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Long-term Research Grant Scheme (LRGS) Sharing The Experience (2012 – 2017)

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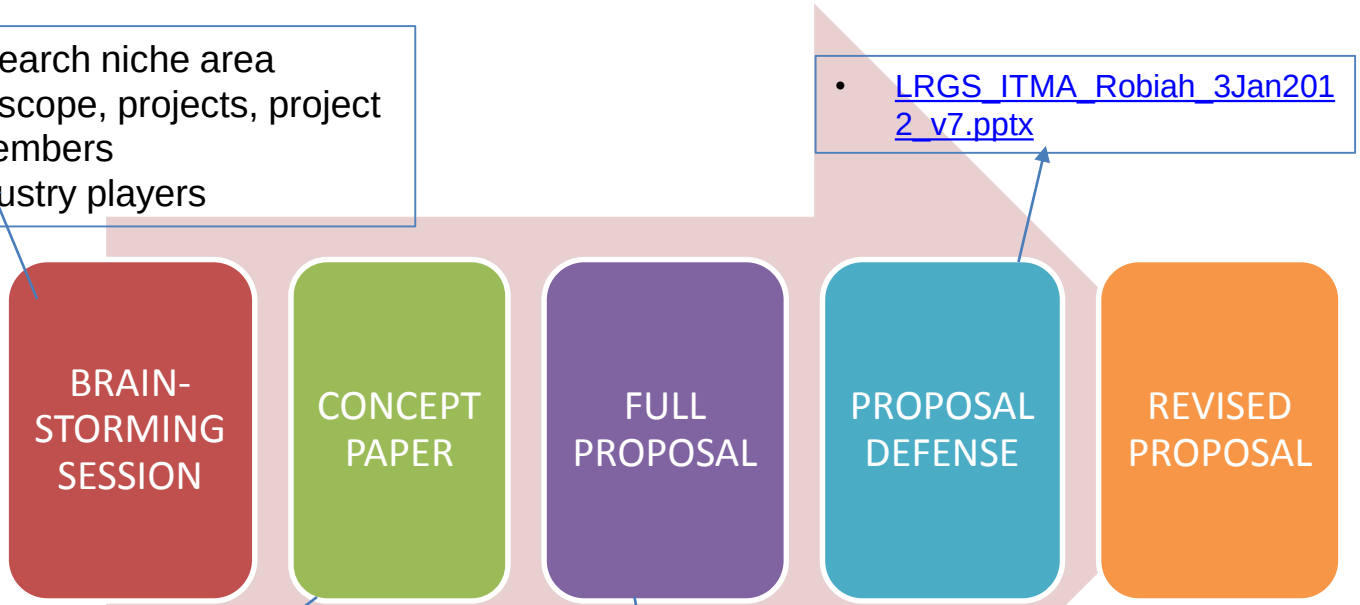
INTRODUCTION

1. MOHE has approved RM5.808 million to UPM in 2012 to conduct fundamental research under LRGS on " Enhancing the Productivity and Sustainability of Palm Oil "
2. Objectives of the program:
   - To improve the existing palm oil milling technologies and
   - To increase biomass utilization through fundamental approaches.
3. The program comprises of 5 projects; 3 projects led by UPM and 2 projects by UITM and UTM.
4. The research program focused on industry-based problems, involving major players in palm oil industries in particular SIME DARBY, FELDA (FGV), DOLPHIN ENG AND FIBALOY INTERNATIONAL

LRGS APPLICATION

- Identify research niche area
- Determine scope, projects, project leaders, members
- Identify industry players



- LRGS_ITMA_Robiah_3Jan2012_v7.pptx

- 5 pages (max)
- LRGS_Robiah_concept_sample.docx

- Program ProposaLRGS_ITMA_2July.docx

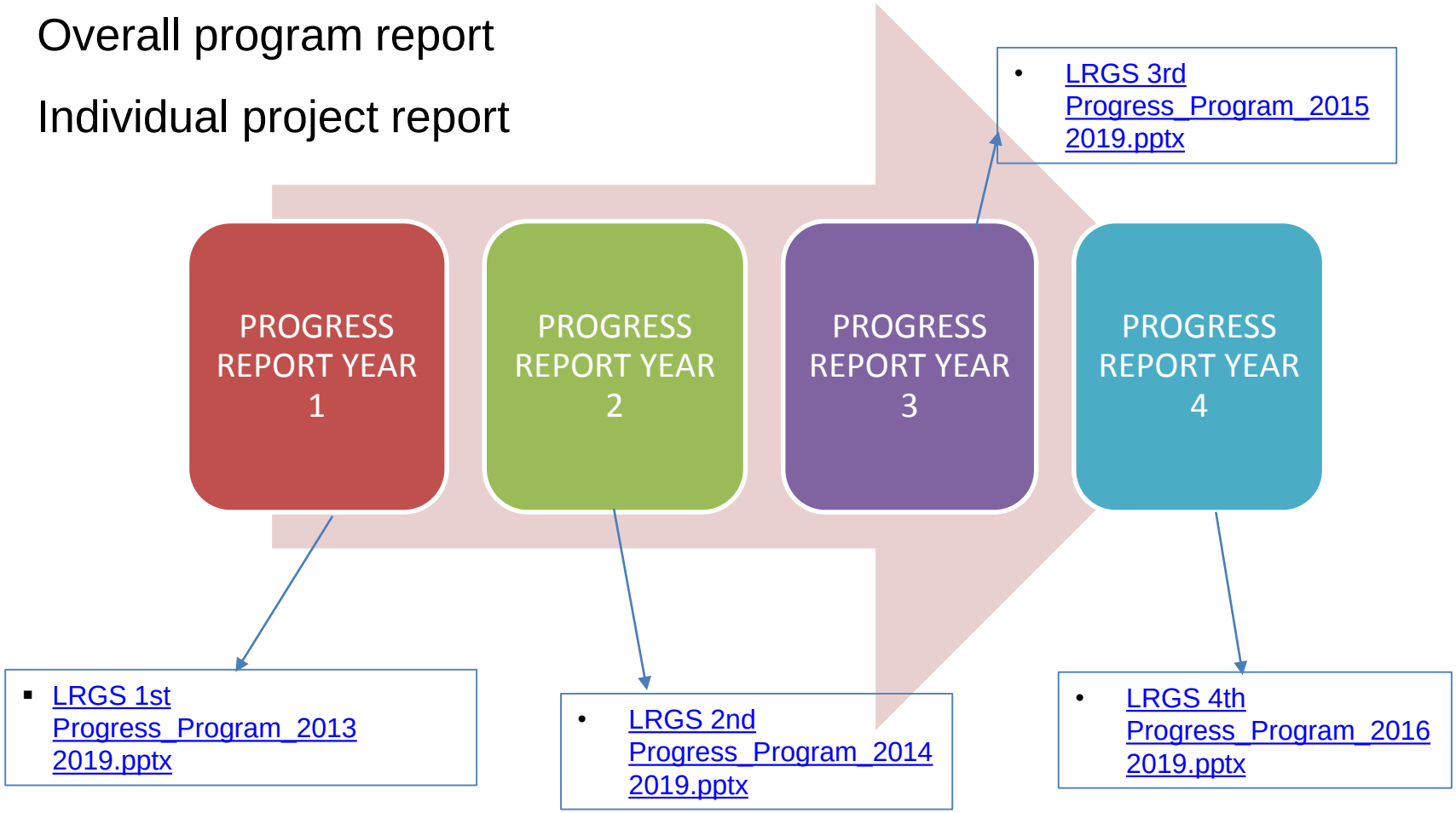
CONCEPT PAPER

1. Executive Summary
2. General Background and Rationale
3. General Objectives
   - Objective for Project 1
   - Objective for Project 2
4. Description of Research Programme and Research Team
5. Methodology
6. Track record of project leaders
7. Expected Results

5 Pages

PROJECT PROGRESS AND MONITORING

- Overall program report
- Individual project report



PROJECT COMPLETION

1. All KPIs for the programme achieved
   i. KPI on students (17 PhD and 33 MS)
   ii. KPI on publication (50 journals and 65 conference papers)
2. 3 journal writing workshops held in 2013, 2014 and 2015.
3. 3 colloquiums held in Dec 2013, Jan 2015, March 2016
4. 5 intensive courses on fundamental issues in palm oil milling processes.
5. 12 workshops organised to monitor the projects progress
6. Licensed two technologies;
   - High Pressure Sterilization has been licensed by Dolphin Eng (2014).
   - A More Efficient Palm Oil Extraction Method has been licensed by Fibaloy International Sdn Bhd (2017)

