ADVANCED MANUFACTURING AND VALUE ADDED MATERIALS

ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY

UPM: UTM: UiTM
Malaysia's palm oil industry is the 4th largest contributor to the economy at RM53 billion of gross national income (GNI). Malaysia's palm oil production is targeted to grow to 18 million tons per year (16.5 million tons for export) over the next 5 years. Among the 12 National Key Economic Areas (NKEAs) under the Economics Transformation Program (ETP), one of the targets is to achieve a GNI of RM178 billion by 2020 with a 47% improvement in salary for low-income independent smallholders and a reduction in dependence on foreign labor by 15 to 20%.
The aim of this program is to ensure the productivity gains in the palm oil industry have a significant impact on GNI growth.

8 EPPs are identified to grow incremental GNI of RM47.1 billion.

**EPP 4: INCREASING THE OIL EXTRACTION RATE**
To increase OER to 23 percent by 2020:
1. Improve the quality of FFB at mill gate with the help of MPOB enforcement officers
2. Enforce proper grading on incoming FFB, based on guidelines produced by MPOB
3. Millers and dealers of FFB must employ competent graders, certified by MPOB
4. FFB price must be paid according to the quality of FFB received

Investment: RM 3.0 billion from public funding
GNI: RM13.7 billion

**EPP 5: Developing biogas at palm oil mills**

**EPP 6: Developing oleo derivatives**
- EPP 7: Commercialising second generation biofuels
- EPP 8: Expediting growth in food- and health-based downstream segments.
Challenges

BRIDGING GAP

Potential yield

RM13.7 billion in GNI

National average

AVERAGE OER IN MALAYSIA

OER (ton oil/ton FFB)

30

25

20

19

YEAR

2005 2006 2007 2008 2009 2010P

Fruit and oil quality

Sterilization

Oil Extraction

Oil Purification and recovery

Economic, social and environmental impacts of new technology

National average

Potential yield

Challenges

RM13.7 billion in GNI

National average

Economic, social and environmental impacts of new technology
PROBLEM STATEMENT

1. The oil extraction rate (OER) which denote the amount obtained from the fresh fruit bunches (FFB) has been hovering below its optimum value around 19 to 20.00%.

2. Oil losses on FFB at 1.8% (w/w) or 40 tons of oil losses/day/mill or RM 120,000/day.
   - It is mainly due to inefficient milling technology and poor separation that lead to oil losses in the press cakes and waste water.

   - Inefficient sterilization contribute to incomplete detachment of fruits from FFB and lead to oil losses and high unstripped FFB (USB).

4. Palm oil mills use large quantity of water in their pressing process and kernel separation
   - Due to formation of emulsions at the oil water boundary at the clarifier, there is poor oil-water separation and lead to oil losses.
OUR SOLUTION: to enhance the productivity and sustainability of palm oil milling industry by improving the OER to 25%.
To study novel and practical automated fruit grading and oil quality monitoring technology in palm oil mills

To evaluate the increase in OER by using improved sterilizer and ultrasound assisted digester and clarifier

To address the fundamentals issues in oil purification technology for improving OER by reducing oil losses in palm oil mill

To elucidate the physico-chemical properties of press cake for opportunity to recover oil and kernel losses from press cake

To determine the social, economic and financial feasibility of the new technologies in Malaysian palm oil milling industry

To increase the productivity and sustainability of the oil palm industry which will contribute to national income (GNI)

To enhance the productivity and sustainability of Malaysian palm oil milling industry by improving the oil extraction rate to 25% through fundamental approach

SPECIFIC OBJECTIVES

OUTPUT

ACTIVITIES

Low cost fruit grading sensor and online FFA analyzer

Low unstripped FFB and increase in OER after pressing

50% oil recovery from EFB, USB, and condensate towards zero discharge.

Oil losses below 1% and kernel losses below 5%.

BCA on Economic and environment, social and safety & health
To assess the performance of new strategies in improving the productivity (OER, Oil losses, kernel losses, waste utilization, zero discharge) and evaluate the economic impacts of the new technologies.

To develop novel strategies for improving the processes by utilizing the advanced materials and processing technologies in enhancing the productivity of palm oil milling industry.

To examine the physical and chemical properties of FFB, EFB, press cakes, waste water and crude palm oil for better understanding of the underlying mechanisms at all stages of palm oil milling processes.
PROJECT 1: AUTOMATED FRUIT GRADING AND OIL QUALITY MONITORING

**FRUIT GRADING**

Sub-Project 1: Establishing the relationship between microwave reflection, moisture content and oil content of fruits at various stages of bunch ripeness

Sub-Project 4: Developing rapid and automated monitoring system for FFA in palm oil utilizing advanced materials and techniques (Microwave based technique, lab on chip based technique).

