Enzymes for Improving Oil Yield in Palm Oil Extraction

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Advanced Enzyme Technologies Ltd., India
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A bit about us

- Pioneered enzyme production in India in 1958
- Leading producer of enzymes in South Asia
- Exports to 45+ countries across 6 continents
- 60+ enzymes and 400+ products
- Safe, eco-friendly and biodegradable solutions for 25+ industries
- State-of-the-art manufacturing facilities that are ISO and WHO cGMP certified
1958: India's first enzyme manufacturing plant (for Papain) is pioneered by Mr. L.C. Rathi

1978: Rathi Papains Pvt. Ltd. was incorporated

1986: Specialty Enzymes & Biotechnologies, United States is set up

1989: Advanced Enzymes is incorporated (Originally under the name of Advanced Biochemicals Pvt. Ltd.)

1994: Commissioning of our 1\textsuperscript{st} fermentation facility at Sinnar, Maharashtra

2008: Commissioning of 2\textsuperscript{nd} fermentation facility at Pithampur, Madhya Pradesh

2016: Listed in stock exchange (BSE)
INTRODUCTION
Facts about Palm Oil

Palm Oil is beautifully defined by Ca’da Mosto, as - “It has the scent of violets, the taste of olive oil and a color which tinges food like saffron but is more attractive”

Current Scenario

- Oil & Fats Production (world 2016/17F) ≈ 213.5 million tons
- Palm Oil Production (2016) ≈ 58.9 million tons
  - Indonesia : 32.1 million tons
  - Malaysia : 17.3 million tons
- Projected demand by 2025 : 85 million tons
- Largest importers of palm oil : India, European Union & China

Source : Oil World

Palm Oil Plantation  Fresh Fruit Bunch  Palm Fruit  Palm Oil
Palm fruit cultivation requires less harvested area to produce the major percentage of vegetable oil.

**Harvested Area of Major Oilseeds**
- Palm: 6.0%
- Soya: 43.0%
- Rapeseed: 13.0%
- Sunflower: 9.0%
- Others: 29.0%

**Oil Production**
- Palm Oil: 30%
- Soya Oil: 25%
- Sun Oil: 8%
- Rapeseed Oil: 12%
- Other Oils: 25%

**Source:** Presentation by Thomas Mielke (Oil World) in POC 2017
Palm Oil: Most efficient oilseed crop 2/2

1. Cost Benefit
2. Expanding Applications
   a. Edible (Specialty Fats)
   b. Non-edible sectors (Oleochemicals, Biodiesel, Cosmetics, etc.)
3. Increase in world population and income
4. Healthy: High carotene and vitamin E content, no risk of trans fatty acid

1. Environmental concerns related to Palm Plantation
2. Limited land availability
3. Climatic uncertainties (El Nino, rainfall, etc.)
4. Oil losses that happen during processing

Drivers

Challenges

Major Jurisdictions

Road Ahead

- Nigeria: 970,000
- Columbia: 1,130,000
- Thailand: 2,200,000
- Malaysia: 20,100,000
- Indonesia: 32,000,000

Indonesia and Malaysia account for 85% of world's Palm Oil

1. Increase the Oil Extraction Rate by optimising production process
2. Accelerate re-planting of palm fruits
3. Make best use out of all the waste that is generated during palm oil production
4. Commercialize second generation bio fuels
Malaysia: Decline in Oil Productivity in Recent Years

The following reasons are contributing to the fall in palm oil productivity in recent years:

1. Environmental Concerns / Sustainability / Water crisis
2. Old plantations are yielding lower fruits, leading to reduced production

Source: Presentation by Thomas Mielke (Oil World) in POC 2017
PALM OIL EXTRACTION
Cell and cell wall components involved in palm oil extraction