Video

https://www.youtube.com/watch?v=CLwUjdKOPqg&feature=youtu.be

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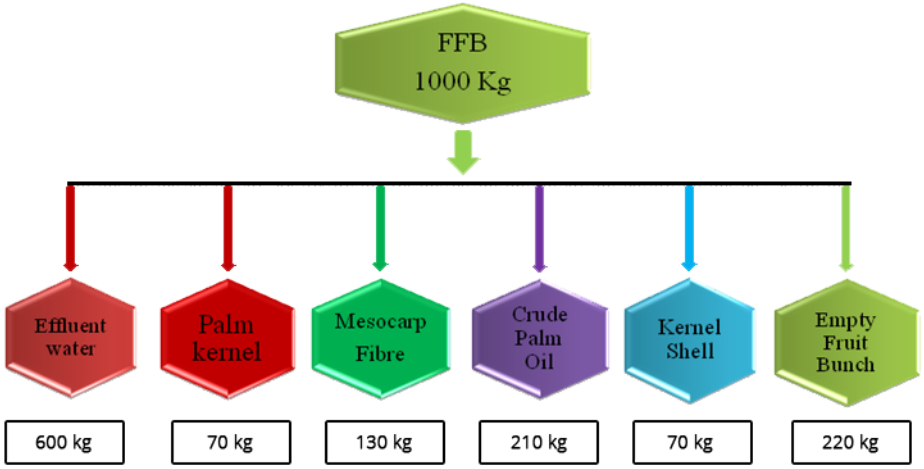
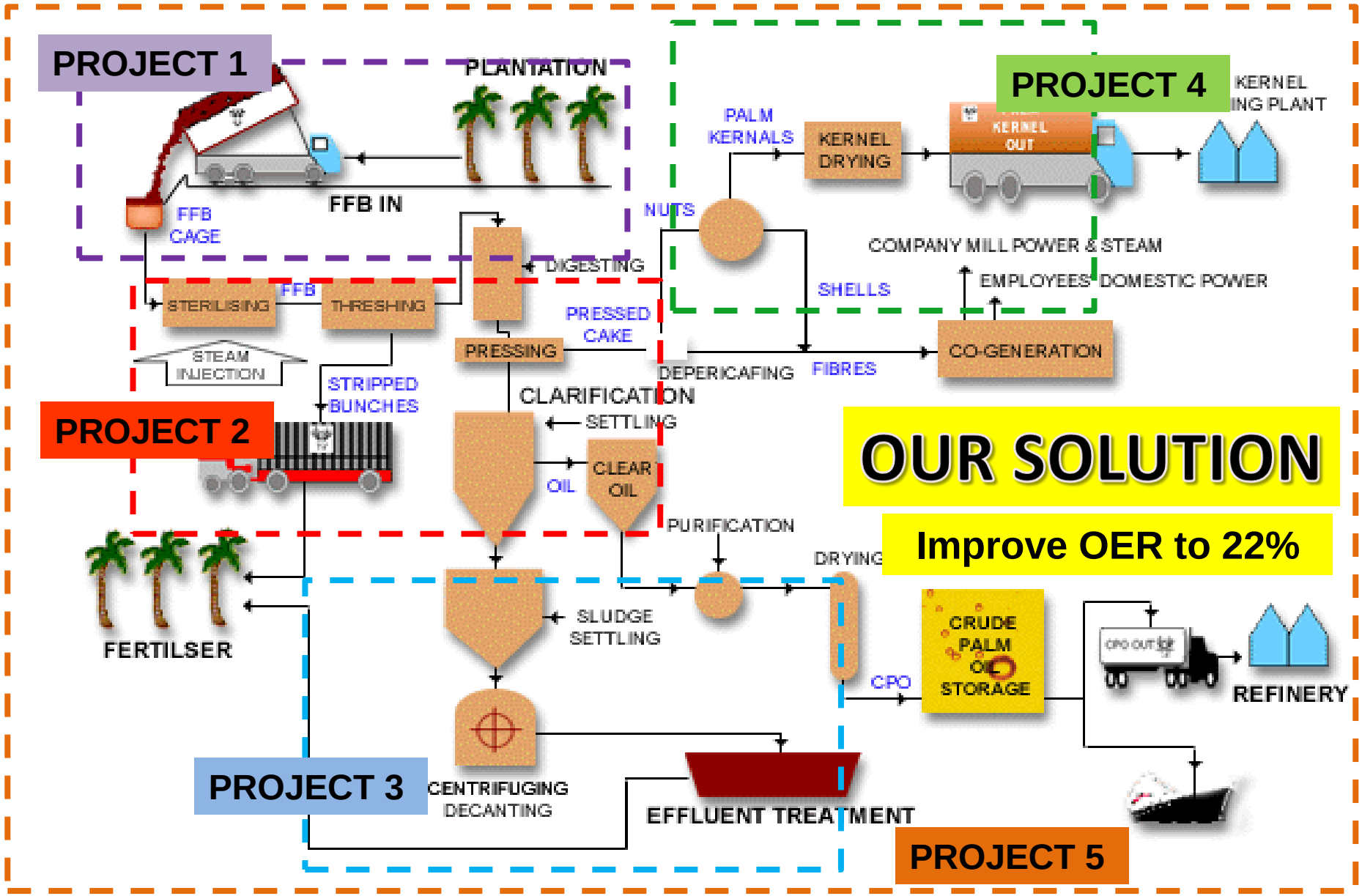
Terima Kasih | *Thank You*

OIL LOSSES IN PALM OIL MILL

- Inefficient milling technology particularly poor oil extraction leads to oil losses.
  - Oil losses in unstripped FFB at 0.4% oil loss/FFB or RM 3.0 million/mill/year
  - 0.7% oil loss/FFB in press fiber and kernel loss, 0.32%/FFB (50% oil in kernel) at or RM 6.8 million/mill/year
  - Oil losses in sludge at 0.32% oil loss/FFB or RM 2.8 million/mill/year
- Major oil losses in palm oil mills occur in the Fibre, Sludge and Steriliser condensate (90 % of all oil losses)
- High oil loss and % of broken kernels in press fibre is due to inefficient sterilization, digestion and screw press.
- Formation of emulsions at the oil/water boundary in clarifier leads to more oil loss.
- Oil loss in condensate occurs due to longer than necessary steriliser cycle or due to over ripe fruit.



ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY



RESEARCH DELIVERABLES

✓Improved OER to 22%
✓RM12 million/year per mill
✓Potential income of ***RM5.4 billion/yr***

✓Fully automated oil palm grading /oil quality system
✓Improved technology

UPM
UTM
UiTM
UKM
UPNM
UNiKL
UMP
USIM
UMT

✓Reduced total oil losses to below 1.0%
✓Reduced kernel losses to below 5%
✓Palm oil milling process with zero discharge

✓54 publications
✓8 patents
✓15 PhD
✓32 MS
✓Trained workers (51 bachelor students)

MPOB SIME DARBY FELDA

OVERALL BUDGET - PROJECT

Project	Allocation for 1st Year (RM)	Allocation for 2nd Year (RM)	Allocation for 3rd Year (RM)	Allocation for 4th Year (RM)	Allocation for 5th Year (RM)	Total Allocation (RM)	Balances after 5 Years (RM)	Percent Expenses
Project 1	651,224	268,152	237,855	109,248	86,636	**1,353,115**	**46, 574.19**	**96.5%**
Project 2	348,816	304,263	310,840	409,849	244,138	**1,617,906**	**32,644.90**	**97.9%**
Project 3	275,600	563,500	179,876	65,200	33,299	**1,117,475**	**26,299.32**	**97.6%**
Project 4	355,760	411,985	394,529	86,803	70,027	**1,319,104**	**1,7777.95**	**99.9%**
Project 5	112,200	113,200	69,000	59,000	47,000	**400,400**	**0.00**	**100%**
Total	1,743,600	1,661,100	1,192,100	730,100	481,100	**5,808,000**	**120,920.5**	**97.9%**

RESEARCH ACHIEVEMENT

PROGRAM

ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY

ACHIEVEMENT PERCENTAGE				
Project progress (milestone)	0-25%	26-50%	51-75%	76-100%
Percentage				**X**

RESEARCH OUTPUT AND HUMAN CAPITAL DEVELOPMENT					
Articles/ Books	Conference/ Proceeding	Intellectual Property	Number of PhD student	Number of Master student	Number of UG student
54 articles 1 book	**71**	**8 (patent pending)**	**15 (M'sian) 2 (Non-M)**	**28 (M'sian) 5 (Non-M)**	**51 (M'sian)**