**OIL QUALITY MONITORING**

Sub-Project 2: Developing a sensor for quick and accurate determination of the quality EFB by establishing the relationship between the dielectric properties of oil palm mesocarp and palm oil.

Sub-Project 3: Studying new materials (magnetic nanoparticles and silicon nanostructure) and reaction scheme (enzymatic reaction) for novel FFA detection system in palm oil and condensate.

Sub-Project 3: Studying new materials (magnetic nanoparticles and silicon nanostructure) and reaction scheme (enzymatic reaction) for novel FFA detection system in palm oil and condensate.
PROJECT 2: ENHANCED STERILIZATION AND OIL EXTRACTION TECHNOLOGY

PREPARATION AND EXTRACTION STAGE

Sub-Project 1: Analyzing the chemistry of fruit-stalk carbohydrate bond and factors that affect the hydrolysis of the binding carbohydrates during sterilization of FFB.

Sub-Project 2: Study the effectiveness of the existing sterilizer by incorporating the thermodynamic effects on the fruits to reduce USB and improve OER.

Sub-Project 3: Comprehensive study on the performance of the existing digester and provides opportunities to improve the oil recovery using ultrasonication.

Sub-Project 4: Improving the processing conditions of existing pressing process to maximize oil recovery through engineering and scientific approaches.

BACK
Sub-Project 1: Determination of oil loss in the empty fruit bunch (EFB) and unstripped bunch (USB) and provides suitable devices to further extract the available oil as to improve the overall oil extraction rate (OER).

Sub-Project 2: Detailed study on the performance of the existing decanter system and provides opportunities to improve the system and oil recovery from the cake produced.

Sub-Project 3: Detailed audit on the oil loss from other sources such as pipings, processing tanks, other purification steps and storage tank and provide solutions to reduce or eliminate then through engineering or other approaches.

Sub-Project 4: Study the effectiveness of the existing sludge-pit design and provide information to further improve the existing design to increase the oil recovery rate from the sludge-pit.

PROJECT 3: RECOVERY OF CRUDE PALM OIL FROM EMPTY FRUIT BUNCHES (EFB), UNSTRIPPED BUNCHES (USB), PALM OIL MILL EFFLUENT (POME) AND DECANTER CAKE (DC)
PROJECT 4: DEVELOPMENT OF GREEN TECHNOLOGY TO RECOVER OIL FROM PRESS CAKES AND TO REDUCE KERNEL LOSSES

Sub-Project 1: Determining the physico-chemical composition of palm press cake to analyse its interphase behaviour to improve oil and kernel recovery

Sub-Project 2: Developing mathematical models for oil recovery process (design and models) for the preliminary design of screw press (lab scale) for palm oil recovery process unit

Sub-Project 3: Studying the mass and heat transfer mechanisms involved in solvent free extraction of oil and evaluating the kinetics of oil extraction

Sub-Project 4: Developing an effective method for dry separation of broken palm kernels from palm kernels by understanding the effects of different air velocity to the separation of loose fibres from palm kernel
Economic, social and environmental impacts of new technology

(1) Determining the physical impacts of new technology developed on the environment and human

(2) Identification of costs and benefits including the environmental effects of new technology developed for the Malaysian palm oil milling industry and under the conventional technology

(3) Estimating the costs and benefits of the new technology and conventional technology based on prevailing market prices in order to calculate the incremental benefits and costs

(4) Determining the economic and financial feasibility of new technology using investment criteria: net present value (NPV), benefit cost ratio (B/C ratio) and internal rate of return (IRR)

(5) Evaluating distribution impact analysis for different groups (consumer, government, and industry) resulting from an introduction of new technology for the Malaysian palm oil industry and national income

(6) Conducting sensitivity and risk analysis of the effects of market parameters such as price, cost, interest rate on investment criteria

(7) Evaluating the impacts of new technology on social, safety and health of the workers and society

PROJECT 5: TO DETERMINE THE SOCIAL, ECONOMIC AND FINANCIAL FEASIBILITY OF THE NEW TECHNOLOGIES IN MALAYSIAN PALM OIL MILLING INDUSTRY
ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY

- Improved OER to 25%
- RM50 million/year per mill
- Potential income of RM14 billion/yr
- Reduced total oil losses to below 1.0%
- Reduced kernel losses to below 5%
- Palm oil milling process with zero discharge
- Fully automated oil palm grading/oil quality system
- Improved technology
- 100 publications
- 2 patents
- 10 PhD
- 10 MS
- Trained workers
Enhancing Productivity and Sustainability of Palm Oil Milling Industry

(Prof. Dr Robiah Yunus - UPM)

