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# **Products, residues and wastes in the UK palm oil supply chain**

Analysis to inform UK guidance development

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# Content

- Context & scope
- Method & approach
- Mapping the palm oil supply chain
  - Oil palm farming
  - Oil palm processing
  - The complete supply chain
- Products, residues and wastes
- Conclusions so far

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# Background

- From the EC:
  - Article 12(2) from the RED: 'double counting' for residues and wastes
  - Section 5.2 from 2010 EC communication on practical implementation sustainability schemes
- Question: What are residues and wastes?

# Goal and approach

- Goals:
  - Identify possible (types of) (co)products and residues / wastes
  - Test practical application of guiding principles in classification materials: (co)product or residue / waste?
- The supply chain of palm oil was selected as test chain because:
  - Palm oil products are diverse in applications, including biofuels and food
  - Significant traded volumes
  - Materials with different economic values

# Data collection

- Desk-based collection and review of publicly available sources, including report, (scientific) literature and information available on websites;
- Interviews by telephone with field expert and stakeholders.

# Four guiding principles

1. The main process should not have been deliberately modified to produce a larger quantity or another quality of the material, at the expense of the main product(s);
2. The primary aim of the process is the material(s) to which the process normally is optimized. Such materials should be regarded as main product or co-product, and the remaining materials are residues (or waste);
3. Primary technology choice for a process should not be determining. Instead the optimization and management of the existing process should be determining;
4. If a material from a process represents/constitutes an essential/considerable outcome of the process (amount and economical value) and this material has uses other than energy production, it should be regarded as a co-product, even where the process is not optimized for this material.

# Four guiding principles

- 1 & 2: Deduced directly from communication of EC
  - 3: Alternative production processes not necessarily 'deliberately modified' as referred to in principle 1
  - 4: materials with a considerable amount and/or economic value should be regarded as a co-products (and not a residue or waste).
- 
- → Principle 1 – 3 require knowledge of processes
  - → 4<sup>th</sup> principle requires knowledge on economic values of all materials

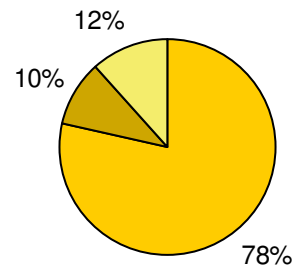


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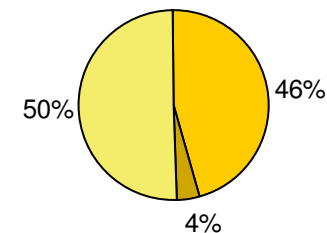
# Oil palm production and import UK [3]

2009 global production (about 55 million tonnes)



■ Palm oil ■ Palm kernel oil ■ Palm kernel meal

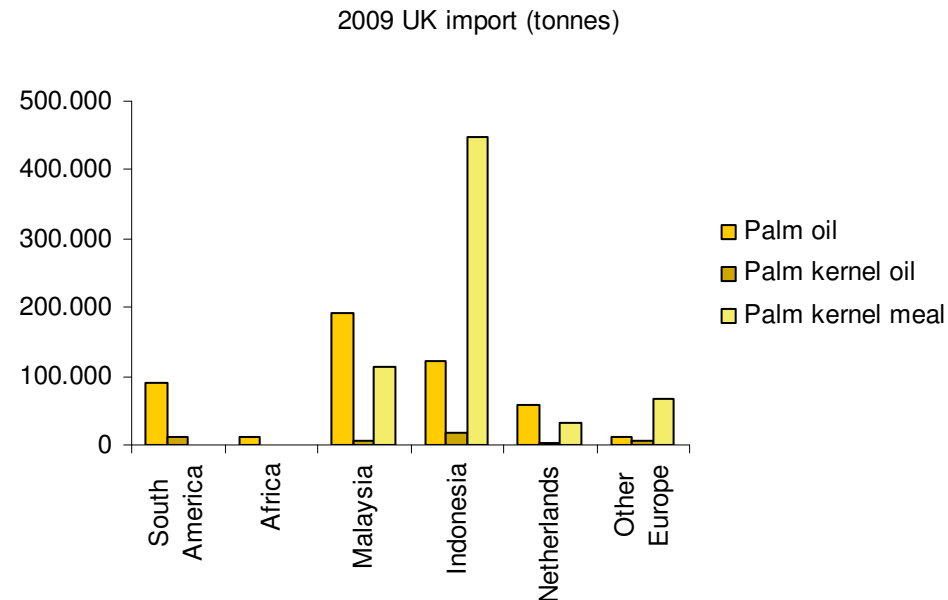
2009 UK import (about 1.3 million tonnes)



■ Palm oil ■ Palm kernel oil ■ Palm kernel meal

- Relative large import of PKM compared to oils
- UK import CPO, PKO and PKM has decreased past 5 years
- Stable import figures for coming years expected

# UK palm oil import [3]



- About 88% of UK import from main producing countries Malaysia and Indonesia
- Large portion of oil imported from EU countries most likely also from Malaysia and Indonesia
- Conclusion: Focus of current study is on oil palm products from Malaysia and Indonesia

# Oil palm nursery



Pre-nursery: palm seeds are sown in poly bags and cultivated for 3 – 4 months.