NEW TECHNOLOGIES FROM PROJECT 1

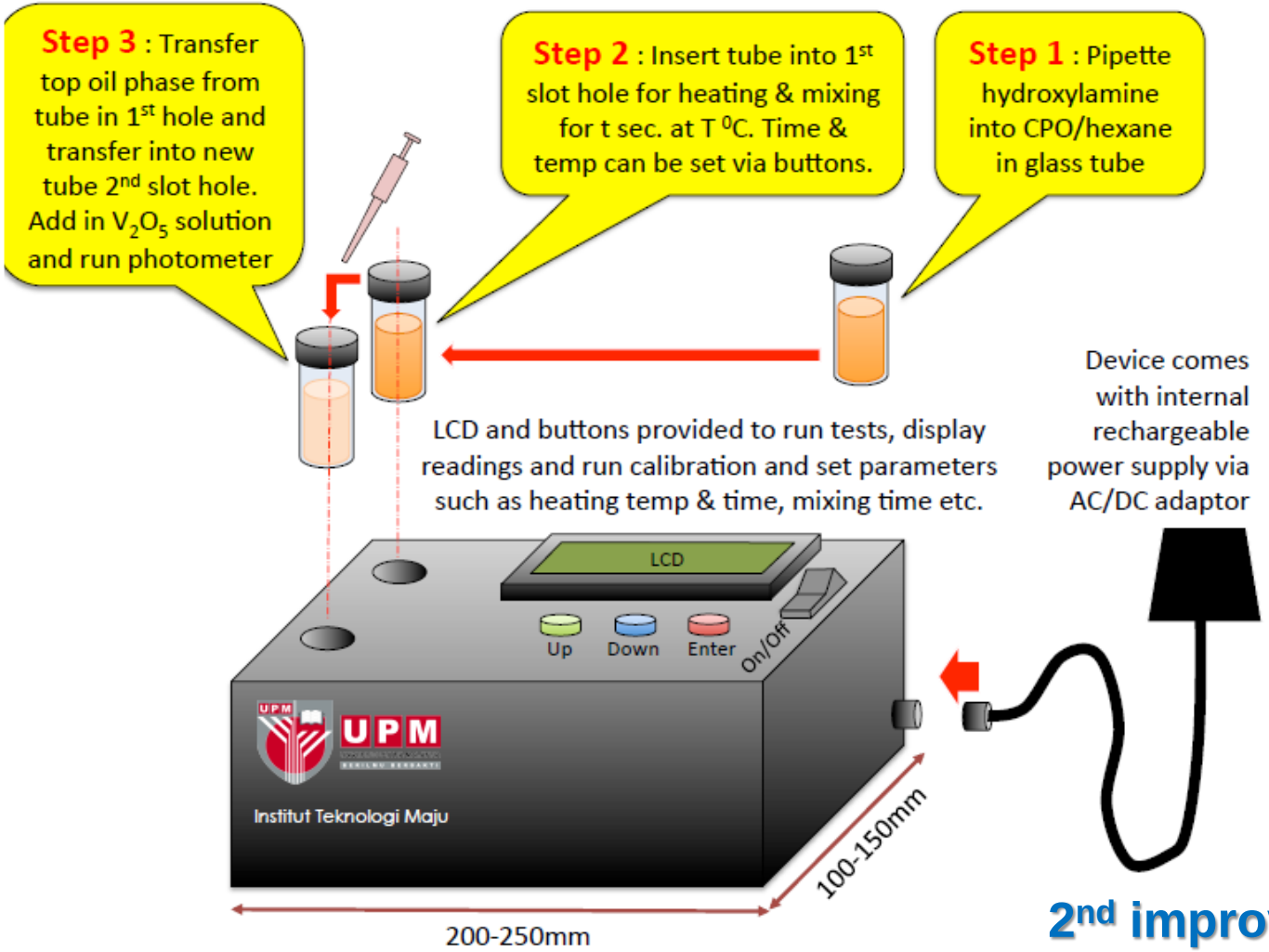
PROJECT 1: Study on Novel and Practical Fruit Grading and Oil Quality Monitoring Technology in Palm Oil Mills

1. Thermal Camera for FFA Determination from FFB at Palm Oil Mill

During the last year we have experimented with different combinations of sensors. From these results, we created models and found that combinations of Sensor 3 (Red Emission, Red Detector), Sensor 2 (DRed Emission), Sensor 2 (FRE Emission), Sensor 4 (Blu Emission) , and Sensor 4 (NIR Emission) showed the best combination to distinguish ripeness of fresh fruit bunch with 79.8% over ripe, 69.4% ripe and 93.3% under ripe. Accuracy values to detect free fatty acids increases to 77% with addition of average temperature as sensor. Accuracy of determining oil content and Peroxide Value (PV) was 91.8% and 83.3% respectively after training and testing the samples.

NEW TECHNOLOGIES FROM PROJECT 1

2. FFA Detection System for Crude Palm Oil



2nd improved prototyped

NEW TECHNOLOGIES FROM PROJECT 1

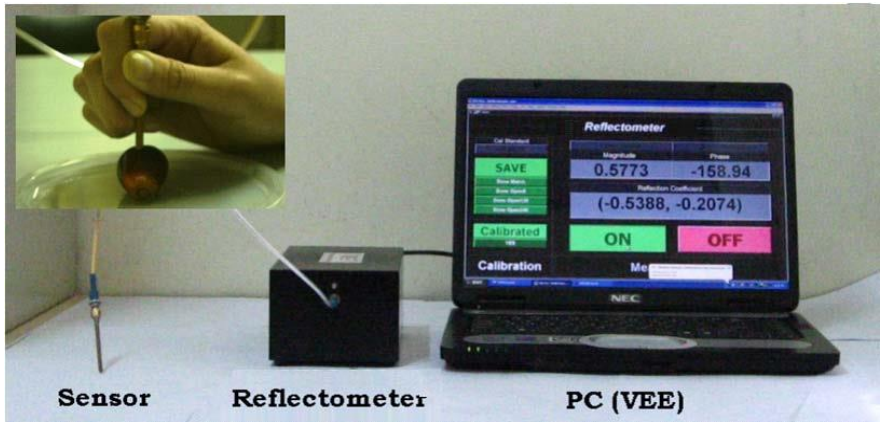
3. Palm Fruit Ripeness Detector

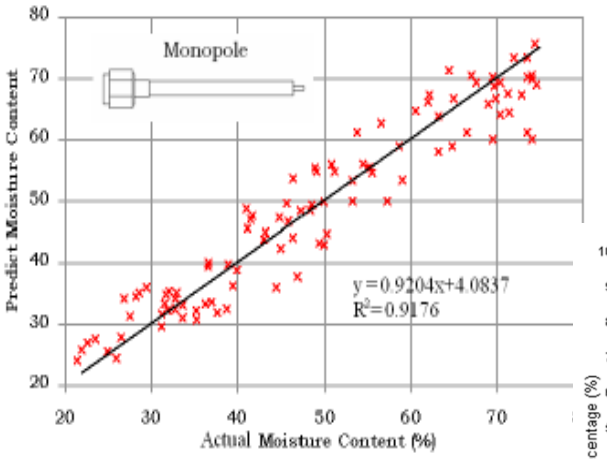
a) A microwave five-port reflectometer for the determination of moisture content in oil palm fruits was developed.

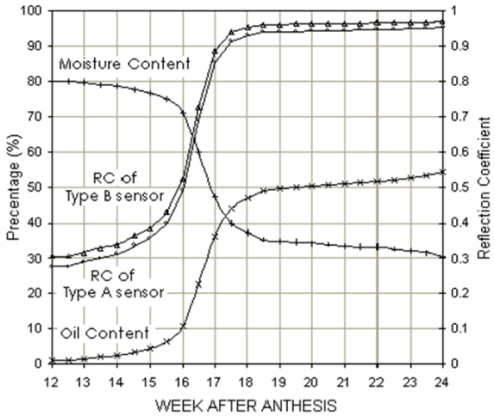
b) The reflectometer was designed to measure both the magnitude and phase of the reflection coefficient of any passive microwave device.

c) The stand-alone reflectometer consists of a PC, a microwave source, diode detectors and an analog to digital converter.

d) All the measurement and data acquisition were done using Agilent VEE graphical programming software. The relectometer can be used with any reflection based microwave sensor.







