INCREASING PALM OIL YIELDS BY MEASURING OIL RECOVERY EFFICIENCY FROM THE FIELDS TO THE MILLS

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CPO yield components

• Yield of FFB produced in the field.
• FFBs harvested and delivered to mill
• Oil content of FFBs plus loose fruits delivered to the mill.
• Extraction efficiency of the mill.
Primary and Final Product

• Primary Product is Fresh Fruit Bunches
• Most important Final Product is Crude Palm Oil (CPO)
Oil Yield and FFB Yield

• 6 t CPO ha$^{-1}$ can be obtained from:
  – 30.0 t ha$^{-1}$ FFB at 20% oil extraction or
  – 26.1 t ha$^{-1}$ FFB at 23% oil extraction
Primary and Final Products and Costs

- Oil palm mills pay producers essentially for the Primary Product, not for a measured content of Final Product.
- Costs of harvest, transport and initial processing proportional to the mass of the Primary Product.
- Higher ratios of Final Product to Primary Product (i.e., higher oil content) result in lower costs of harvest, transport and initial processing costs per unit Final Product.
# Importance of Oil Content

<table>
<thead>
<tr>
<th>Extraction rate (%)</th>
<th>t FFB per t CPO</th>
<th>Cost of FFB per t FFB at mill</th>
<th>Cost of t CPO in FFB</th>
<th>Cost per t CPO primary process</th>
<th>Cost per t CPO of FFB + Primary Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>5.56</td>
<td>474 *</td>
<td>2633</td>
<td>167</td>
<td>2800</td>
</tr>
<tr>
<td>20</td>
<td>5.00</td>
<td>522</td>
<td>2610</td>
<td>150</td>
<td>2760</td>
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<tr>
<td>22</td>
<td>4.54</td>
<td>514</td>
<td>2336</td>
<td>136</td>
<td>2473</td>
</tr>
</tbody>
</table>

**Malaysian Ringit**  
Costs quoted 14th June 2014 MYR, * Grade C  
Cost of primary processing per t FFB  30 MYR
Massive variation in Oil Content

\[ y = 0.0056 \ln(x) + 0.2567 \]
\[ R^2 = 0.0203 \]
Major questions

• How may we increase the oil content of the bunches?
• How can we ensure the oil produced in the field reaches the mill?
• How can mills increase the efficiency of extraction?
Basic Principle: What you don’t measure you cannot manage.

- Sugar mills and cassava (tapioca) starch factories routinely measure:
  - the amount of final product arriving at the mills and pay accordingly
  - the efficiency of extraction of the final product so that they can monitor efficiency of mill operations.

- In oil palm loose fruits are used to determine quality.

- With current methods it is impossible to carry out a mass balance of oil in the mill processing.
How could we manage to increase oil content and reduce oil losses

• Managing increased oil content:
  – Selection of high oil content populations and management for high oil content
  – Harvest bunches when oil content is high

• Extracting all the oil produced in the field
  – Harvest all bunches
  – Harvest ripe bunches
  – Transport and process bunches rapidly
  – Increase extraction efficiency in mill
    • Higher extraction efficiency with higher oil content.
    • Processing efficiency
Critical Measurements

• **Field Oil Recovery Efficiency (FORE)**
  – The oil delivered to the mill as a percentage of the total oil produced in the field if all the bunches were at optimal maturity and there were no loose fruit losses.

• **Estimated Potential Oil Extraction Rate (EOER\textsubscript{p})**
  – The weight of oil in the bunches as a percentage of the overall FFB weight delivered to the mill.

• **Mill Oil Recovery Efficiency (MORE).**
  – The weight of the oil extracted as a percentage of the weight of oil delivered to the mill in the bunches.
Specific data needed

- \( \text{BNO}_{\text{NH}} \), Bunch number not harvested
- \( \text{BNO} \), Bunch number
- \( \text{ELF}_B \), Number of loose fruits per bunch
- \( \text{LFW}_{\text{AV}} \), Average loose fruit weight
- \( \text{FFB}_R \), Weight of FFB at the weighbridge
- \( \text{PFFB}_{\text{IM}} \), percentage unripe fruit bunches
- \( \text{EOC}_M \), Estimated Oil Content of mature FFB
- \( \text{EOC}_\text{LF} \), Estimated Oil Content of loose fruit
- \( \text{EOC}_{\text{IM}} \), Oil content of immature or unripe FFB
- \( \text{TOO} \), Total oil output

Colour code: Standard measurement, harvest audit, Bunch Analysis, estimated
Currently standard measures

- $\text{FFB}_R$, Weight of FFB at the weighbridge
- BNO, Bunch number
- $\text{PFFB}_{\text{IM}}$, Percentage of unripe fruits obtained from the evaluation on delivery at the mill*
- TOO total oil output

*Note: Unripe fruits also obtained from harvest audits, but mill estimates always lower.
Can be measured by Harvest Audits

- $\text{ELF}_B$, Number of loose fruits per bunch
- $\text{BNO}_{\text{NH}}$, Bunch number not harvested
  - Colombian flagging system is interesting
- $\text{PFFB}_{\text{IM}}$, Percentage of unripe fruits
Can be estimated by Bunch Analysis

- \( \text{LFW}_{AV} \), Average loose fruit weight
- \( \text{EOC}_M \), Estimated Oil Content of mature FFB
- \( \text{EOC}_{LF} \), Estimated Oil Content of loose fruit
- \( \text{EOC}_{IM} \), Oil content of immature or unripe FFB taken as a percentage of \( \text{EOC}_M \)
Bunch Analysis

• Has been known for a long time but is not widely used on a routine basis.

• Attempts to develop new methods
  – Nurul Aslah I. 2010. *Quick determination of actual oil content in oil palm fruit bunch using near infra red (NIR) scanning spectrometer.* Universiti Malaysia Pahang
Alternatives to Bunch Analysis

- Near Infrared Reflectance (NIR) accurately determines the composition of many biological products.
- NIR systems are initially expensive and need careful calibration.
- Operational costs once calibrated are low and results are obtained extremely rapidly.
Alternatives to Bunch Analysis

• Cane sugar mills often use a core sampler to take a representative sample of all cane arriving at the mill in wagons. The sample is then ground or milled and read directly by Near Infrared Reflectance.

• Could a similar system be developed for oil palm that would determine Estimated Potential Oil Extraction Rate (EOER$_p$) for all batches entering mills?
Core Sampler
Consequences of routine EOER\textsubscript{p} Measurement

- Mills pay for the true oil in FFB.
- Growers have incentive to improve oil content.
- Growers obtain feedback on quality of FFB and use this to improve quality.
- Transparent evaluation.
  - Growers and mills trust each other.
- Milling Overall Recovery Efficiency used to improve processes.
Harvest Audits

Harvest audits, coupled with the accurate determination of $\text{EOER}_p$, would allow growers to:

– Determine losses due to missing FFBs at harvest
– Use the information obtained from the analysis to determine harvest protocols that maximize oil content and at the same time minimize losses.
Conclusion

• Improved monitoring will:
  – Reduce friction between growers and mills
  – Provide incentives for growers to improve the quality of FFB
  – Provide insights to growers on how to improve FFB quality and reduce losses in the field.
  – Allow mills to obtain better quality FFB.
  – Allow mills to measure extraction efficiency and hence improve extraction processes