Nursery, early stage: seedlings are cultivated in larger poly bags for 3 – 5 months.



Nursery, final stage: Palms of  $\approx$  1 year old are ready for planting in plantation.

# Oil palm plantation



Newly planted palms. On average 142 palms per hectare.



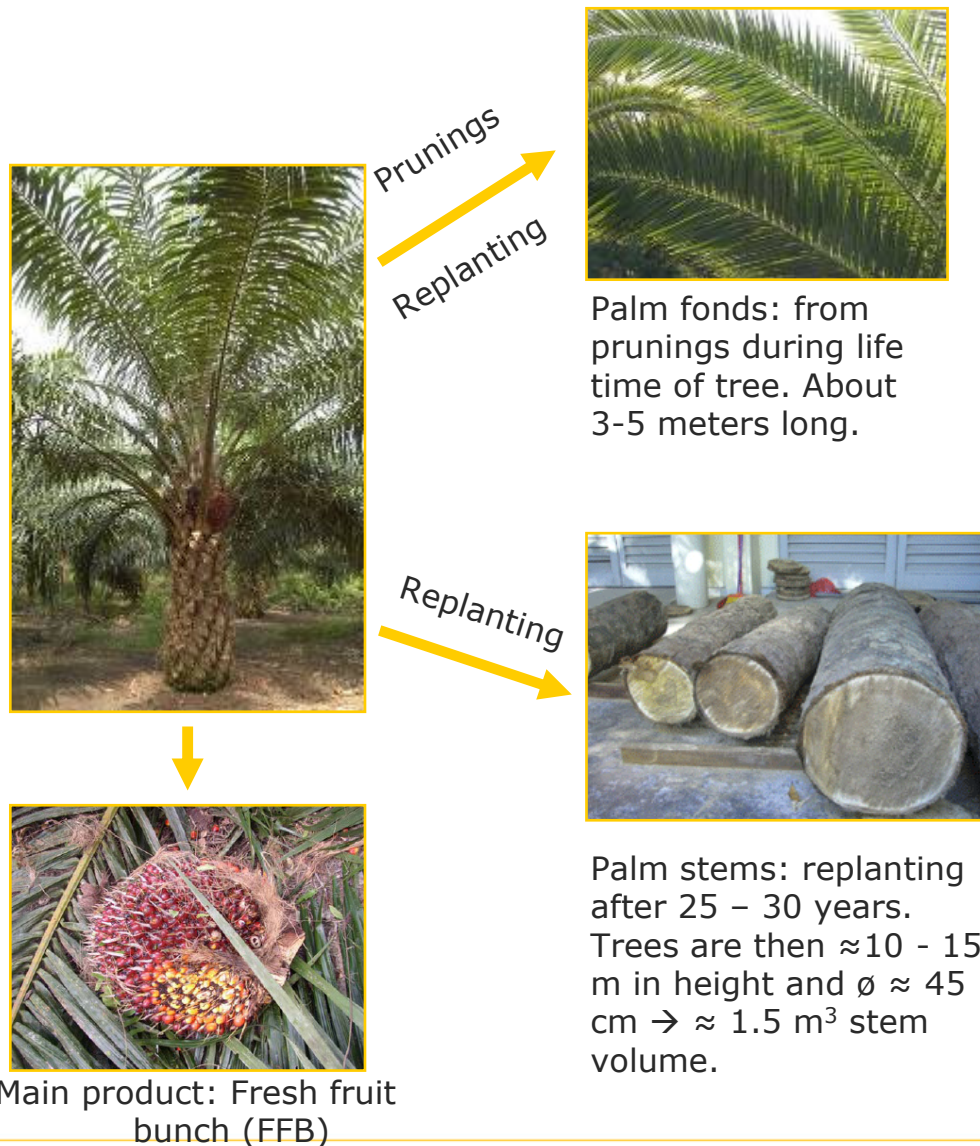
Mature oil palm. The trees are mature and producing from 2 until approximately 25 years after planting.

One Fresh fruit bunch (FFB) is harvested manually on alternate weeks, year round. The fronds (leaves) below the FFB are pruned to get access to the FFB. The fronds are placed in the fields for mulching (inset).