NEW TECHNOLOGIES FROM PROJECT 2

RM 12 mil per year

Oil losses in unstripped FFB amounts to RM 3.0 million/ mill/year (0.4%/FFB)

Oil losses in press fiber and kernel loss, amounts to RM 6.8 million/ mill/year (0.7%/FFB)

Oil losses in sludge oil amounts to RM 2.8 million/ mill/year (0.32%/FFB)

Sterilization

Extraction

Separation

NEW TECHNOLOGIES FROM PROJECT 2

HIGH PRESSURE STERILIZATION

Kilang Sawit Bukit Kapah, Hulu Terengganu

In 2014/15 Fibaloy and Dolphin Application Sdn Bhd integrated UPM's Dr. Azis's High Pressure Sterilization patent and LRGS research into development of Dolphin's Robo-REST sterilization system.

70 psi , 30 minutes sterilization

40 psi , 30 minutes sterilization

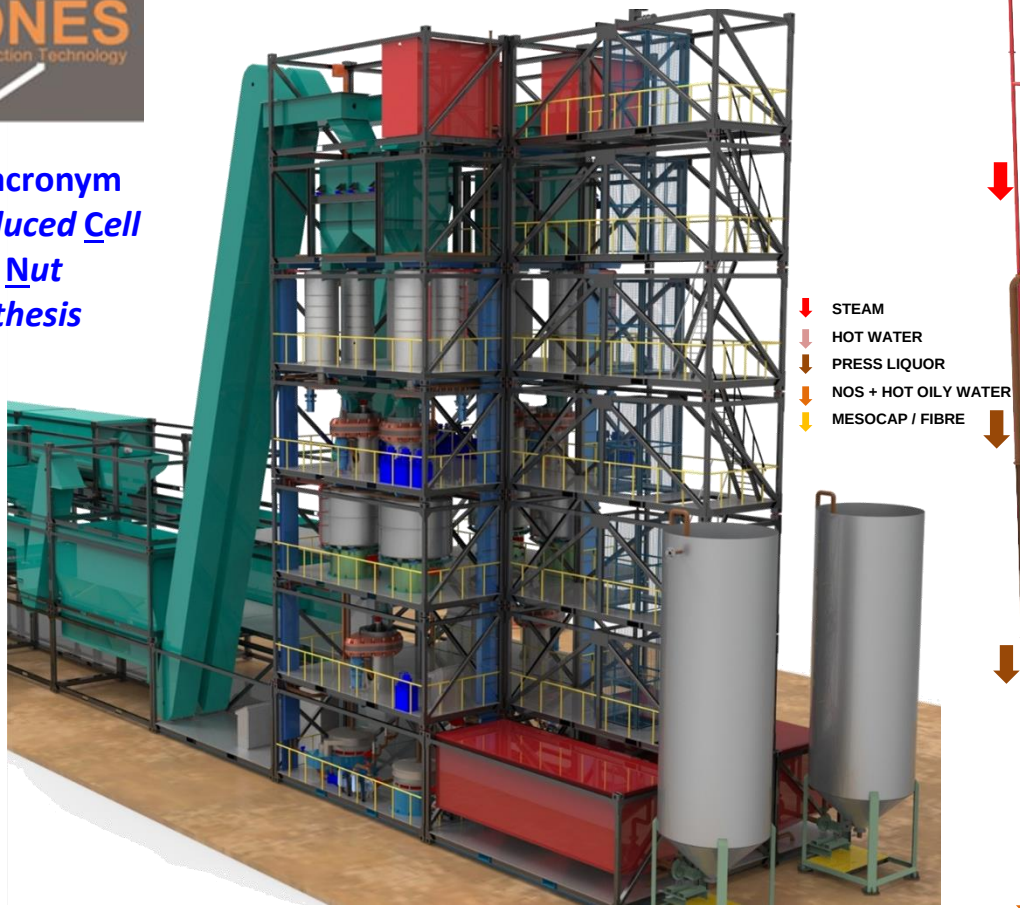
Robo-REST

NEW CPO EXTRACTION TECHNOLOGY

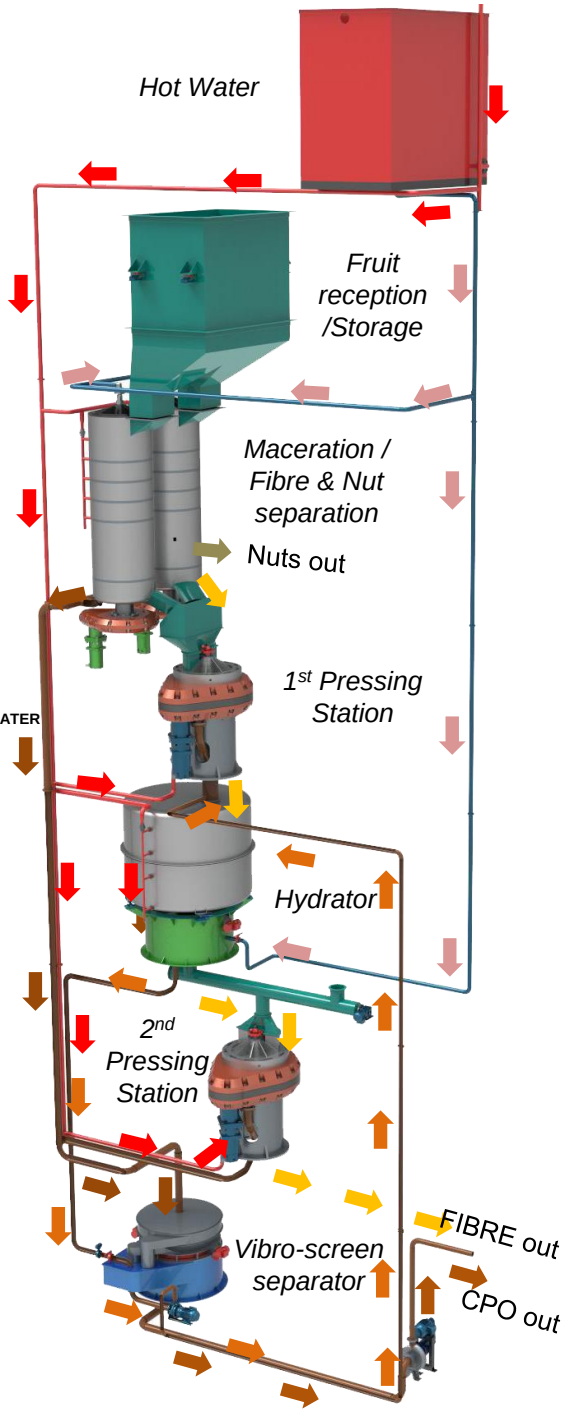
MICRONES is an acronym for *Maceration Induced Cell Rupturing Oil Nut Extraction Synthesis*

Microncs is designed to work with;

- Conventional sterilisers
- Continuous sterilizers.

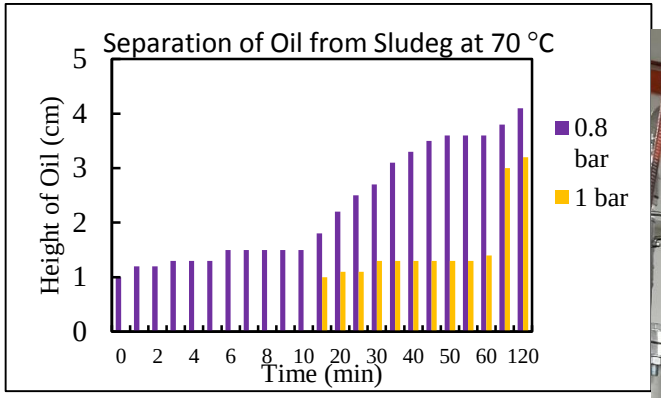


60 ton FFB MICRONES System



CLARIFIER

- Clarification is a process to remove water and sludge from oil.
- Most mills use gravitational clarifier to obtain clarified oil in 3 to 5 hours.
- However, oil loss in sludge is among the highest in mills.
- Our new approach is to apply vacuum during clarification process.
- Lower oil loss in sludge crude palm oil and shorter process time during clarification process are process challenges.