1. Studies on novel and practical automated fruit grading and oil quality monitoring technology in palm oil mills (Assoc.Prof. Dr. Norazah – UPM)

2. Social, economic and financial feasibility of new technologies in palm oil mills (Prof Dr Awang Noor Abd Ghani – UPM)

3. Studies on the use of advanced manufacturing technology in improving oil extraction rate (OER) and reducing un-striped FFB (Prof. Dr. Robiah Yunus - UPM)

4. Improvement in purification technology to recover oil loses from EFB,USB, sludge and wastewater towards zero discharge (Dr Alawi Sulaiman (UiTM))

5. Development of green technology to recover oil from press cakes and to reduce kernel losses (Assoc Prof Mustapha Kamal Abdul Aziz (UTM))

With Knowledge We Serve
## THE TEAM

<table>
<thead>
<tr>
<th>PROJECT LEADERS</th>
<th>Expertise</th>
<th>H-INDEX</th>
<th>CITATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr. Robiah Yunus</td>
<td>Palm oil product and process development</td>
<td>10</td>
<td>217</td>
</tr>
<tr>
<td>Assoc Prof Dr Nor Azah Yusof</td>
<td>Sensor technology</td>
<td>7</td>
<td>142</td>
</tr>
<tr>
<td>Prof Dr Awang Noor Abd Ghani</td>
<td>Agro economics, LCA</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Assoc Prof Mustapha Kamal Abdul Aziz (UTM)</td>
<td>Palm oil milling technology</td>
<td>4</td>
<td>46</td>
</tr>
<tr>
<td>Dr Alawi Sulaiman (UiTM)</td>
<td>EFB composting, palm oil mills waste water treatment</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>

- **Publications:** >100 ISI
- **Commercialized products:** 3
- **Patent filed:** 15 (3 Granted)
# TEAM MEMBERS

## Project 1
- **Project leader:** Assoc. Prof. Dr. Nor Azah Yusof (UPM)
- Dr. Zulkifly Abbas (UPM)
- Dr. You Kok Yeow (UTM)
- Assoc. Prof. Dr. Mohd Nizar Hamidon (UPM)
- Assoc. Prof. Dr. Abdul Rashid Mohamed Shariff (UPM)
- Dr Mohamad Din (MPOB)

## Project 2
- **Project Leaders:**
  - Prof. Dr. Robiah Yunus (UPM) – Chemical Engineering
  - Assoc Prof Dr Abdul Azis Ariffin (UPM)
  - Dr Zurina Zainal Abidin (UPM)
  - Dr Chong Gun Hean (UPM)
  - MPOB

## Project 5
- **Project Leaders:**
  - Prof. Dr. Awang Noor Abd. Ghani (UPM)
  - Prof. Dr. Mohd. Shahwahid Hj. Othman (UPM)
  - Dr. Shamsul Bahari Mohd Tamrin (UPM)
  - Dr Norhasliza
  - Dr. Alias Radam (UPM)
TEAM MEMBERS

**Project 3**
- **Project leader**: Dr. Alawi Sulaiman (UiTM)
- Dr. Azhari Samsu Baharuddin (UPM)
- Dr-Ing. Mohd Noriznan Mokhtar (UPM)

**Project 4**
- **Project Leaders**: Assoc Prof Mustapha Kamal Abdul Aziz (UTM)
- Assoc Prof Dr Norazian Morad (UTM)
- Dr. Mohd Halim Shah Ismail (UPM)
- Dr Mohamad Amran Mohd Salleh (UPM)
- Dr Rosnah Shamsudin (UPM)
## PROJECT RISKS

### RISKS

- Industry/workers reluctance to adopt new technology
- Inconsistent fruit (FFB) quality due to poor grading
- High costs of technology upgrading
- Stricter legislations

### MITIGATION

- Road shows and hands on training given by the experts from the university
- R&D to only focus on improving the existing technology
- Incentives from the government to the mills with 25% OER

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**ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY**
SUMMARY

LRGS
RM14.2 million

ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY

OER 25%
RM 7 billion/yr
(50% of 434 mills)

Thank You
robiah@eng.upm.edu.my
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Sub-Project 4: Improving the processing conditions of existing pressing process to maximize oil recovery through engineering and scientific approaches.
Project 2: Enhanced Sterilization and Oil Extraction Technology

- Maximizing the hydrolysis of binding sugar molecule to allow complete detachment of fruits from the FFB
- Maintaining the intactness of the oil bearing mesocarp by keeping high water to oil ratio in press fiber
Project 3: Recovery of Crude Palm Oil From Empty Fruit Bunches (EFB), Unstripped Bunches (USB), Palm Oil Mill Effluent (POME) and Decanter Cake (DC)

**PURIFICATION STAGE IN THE PALM OIL MILL PROCESS**

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