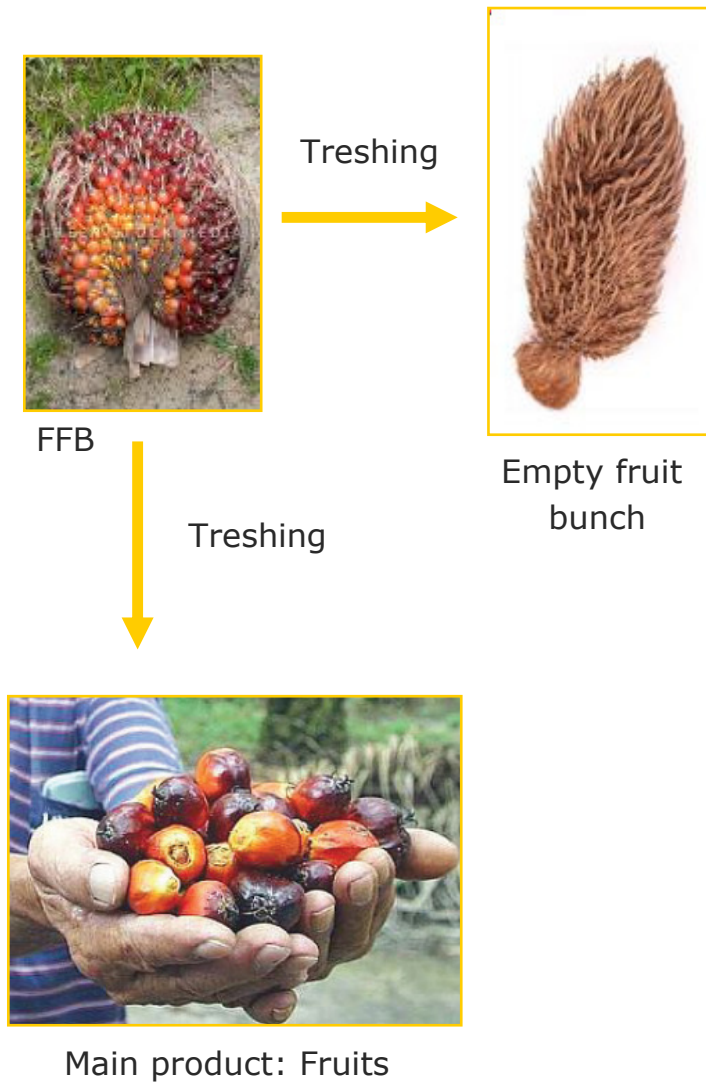


# Plantation residues: Frond & trunks



- Current dominant use is application as mulch in plantation (fertilizer, nutrition recycling) [8]. Also composted and burned in fields.
- On limited scale / possible:
  - Feed for ruminants (shreddered)
  - Energy generation
  - Fibre board
- Current dominant use is mulch for replanting (fertilizer, nutrition recycling) [8,9].
- Inferior as timber (degradation due to high moisture and sugar) compared to f.i. coconut palm stems [7]. Plywood / furniture production emerging [9]
- High sugar and starch gives opportunities for ethanol production. This is researched, but not (yet) commercialised.

# Mill: Empty fruit bunches

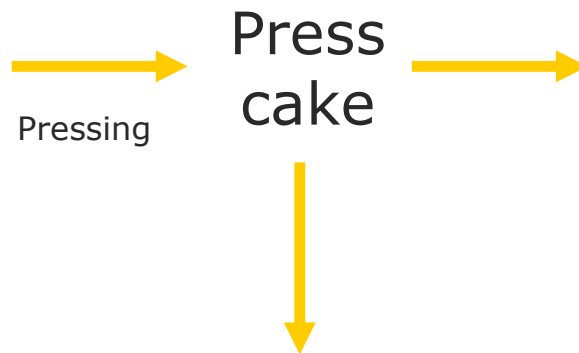


- Current dominant uses:
  - Application as mulch in the plantation
  - Burned + ash back to fields
  - Land filling
  - Fuel for energy generation in mill
- Possible uses:
  - Fibre board
  - pulp / paper industry

# Mill: Press cake, kernels and fibre



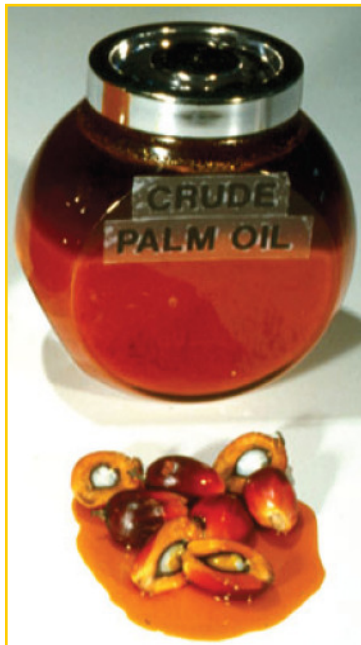
Fruits  
↓ Pressing



Press  
cake

Mesocarp fibre

- Current dominant uses:
  - Fuel for boilers at mill
- Possible uses:
  - Fibre board
  - Particle board



Main product: CPO



Main product: palm kernels



# Mill: POME

- Palm Oil Mill Effluent (POME): waste water from palm oil mills:
  - Steriliser condensate
  - Clarification water
  - Hydro cyclone waste water nut/fibre separation
- Current practise:
  - Anaerobic digestion in open pond (73% of POM's in Malaysia in 2008): methane emissions [16]
- Emerging:
  - Recovery of methane with covered ponds or digestion in tanks. Biogas could be used in gas engine.