NEW TECHNOLOGIES FROM PROJECT 3

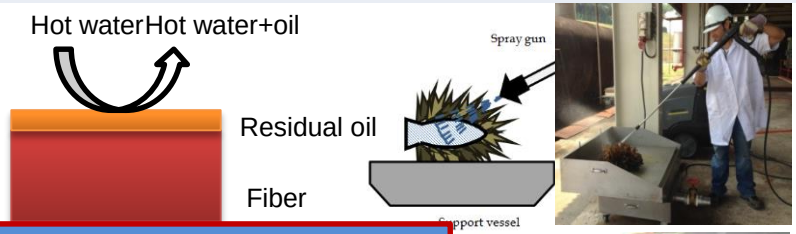
1. Oil Recovery from EFB

1. Completed Works: Mechanism of oil attachment

Oil presence confirmed using dye method

Oil loss- portion of oil impregnated onto the surface of EFB due to mechanical processes. Oil mainly located on the spikelet rather than the stalk

Mechanical processes (conveyor, sterilization, thresher equipment etc.) mainly contribute to the oil transfers from fruit to bunches



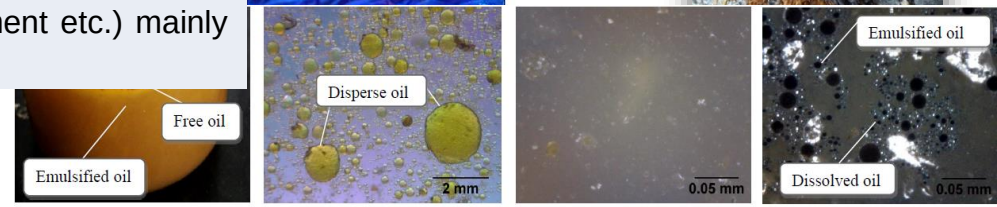
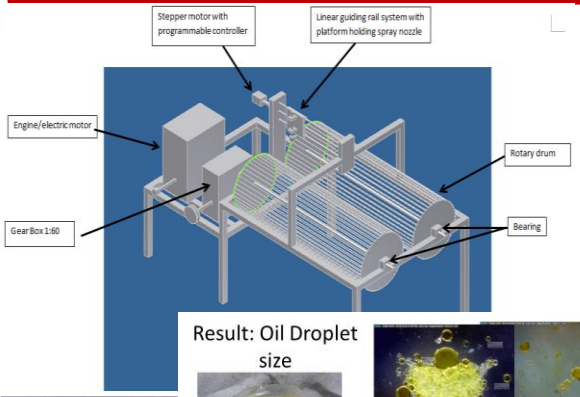
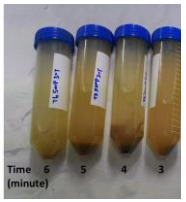


Fig 13. a) Collected product after HYSASE process, b) Oil droplet before gravimetric method (40x magnificent), c) Oil droplet after gravimetric method (470x magnificent), d) Oil droplet after gravimetric method with Black Sudan dye staining (470x magnificent).

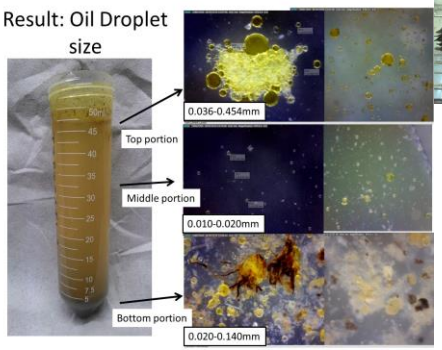
2. Completed Work: EFB oil recovery system (1st Concept)

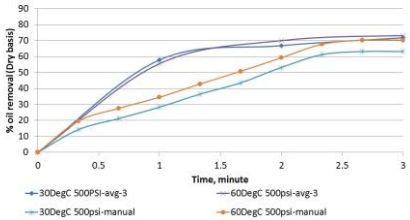
3. Completed Work: EFB Oil Recovery (2nd Concept)





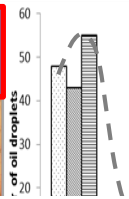
Result: Oil Droplet size



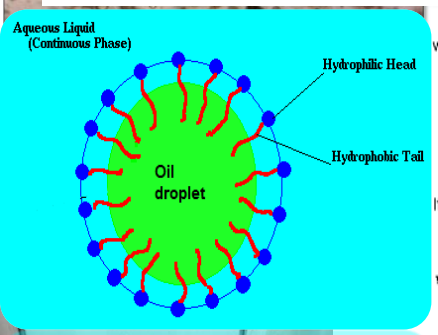


NEW TECHNOLOGIES FROM PROJECT 3

1. Completed Work: Mechanism of oil attachment



Sufficient evidence that; CPO presence mainly free and small droplet size (< 100 um).



18 η

where

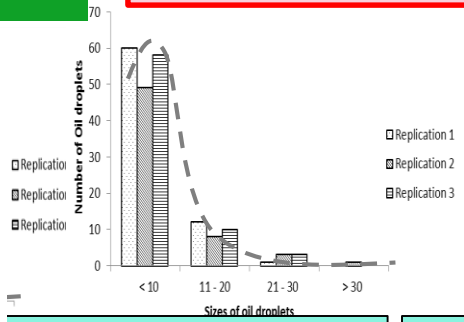
V_v	rising velocity of the bubble (m/s)
g	gravitational constant (9.81 m/s^2)
D_v	the bubble diameter (m)
ρ_l	the density of the liquid (kg/m^3)
ρ_v	the density of the vapour (kg/m^3)
η	the dynamic viscosity of the liquid (Pa s)

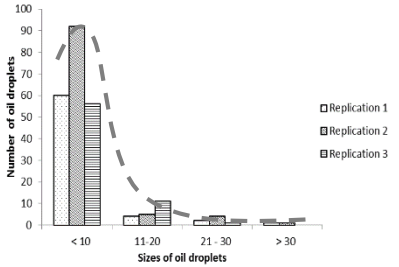
It is generally assumed that proper liquid degassing is achieved whe bubbuls of 200 micron and larger are removed. In this case formula 4.8 can be simplified to:

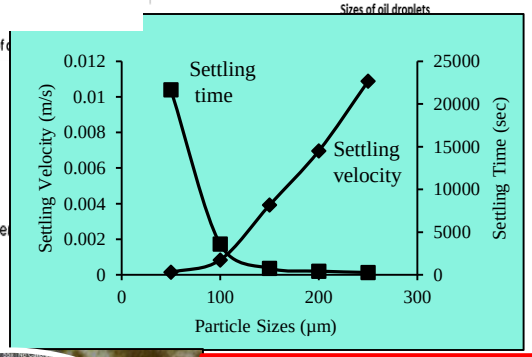
$$v_v = 2.2 \times 10^{-8} \frac{(\rho_l - \rho_v)}{\eta} \quad (4.9)$$

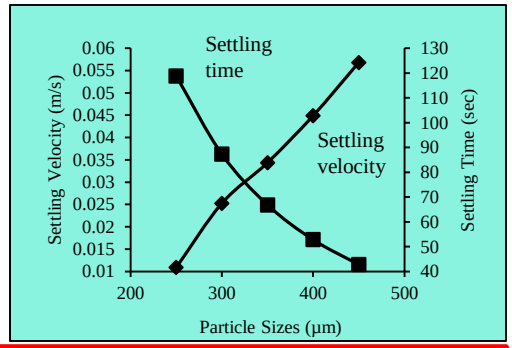
2. Completed Work: Small scale of oil recovery unit

2. Oil Recovery from POME

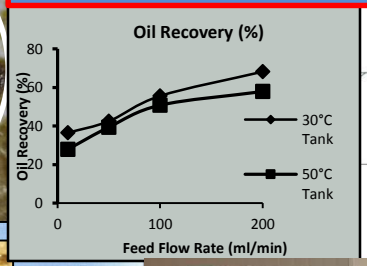


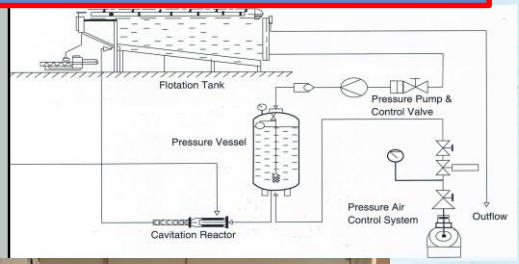






3. Microbubbles Technique Dissolved Air Floatation Technology





NEW TECHNOLOGIES FROM PROJECT 3

3. Oil Recovery from OPDC

1. Completed work : Green solvent (d-limonene) used to recover oil in OPDC. The OPDC contained approximately 12.55±3.15% (dry). d-limonene successfully recovered 100% of oil with 90% recycling rate.

RCPO content in OPDC' [% dry basis] **12.55±3.15**

	d-limonene	n-hexane
RCPO recovery [%]	100	100
Solvent recovery [%]	90	70
Carotene [ppm]	756.16	614.67
C16:0 Palmitic acid	39.22	47.99
C18:1n9c Oleic acid	31.05	37.36

Ultrasonic Assisted Soxhlet Extraction for faster oil

4. Oil Loss and OER Study

Sub-project 4 progress : Clear indication of sources of oil loss in the mill – evaporation , sterilisation condensate, unstripped fruit bunches, hard bunches, hydrocyclone or claybath effluent, clarification section, empty fruit bunches and decanter cake.