Composition of mass which enters the digester

<table>
<thead>
<tr>
<th>Structural Characteristics</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total lipid content</td>
<td>56.68</td>
</tr>
<tr>
<td>Soluble sugars</td>
<td>2.89</td>
</tr>
<tr>
<td>Total structural carbohydrate</td>
<td>13.76</td>
</tr>
<tr>
<td>Glucan</td>
<td>8.27</td>
</tr>
<tr>
<td>Xylan</td>
<td>4.52</td>
</tr>
<tr>
<td>Arabinan</td>
<td>0.97</td>
</tr>
<tr>
<td>Soluble lignin</td>
<td>3.58</td>
</tr>
<tr>
<td>Insoluble lignin</td>
<td>0.038</td>
</tr>
<tr>
<td>Water extractives</td>
<td>17.16</td>
</tr>
<tr>
<td>Ethanol extractives</td>
<td>17.98</td>
</tr>
</tbody>
</table>


Fresh palm fruit
O=Oil, CW=Cell Wall, ML=Middle Lamella

Mass Passing to Digester
Enzymatic Oil Extraction: A boon

Palm Oil Extraction Process

**Mechanical Process**
- Sterilization, bunch stripping or threshing, digestion of fruits, pressing of pulp, followed by clarification and purification

**Disadvantages:**
- Oil loss at every step which cannot be recovered
- Time consuming process
- Intense human labour required
- Harsh treatment leads to loss of oil
- Amount of water required is huge
- High energy consumption

**Enzymatic process**
- Stripped fruits are subjected to enzymatic treatment throughout the digester followed by pressing for maximum oil extraction

**Advantages:**
- Almost complete oil recovery
- Overall nutritional quality is maintained
- Higher anti-oxidant concentrations in extracted oil
- Improved mash viscosity, oil bleachability
- Reduced FFA content in the final oil
Mass Balance

FFB: Fresh Fruit Bunch
MF: Mesocarp Fiber
EFB: Empty Fruit Bunch
POME: Palm Oil Mill Effluent

FFB: 100 kg
Fruits: 65.71 kg
EFB: 24.29 kg
Debris: 10 kg

Oil Extraction Rate: 20.34 kg
Mill Oil Loss: 1.86 kg
Bounded Oil Loss: 3.82 kg
Oil to Bunch: 26.02 kg

Shell: 5.26 kg
Kernel: 4.6 kg

MF: 0.4 – 0.6% Loss
EFB: 0.4 – 0.6% Loss
POME: 0.7 – 1.0% Loss

Moist MF: 29.83 kg
ROLE OF AETL IN PALM OIL EXTRACTION
With the focus of enzyme application getting diversified in various industries, AETLs initiative to start palm oil extraction using enzymes has rendered good results.

Success and positive results at every step, it has been a morale booster for AETL to further expand its work in the area of palm oil extraction.

AETL is working in close association with palm oil producers in India, Malaysia, Indonesia and Thailand.
Laboratory Process

Raw Fruit → Sterilization in Autoclave 146°C, 90 min → Threshing → Set 1: Enzyme addition incubate @ > 50°C, 30 – 120 mins. reqd. water added
Set 2: Control

Fiber + Seed → Filter → Oil & Liquid layer

Hot water wash → Oil & Liquid layer

Recovered Oil & Liquid

Centrifuge → Sediment

Oil & Liquid layer

Hot water wash & Centrifuge
Observations 1/2

**Viscosity**

**CONTROL**
- Highly viscous

**ENZYME TREATED**
- Free flowing

**Filtrate**

**CONTROL**
- Lower quantity

**ENZYME TREATED**
- High quantity
Observations 2/2

**CONTROL**
- Fiber and Seed component: Dark color and gummy
- Oil Extracted: High sediments and dark color

**ENZYME TREATED**
- Fiber and Seed component: Dry and non-gummy
- Oil Extracted: Clear and light color
## Sample Data from Laboratory Set Up

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Enzyme Treated Palm Fruit</th>
<th>Control Palm Fruit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity of mash (cP)</td>
<td>&lt; 50</td>
<td>&gt; 1500</td>
</tr>
<tr>
<td>Oil recovered (ml)</td>
<td>54 – 71</td>
<td>27 – 40</td>
</tr>
<tr>
<td>Oil recovery as % of fruit</td>
<td>38.6% – 50.7%</td>
<td>19.3 – 28.6%</td>
</tr>
<tr>
<td>Estimated oil recovery as % of FFB</td>
<td>28.9% – 38.0%</td>
<td>14.5% - 21.4%</td>
</tr>
</tbody>
</table>