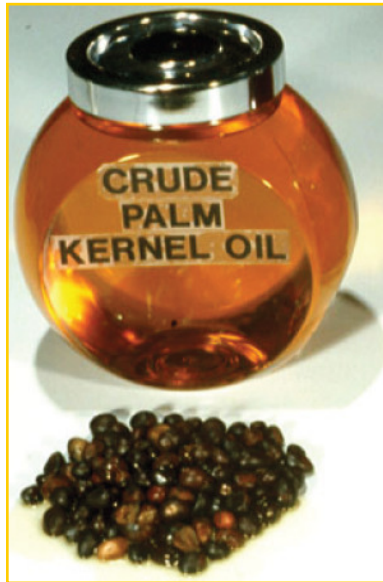
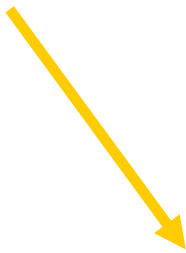
# Palm kernel processing



Palm kernels



Palm kernel meal (PKM)



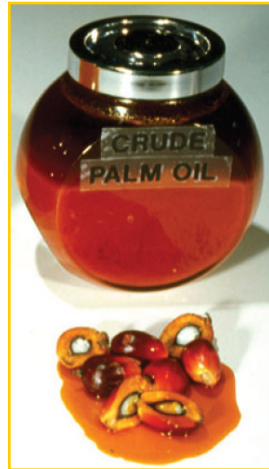
Main product: PKO



Palm kernel shells (PKS)

- Current dominant uses:
  - Animal feed (dairy cattle, because of high protein content)
- Current alternative use:
  - Fuel in mill
  - Fertilizer
- Current dominant use:
  - Fuel in mill

# Crude palm oil refining



CPO



Main product: RBD palm oil from physical refining (refined, bleached, deodorized) or NBD palm oil from chemical refining (neutralized, bleached, deodorized).

Physical  
refining

Chemical  
refining

## PFAD (palm fatty acid distillate)

- Main component: FFA (free fatty acids)
- Light brown / yellow, solid at room temperature
- Main uses:
  - Soap industry
  - Animal feed
  - Oleo chemical industry



## PAO (palm acid oil)

- Similar composition as PFAD.  
Usually slightly lower FFA content
- Main uses: same as PFAD
- Chemical refining process is replaced by physical refining in the past decades since this is more cost effective and environmental friendly.



# Crude palm oil refining: Bleaching earth

- Used to bleach palm oil
- Per ton of RBD / NBD oil:
  - 4.5 kg bleaching earth
  - 6.4 kg spent bleaching earth (30% oil)
- Currently spent material is land filled [8,11]. Sometimes incinerated, blend in feed
- Possible uses:
  - (co)digestion
  - Recovery of the oil (lower quality due to high FFA content) that can be used for f.e. biodiesel [11]



# RBD palm oil fractionation

- Low cloud point PO desirable for most applications. Therefore fractionation of RBD / NBD palm oil
- Fractionation by crystallization and subsequent filtration



RBD palm oil

## Palm oil olein

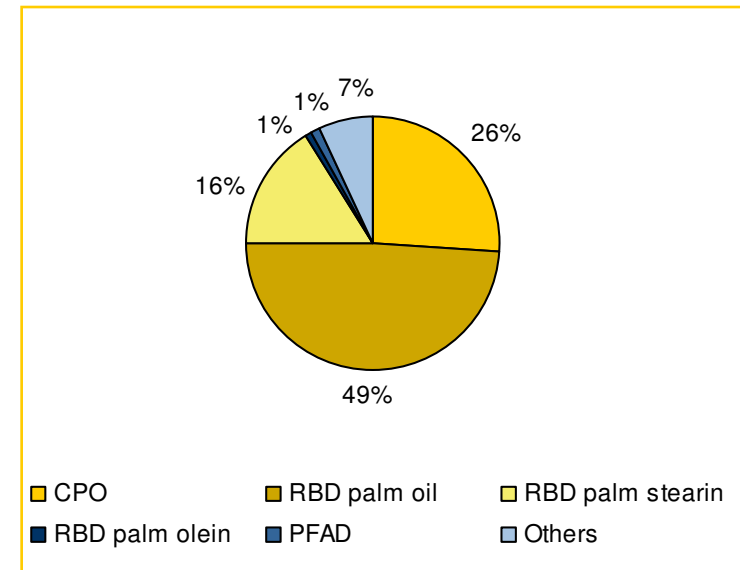
- Main product; available in several grades
- More liquid fraction
- Use in food industry