Originality - A new method to representing OER performance which include OER and OIL LOSS DATA

OER		Ex : CONTINUOUS STERILIZER SYSTEM (CS)	OIL LOSS	
RATING	RANGE	INDICATOR	RANGE	RATING
1	18.00 – 19.24	LOW	1.10 – 1.31	4
2	19.25 – 20.49	AVERAGE	1.32 – 1.54	3
3	20.50 – 21.74	HIGH	1.55 – 1.77	2
4	21.75 – 23.00	VERY HIGH	1.78 – 2.00	1

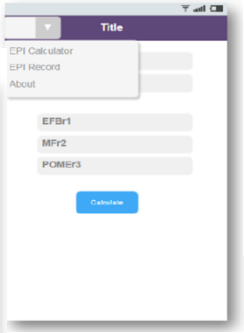
OEROL PI	RANGE	INDICATOR
1	1.00 – 1.72	POOR
2	1.73 – 2.26	AVERAGE
3	2.27 – 2.99	GOOD
4	3.00 – 4.00	EXCELLENT

Click on EPI Calculator will display the information need to be input by the user.
Each of the variables meaning will be available from the menus.
Once all the value are input accordingly, press "Calculate'.

"About" page shows the apps version and description. Appears when the users selects it in menu.

Page 07 – About

Page 01 – Menu in this application



Page 02 – EPI Calculator Page

Page 03 – Result

This result shown the EPI of palm oil calculated from previous equation.

The "Save" button available for saving the data into cloud database.

For this purpose, internet connection is needed.

NEW TECHNOLOGIES FROM PROJECT 4

Hot Compressed Water Extraction

(HCWE)

Green Solvent Extraction & Crystallization

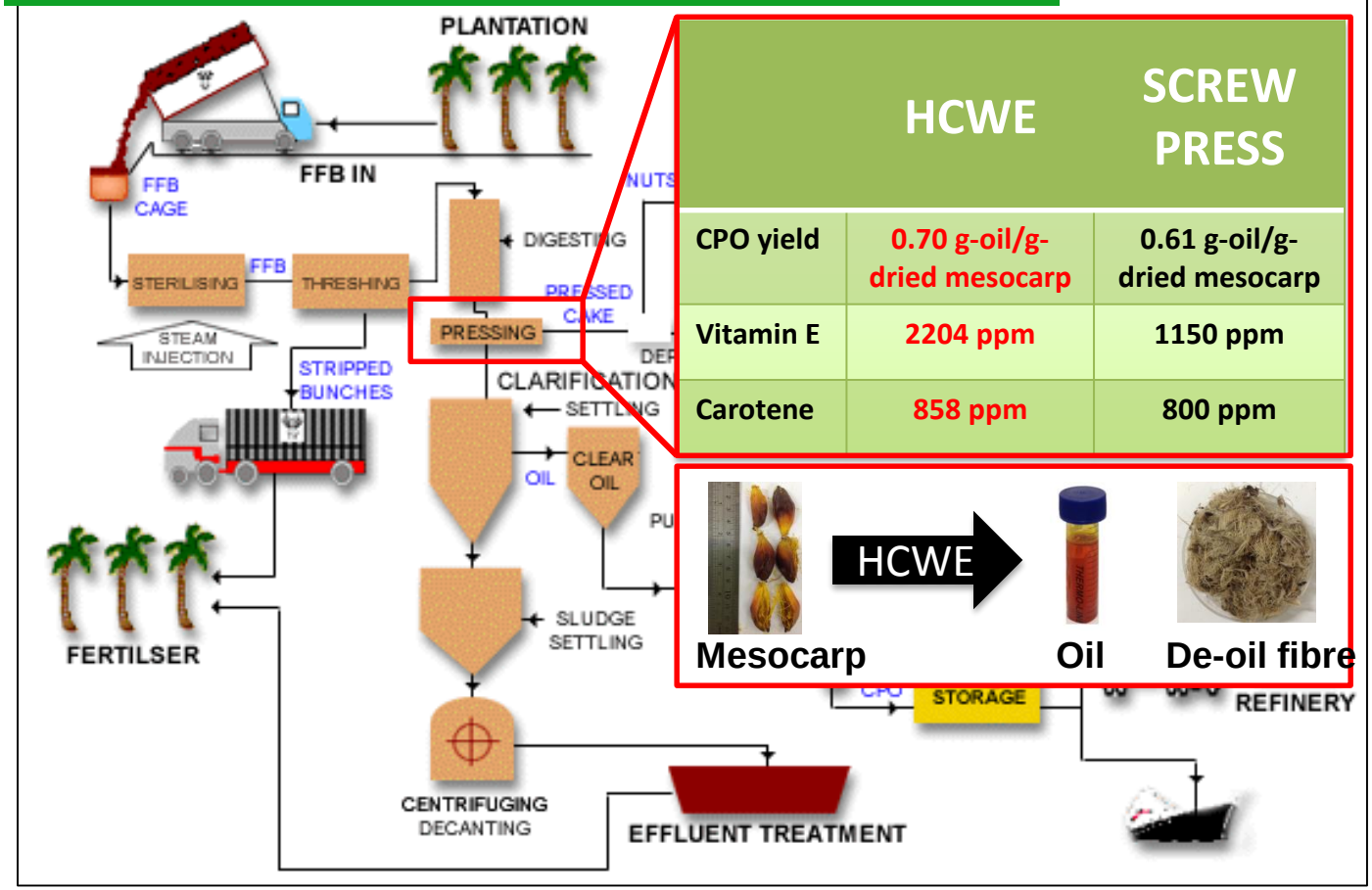
Air Classifier with Air Disturbance System

Supercritical Carbon Dioxide Extraction

(SC-CO2)

NEW TECHNOLOGIES FROM PROJECT 4

Hot Compressed Water Extraction (HCWE)



	HCWE	SCREW PRESS
CPO yield	0.70 g-oil/g-dried mesocarp	0.61 g-oil/g-dried mesocarp
Vitamin E	2204 ppm	1150 ppm
Carotene	858 ppm	800 ppm

Palm Pressed Fibre

HCWE

Oil

De-oil fibre

	CPO	PPF-HCWE
Vitamin E	600 – 1000 ppm	11139.39 ppm
Carotene	500 – 700 ppm	3866.53 ppm

NEW TECHNOLOGIES FROM PROJECT 4

Oil Palm Mill Biomass & Refinery Waste

Green & Biodegradable Oil Palm Based Coatings

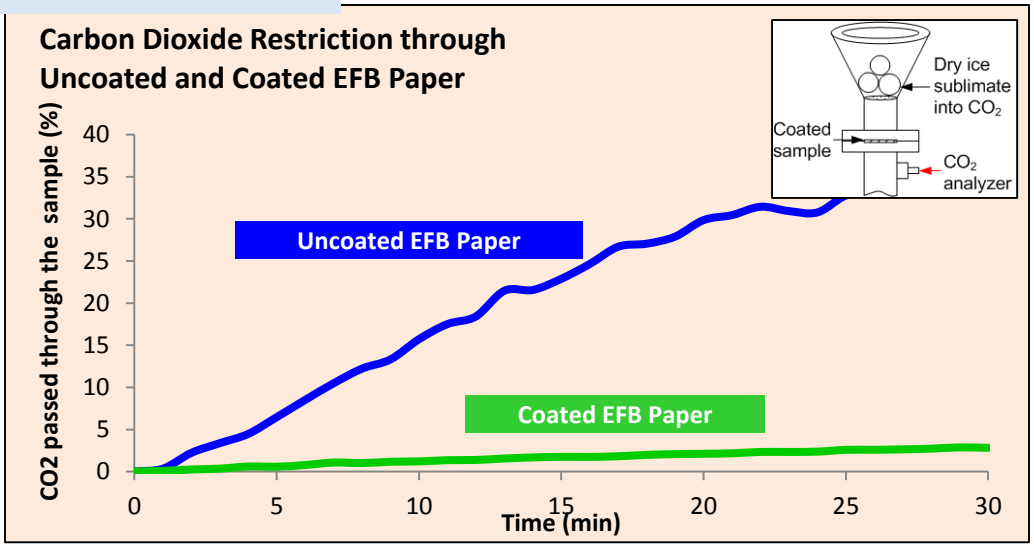
Green Solvent Extraction & Crystallization

- Water resistant
- Gas resistance ideal for MAP (Modified Atmosphere Packaging)
- Biodegradable
- Sustainable resources

