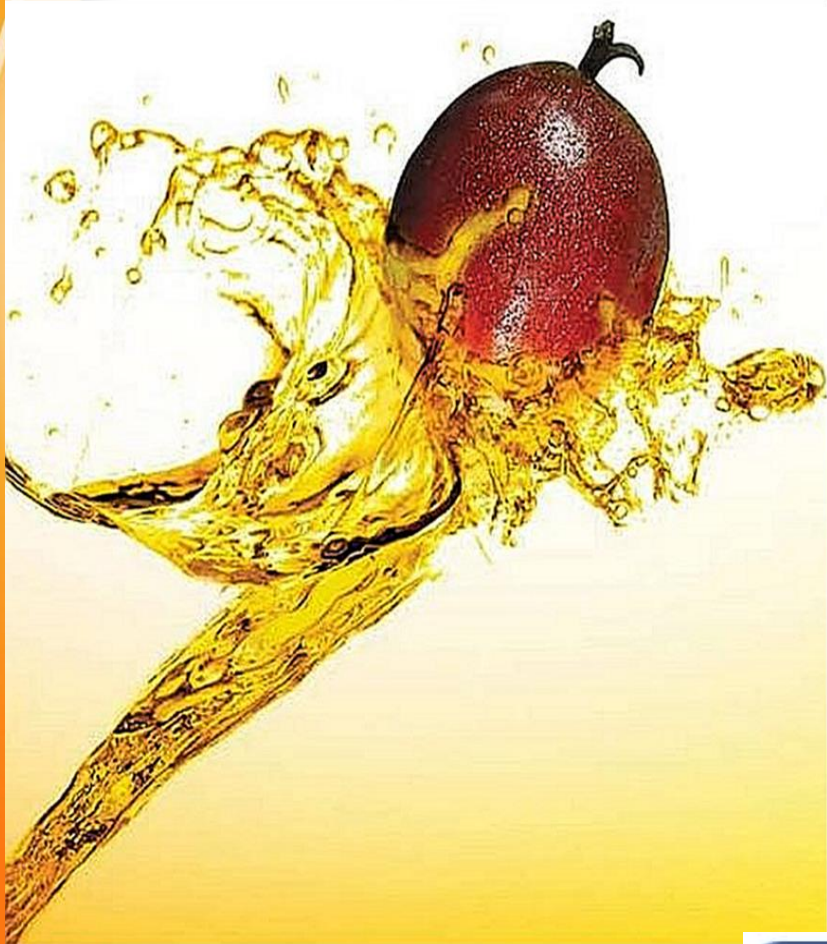
**M P O B**

Malaysian Palm Oil Board (MPOB)

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Ministry of Plantation Industries and Commodities





# THANK YOU

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