## Palm oil stearin

- Co-product (lower value than olein and RBD palm oil)
- More solid fraction
- Use in food industry (f.e. pastry and bakery)

# FAME / biodiesel

- Feedstock:
  - Mainly RBD palm oil; significant use of CPO (see 2009 graph Malaysia as example [12])
  - PKO and RBD olein value too high, so not used
- Biodiesel industry is seeking for cheaper feedstocks. These alternatives include from the palm oil chain:
  - RBD stearin
  - PFAD / PAO
- Traditional process (transesterification) produces about 10% crude glycerine. See next slide.



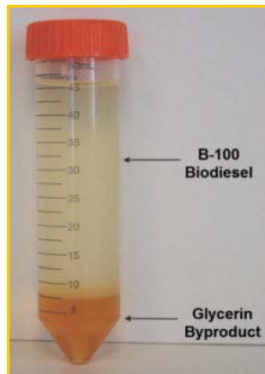


# Crude glycerine

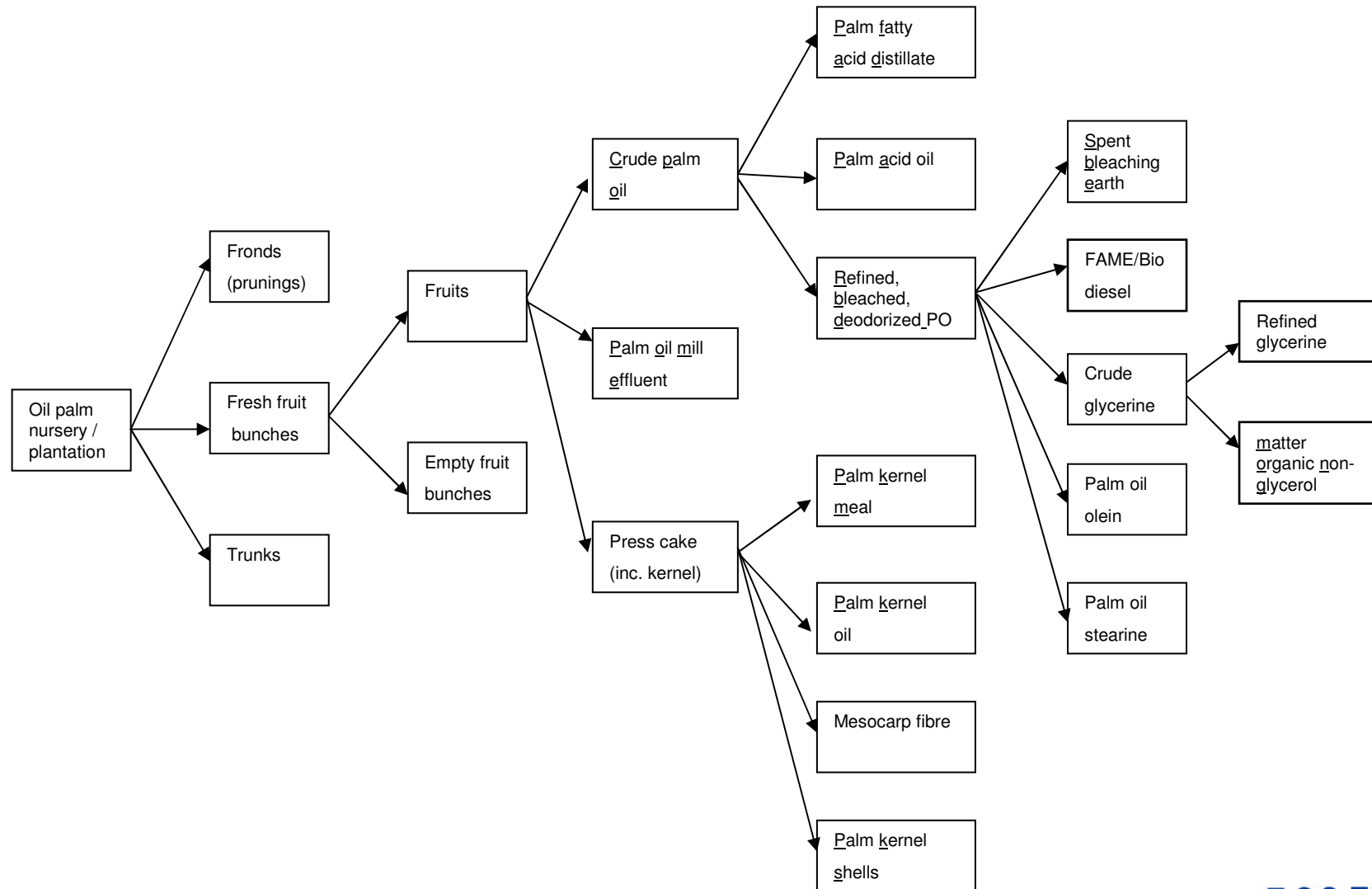
- Clear, odourless, viscous liquid
- Available in several purities: larger and newer plants purify more; smaller and older plant less [13]. Typical purity: 80%