	GF	BW	CPO
FFA, %	1.23	25.19	3 - 5
Kinematic Viscosity (mm^2/s)	66.07	77.89	45.34
Carotene (ppm)	3.3	103.1	474 to 689

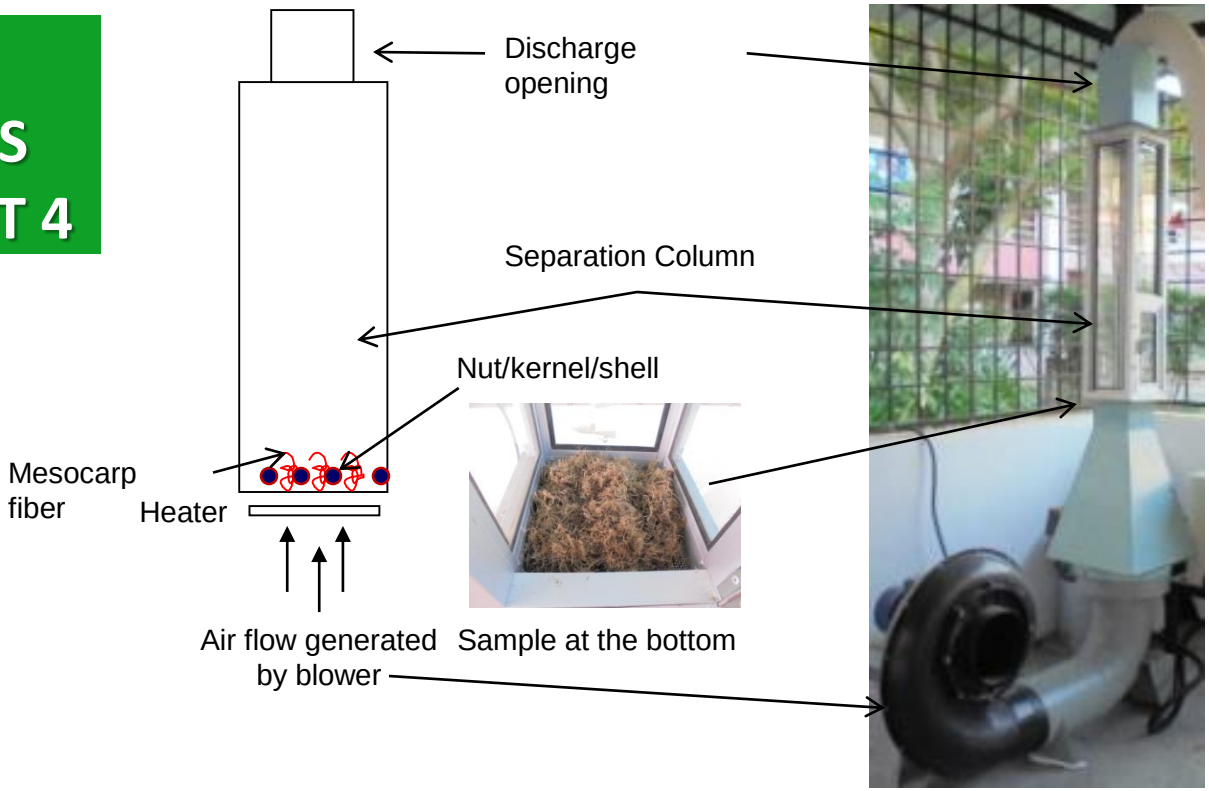
NON-FOOD APPLICATIONS

- **A sustainable alternative to Paraffin Wax**



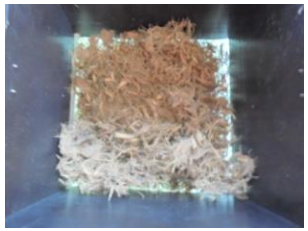
NEW TECHNOLOGIES FROM PROJECT 4

Air Classifier with Air Disturbance System

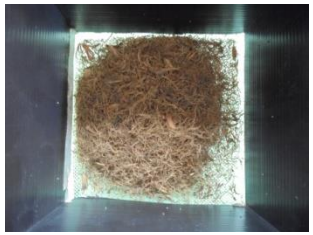


- **Used air disturbance system (injected air pressure to the bottom of separator column)**
- **40% efficiency improved**
- **Reduced air velocity usage**
- **Reduced separation time more than 80%**

Velocity : 3.2 m/s
Setting time : 1 minute
Sample ratio : 60/40
Result : **98.60%**



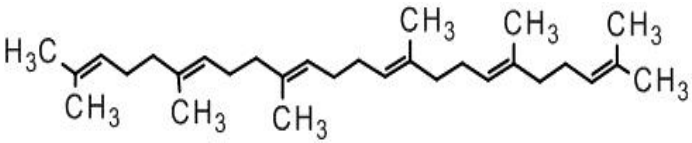
Velocity : 1.8 m/s
Setting time : 30 second
Sample ratio : 60/40
Result : 75.80%



NEW TECHNOLOGIES FROM PROJECT 4

Mesocarp

SC-CO2 →

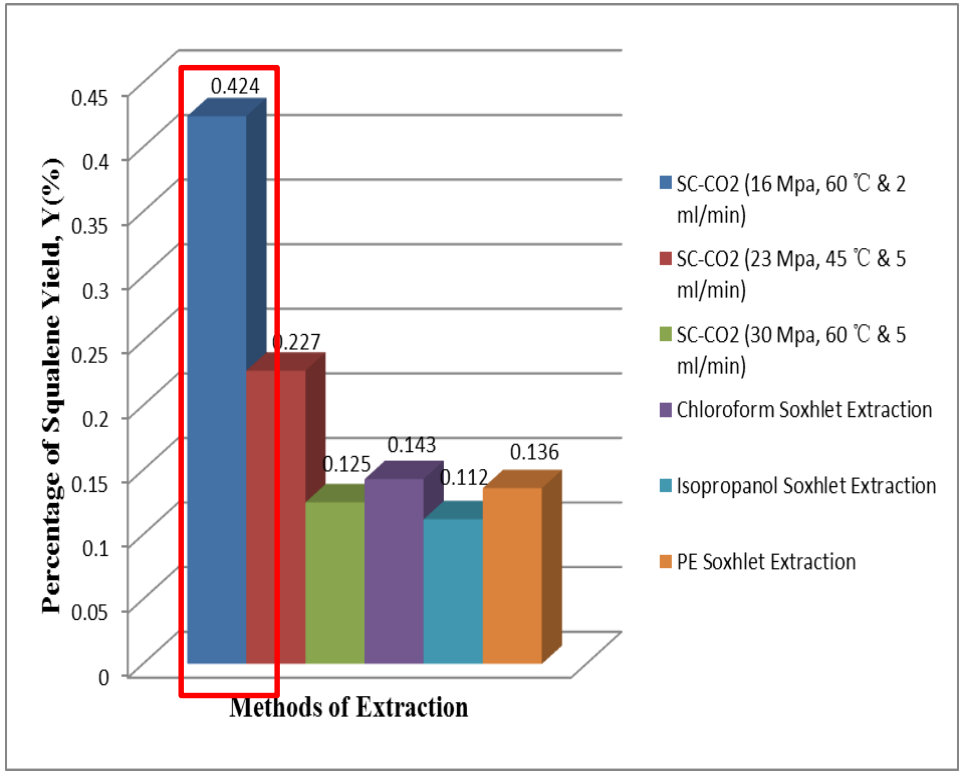


Squalene , $C_{30}H_{50}$

Supercritical Carbon Dioxide Extraction

(SC-CO2)

- **Low-cost substitute resource of Squalene which is usually found in shark and whale oils**

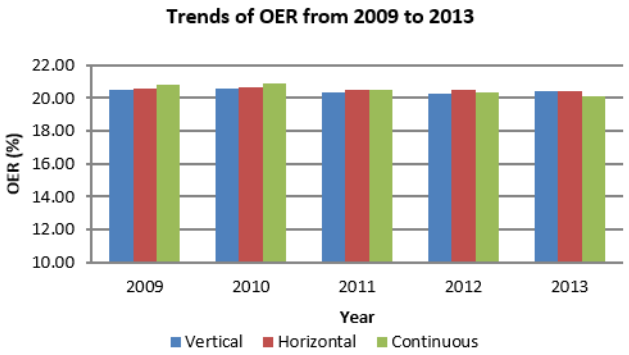


NEW FINDINGS FROM PROJECT 5

PROJECT 5: Determination of Social, Economic and Financial Feasibility of New Technologies In Malaysian Palm Oil Milling Industry