*Note: The variations are observed due to origin, ripeness and size of fruit*
Plant Process

FFB → Steriliser → Stripper / Thresher → Digestor → Screw Press

Vacuum Dryer ← Purifier ← Clarifier ← Vibro Screen

Oil ← Nuts ← Fibre

Palm Kernel Oil

Crude Palm Oil (CPO)
## Summary of Plant Trial Results

### Qualitative Parameters:

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Conventional Process</th>
<th>Process using Enzyme Blend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre (screw press output)</td>
<td>Still having gums attached Dark colour &amp; glossy (indicating oil residue)</td>
<td>Light colour and no gums visible (indicating lesser oil residue)</td>
</tr>
</tbody>
</table>
## Summary of Plant Trial Results

### Qualitative Parameters:

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<tr>
<td>CPO Quality</td>
<td>Partially hazy / suspended particles observed</td>
<td>Less hazy / less suspended particles</td>
</tr>
</tbody>
</table>
Calculations – Increased OER

- Increase in Oil Yield by 8%
  - Oil increase 8% x 20.34 kg = 1.63 kg
  - In terms of OER = 20.34 + 1.63 = 21.97%

- Process throughput: 40 ton FFB / hour

- Assuming 1.5% increase in OER

- Additional Oil: 40 T/h x 1.5% x 20 h/day
  = 12 tons per day
  Or **3,600 Tons per year** (300 days)!
  i.e. ~ **2.2 million USD per year!!**
### AETL’s enzyme blends – Asset to palm oil producers

**PROVEN**

- Increases the oil yield by 5-15% i.e. about 10 – 30 kg of oil per ton of FFB.
- Lesser Effluent, easier biomass treatment
- Enzymes are lipophobic, no traces remain in oil
- Destabilization of oil-water emulsion
  → easier separation in decanters
  → Improved filterability

**FURTHER RESEARCH FOCUS**

- Higher recovery of Oleoceuticals (tocotrienols & carotenoids)
- Reduces/eliminates the need for organic solvents
- Possibility to eliminate degumming step
- Potential to deliver fermentable sugar solution which can be readily utilized for ethanol production
- Increase in overall processing capacity
CONCLUSION
Possible revolution in palm oil industry!

Major Issues faced by Palm Oil Industry:

- Rise in Oil Demand
- Limited land Availability
- Low Productivity
- Loss of Oil at every step of Processing

Possible Solution:

Make the best output in terms of oil extracted

How to achieve the solution:

USE ENZYMES
Solutions from Advanced Enzymes:

Apart from Palm Oil Extraction, Advanced Enzymes also offers solutions for:

- Yield improvement in PKO production along with High value PK Meal using Enzymes
- Free Fatty Acid Reduction in CPO & other oils by Enzymatic Remediation
- Enzymatic Hydrolysis of CPO and other oils to produce fatty acids
- Enzymatic Esterification for Production of Mono & Di Esters from various fatty acids
- Production of Enzymatic Biodiesel
- Enzymatic Interesterification for production of trans-free fats
Solutions from Advanced Enzymes:

...continued

- Holding global patent on use of Enzymes as Plant Growth Promoter
- Production of Structured Lipids like Human Milk Fat Substitutes (HMFS) and Cocoa Butter Equivalents (CBE)
- Fish Oil Applications: Production of Ethyl Esters and Omega 3 concentrates
- Biomass
- Production of Mono- & Di Glycerides
- Oil Degumming
References

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  - http://theoilpalm.org/the-future-of-palm-oil/
  - http://www.schusterinstituteinvestigations.org/palm-oil-industry-response
- AETL’s lab trial data
- AETL’s plant trial data
- AETL PCT application
THANK YOU!