- Refining is removal of methanol, FFA, salts
- Two types of use:
  - Refined to higher grades (technical: >97%; refined: >99.7%) to be used in conventional applications (refining is expensive). Waste / co-product is MONG (matter organic non-glycerol).
  - Use as crude: digestion (biogas), animal feed, combustion as fuel, feedstock for chemicals production (f.e. methanol), etc.



# Palm oil supply chain





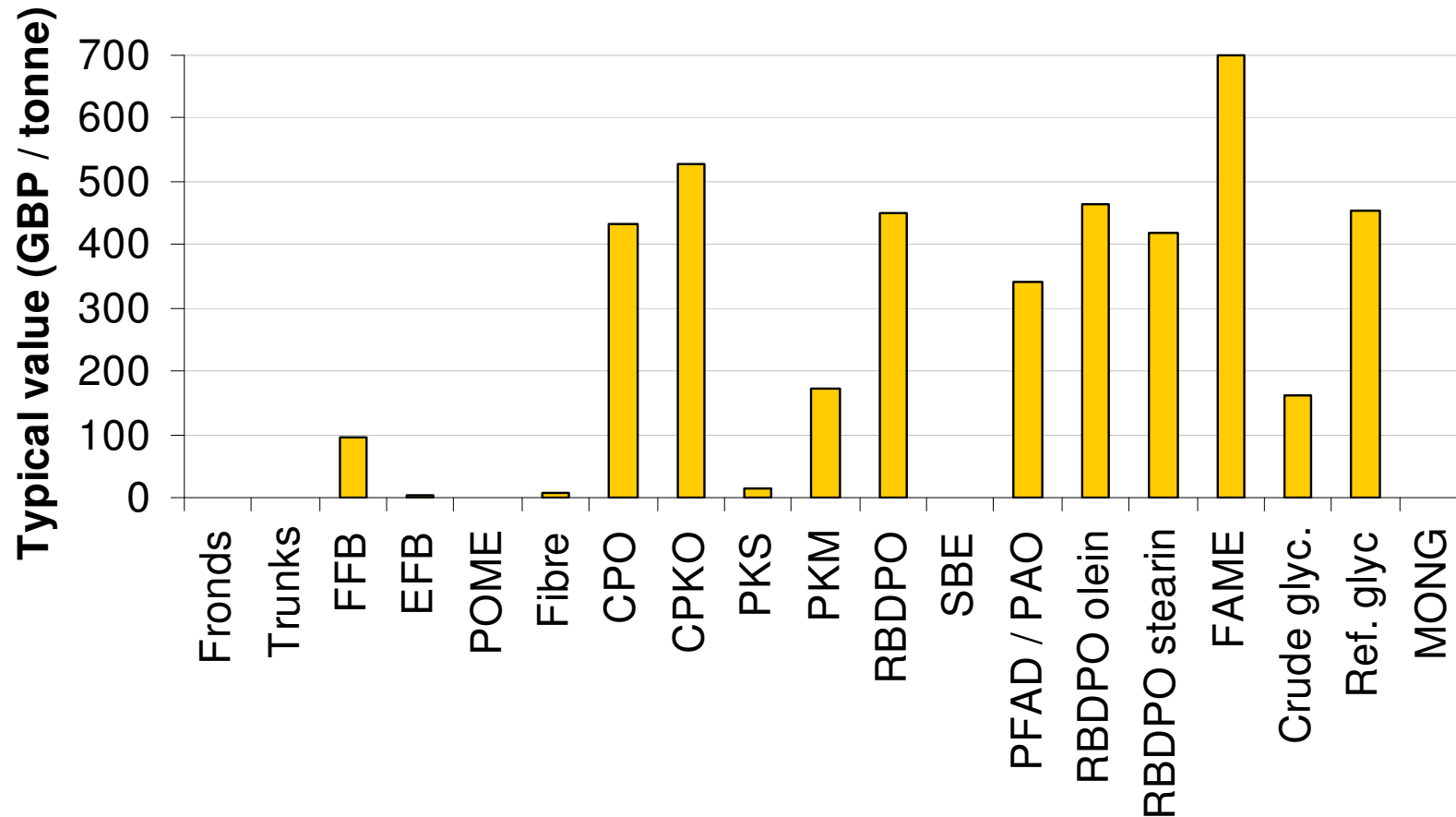
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# Prices: Detailed table (for reference)