INDUSTRIAL SURVEY OF OIL PALM INDUSTRY

- **The national average oil extraction rate (OER) in Malaysia since 2009 until 2016 have fluctuated from a low of 20.04% in 2006 to a high of 20.62% in 2014, although there were a tremendous increase in the number of mills (from just 10 in 2010 to 24 in 2015) that have obtained more than 23% OER between 2010-2015.Clearly, changes in OER have a significant impact on the national economy. Changes in OER has a bearing on the economy as such changes can result in higher or lower output of Crude Palm Oil (CPO).**



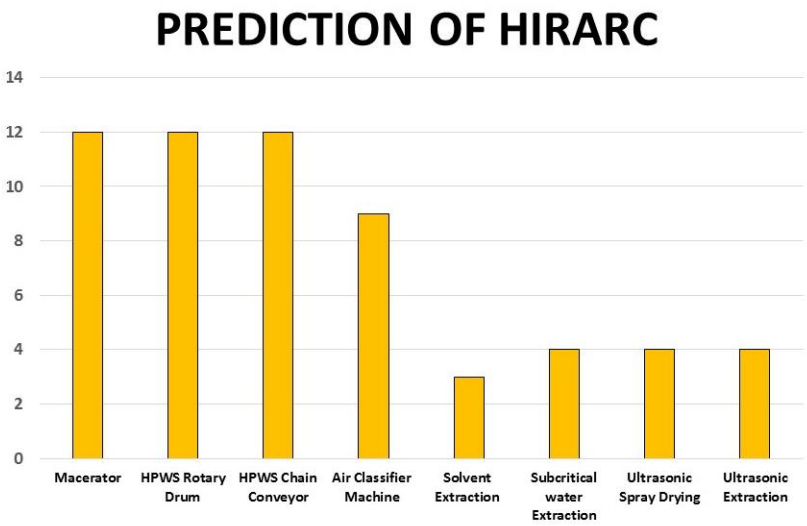
OER Performance for 2014 and 2015 (MPOB, 2016)

Region	2015 (%)	2014 (%)	Diff. (%)
Peninsular Malaysia	20.01	20.19	∨ 0.9
Sabah	21.57	21.49	∧ 0.4
Sarawak	20.15	20.43	∨ 1.4
Malaysia	20.46	20.62	∨ 0.8

NEW FINDINGS FROM PROJECT 5

New prediction of HIRARC for new technologies showed that the technologies is predicted to contribute medium to low risk towards workers.

	Type of Hazards					Categories of risk		
Workstations	Physical	Chemical	biological	ergonomic	psychosocia	Low	Medium	High
Loading ramp	18.5	0	15.6	12.2	14.3	15.8	13.8	0
Sterilizer	19	0	11.1	9.4	14.3	16.5	7.3	100
Press	8.5	0	11.1	10.8	14.3	8.1	16.3	0
Oil room	12.7	0	11.1	15.8	14.3	14.4	4.1	0
Kernel	7.1	4.8	17.8	15.8	14.3	10.8	17.9	0
Workshop	19.8	71.4	22.2	18	14.3	21.5	20.3	0
Boiler	14.4	23.8	11.1	18	14.3	12.9	20.3	0
Total (%)	100	100	100	100	100	100	100	100



NEW FINDINGS FROM PROJECT 5

KAP LEVEL

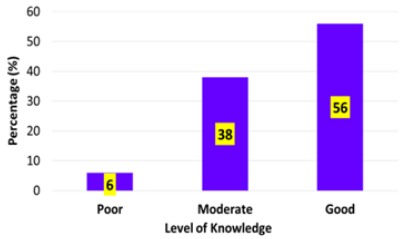


Figure 1: Level of Knowledge

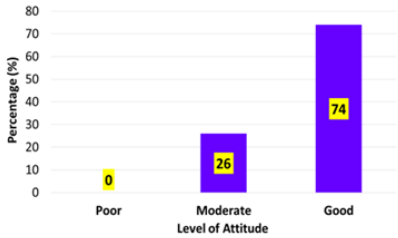


Figure 2: Level of Attitude

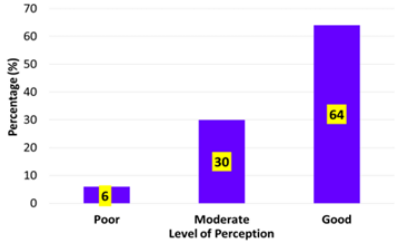
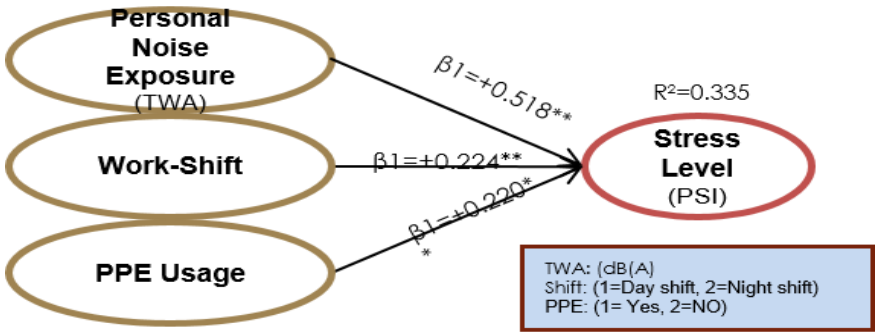


Figure 3: Level of Perception

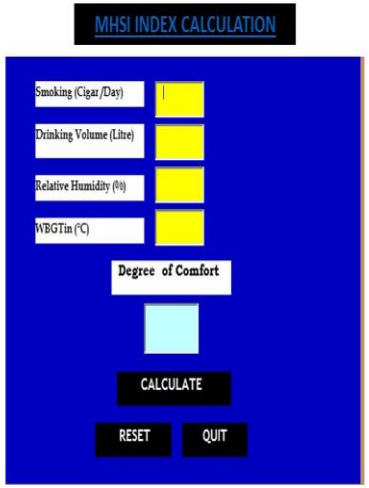
- The respondents were scored good (56%) level of knowledge, good (74%) level of attitude and good (64%) of perception.
- In line with study of KAP in textile workers who scored the good in knowledge, attitude and practising the preventive measure appropriately (Khoso & Nafess, 2015)

Statistical Model of Stress in Relation with Noise



PSI score= -39.308+0.570(TWA)+6.732 (Shift)+4.838(PPE)

DEVELOPMENT OF MALAYSIAN HEAT STRESS INDEX (MHSI)



MALAYSIAN HEAT STRESS INDEX	
Range	Degree of Thermal Comfort
<31.5	No Discomfort
31.6-37.2	Discomfort
>37.3	Dangerous

** The assumption of this index as follow: Range of Relative Humidity, % (20-100), Range of WBGTin, °C (29.5-40.0), Drinking Volume should be at least 0.5 litre and Smoking (number of cigarette/day), if non smoker = 0

- Workers good level in knowledge, attitude and perception towards hazard in palm oil mills.
- High stress level (PSI) due to personal noise exposure, work shift and PPE usage.
- MHSI software also developed to estimate the comfort level among palm oil mill works based on environmental factor and drinking water intake per day.

NEW FINDINGS FROM PROJECT 5

Economics and Financial Feasibility of New Extraction Technology

i) **OVERALL COST (15 Ton FFB/hr system)**

RM 6,000,000 plus RM 1,920,000 (OPEX for three years)

Product cost:

RM 1,020,000 (15 FFB t/hr oil extraction system) to RM 4,080,000 (60 FFB t/hr) /unit

Selling price:

RM 1,500,000 (15 FFB t/hr oil extraction system) to RM 6,000,000 (60 FFB t/hr) /unit

ii) **EXPECTED SALES:**

For first year (2021) as shown in the table: RM 58,500,000

1 stand alone 15 FFBt/hr system, 2 upgrade from 15 FFBt/hr to 30 FFB t/hr system, 4 stand alone 30 FFBt/hr system, 2 upgrade from 30 FFBt/hr to 45 FFBt/hr system, 4 stand alone 45 FFBt/hr system, 2 upgrade from 45 FFBt/hr to 60 FFBt/hr system and 3 stand alone 60 FFBt/hr system.

For year 2 (2022): RM 94,500,000

8 stand alone 30 FFBt/hr system, 4 upgrade from 30 FFBt/hr to 45 FFBt/hr system, 5 stand alone 45 FFBt/hr system, 4 upgrade from 45 FFBt/hr to 60 FFBt/hr system and 6 stand alone 60 FFBt/hr system.

iii) BREAK EVEN POINT

37 months based on the above projected cash flow table.

http://www.upm.edu.my/news/microns_innovation_helps_overcome_loss_of_crude_palm_oil_during_extraction-31284