Material	Acronym	Main current uses	Basis for value	Approximate value (wet material)	Typical moisture	Approximate value (dry material)
Fronds	Fronds	Mulch		0,00	74%	0,00
Trunks	Trunks	Mulch, some emerging applications	2010 price range in Malaysia when occasionally sold.	1,56 GBP/tonne	53%	0,73
Fresh fruit bunches	FFB	CPO production	2009 and 2010 prices from MPOB, mill gate	93,98 GBP/tonne	20%	75,18
Empty fruit bunches	EFB	Mulch, energy generation	Generation of electricity in Malaysia with 25% efficiency and feed to grid.	2,62 GBP/tonne	65%	0,92
Palm oil mill effluent	POME	Treated in open ponds	POME disposal costs money. Untreated discharge not allowed	0,00	5%	0,00
Mesocarp fibre	Fibre	Fuel in mill	Local fuel price fibre of 0,8 GBP/MJ	7,86 GBP/tonne	40%	4,72
Crude palm oil	CPO	Food (~80%), energy, personal care, cleaning, industry	Malaysia, local delivered, average 2009 and 2010	433,19 GBP\$ / tonne	0%	433,19
Crude palm kernel oil	CPKO	Food	Malaysia, local delivered, average 2009 and 2010	526,36 GBP / tonne	0%	526,36
Palm kernel shell	PKS	Fuel in mill	Fuel price local of	15,42 GBP / tonne	10%	
Palm kernel meal	PKM	Feed	Feed prices UK, average last 5 year	171,00 GBP / tonne	11%	152,19
RBD palm oil	RBDPO	Food	Malaysia, FOB	451,21 GBP / tonne	0%	451,21
Spent bleaching earth	SBE	Land filled	Waste	0,00		0,00
Palm fatty acid distillate / Palm acid oil	PFAD / PAO	Soap industry, feed	Malaysia, FOB	339,95 GBP/tonne	0%	339,95
RBD palm oleine	RBDPO olein	Food	Malaysia, FOB	464,72 GBP / tonne	0%	464,72
RBD palm stearine	RBDPO stearin	Food	Malaysia, FOB	419,64 GBP / tonne	0%	419,64
FAME / biodiesel	FAME	Automotive fuel	Global commodity price without taxes	700,00	0%	700,00
Crude glycerine	Crude glyc.	Upgrade to higher grades	Price index	162,50 GBP/tonne	19%	132,44
Refined glycerine	Ref. glyc			455,00 GBP/tonne	0%	455,00
Matter organic non-glycerine	MONG		Bilateral trade prices	0,00 GBP/tonne	0%	0,00

# Prices: Summary



- Zero or negative value: Fronds, POME
- No value found yet:
  - SBE → bilateral price agreements
  - MONG → bilateral price agreements

# Assessment: Assumptions

- Two tests based on guiding principles 1 – 4. A material is a (co)product when:
  - 1 – 3: the process is optimized for this material
  - 4: the economic value of the material is >15% of the highest economic value of the same process step.
- Seven process steps identified:
  1. Oil palm plantation
  2. Palm fruit mill
  3. Palm kernel mill
  4. CPO refining
  5. RBD palm oil fractionation
  6. Biodiesel production
  7. Glycerine purification
- Economic values at actual moisture content

# Assessment: results

	Material	Value (£/t <sub>wet</sub> )	Guiding principles 1 - 3	Guiding principle 4 (>15% of product)	Comments
Oil palm plantation	Fronds	0	Residue	Residue	
	Trunks	1.6	Residue	Residue	
	FFB	94	<b>Product</b>	<b>Product</b>	
Palm fruit mill	EFB	2,6	Residue	Residue	
	POME	<0	Residue	Residue	Disposal costs
	Fibre	7.9	Residue	Residue	
	CPO	433	<b>Product</b>	<b>Product</b>	
Palm kernel mill	CPKO	526	<b>Product</b>	<b>Product</b>	
	PKS	15	Residue	Residue	
	PKM	171	Residue	<b>Co-product (33%)</b>	Fairly close to 15% ←
Crude palm oil refining	RBDPO	451	<b>Product</b>	<b>Product</b>	
	SBE	0	Residue	Residue	
	PFAD / PAO	340	Residue	<b>Co-product (75%)</b>	Clearly > 15% ←
RBD PO fractionation	RBDPO olein	465	<b>Product</b>	<b>Product</b>	
	RBDPO stearin	420	Residue	<b>Co-product (90%)</b>	Clearly > 15% ←
Biodiesel production	FAME	700	<b>Product</b>	<b>Product</b>	
	Crude glyc.	163	Residue	<b>Co-product (23%)</b>	Close to 15% + fluctuating prices ←
Glycerine purification	Ref. glyc.	455	<b>Product</b>	<b>Product</b>	
	MONG	?	Residue	?	

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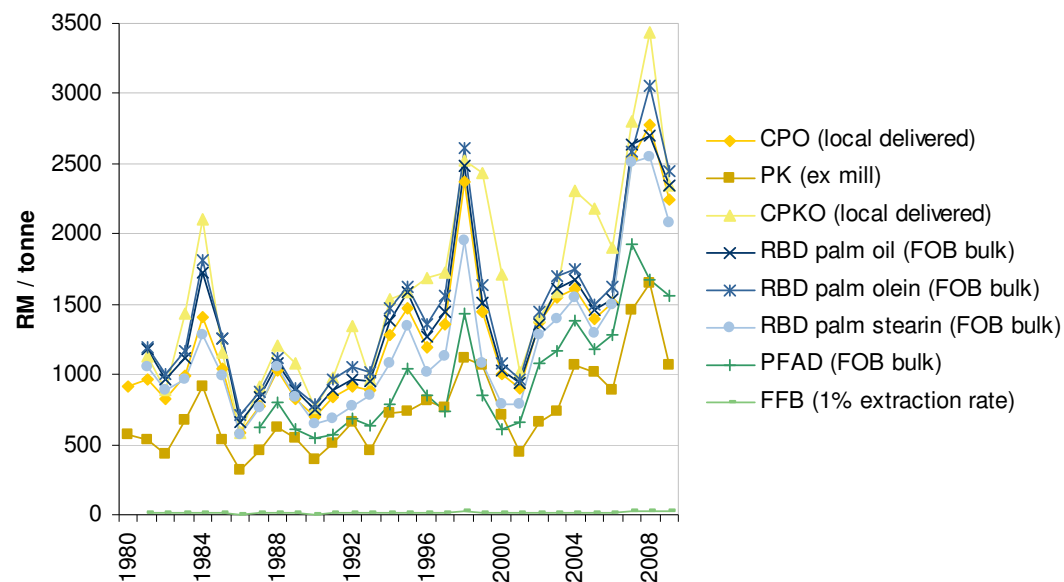
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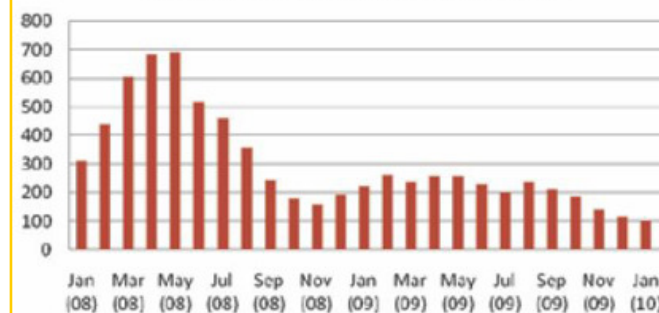
- Prices of most materials could be found or estimated.
- Some prices are difficult to determine. These are materials that were clearly wastes and are used now and not in the past (MONG, SBE)
- Most materials are clearly (co)products or wastes: value  $\gg$  10-15% or  $\ll$  10-15%. Few are close to this limit.
- Prices of both main product as residues can change significantly (examples next slide), so materials close to the 15% limit can change from residue to co-product and back in time.
- Guiding principles 4 is based on market information. 1-3 should be checked on individual process basis.

# Price fluctuations in (co)products

Long term price development oil palm products Malaysia



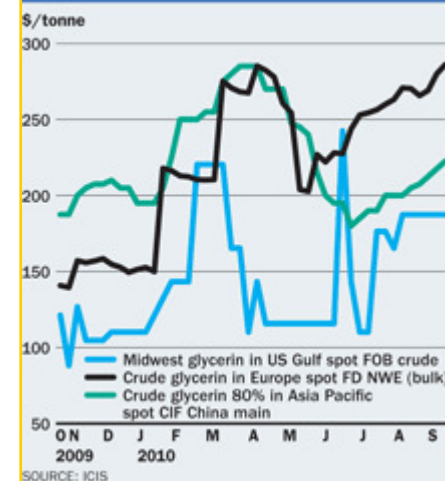
Price differential between RBD Palm Oil and PFAD (FOB US\$/MT), West Malaysia



WESTERN GLYCERIN PRICE STRUGGLES



CRUDE GLYCERIN IS VOLATILE





# Discussion

- Which prices to use:
  - Local prices in country of process?
  - Current price, average last years, year, month(s)?
- What is 'the main product'?
  - Main product complete supply chain?
  - Main product from single step?
    - What is a single step: a plant (gate price)?
- Guiding principles 1 -3: Should be checked on individual case basis.
- Will a 'economic value' limit stand up legally?
- ...

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