Bioconversion of wastes (wastewater sludge, glycerol) to biodiesel

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23/04/2015

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Why biofuels? -----Energy crisis

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- Fossil fuel- **80%** of world energy demand
- **50%** of available oil – exhausted
- Current consumption rate - merely **32 years!**

Why biodiesel?

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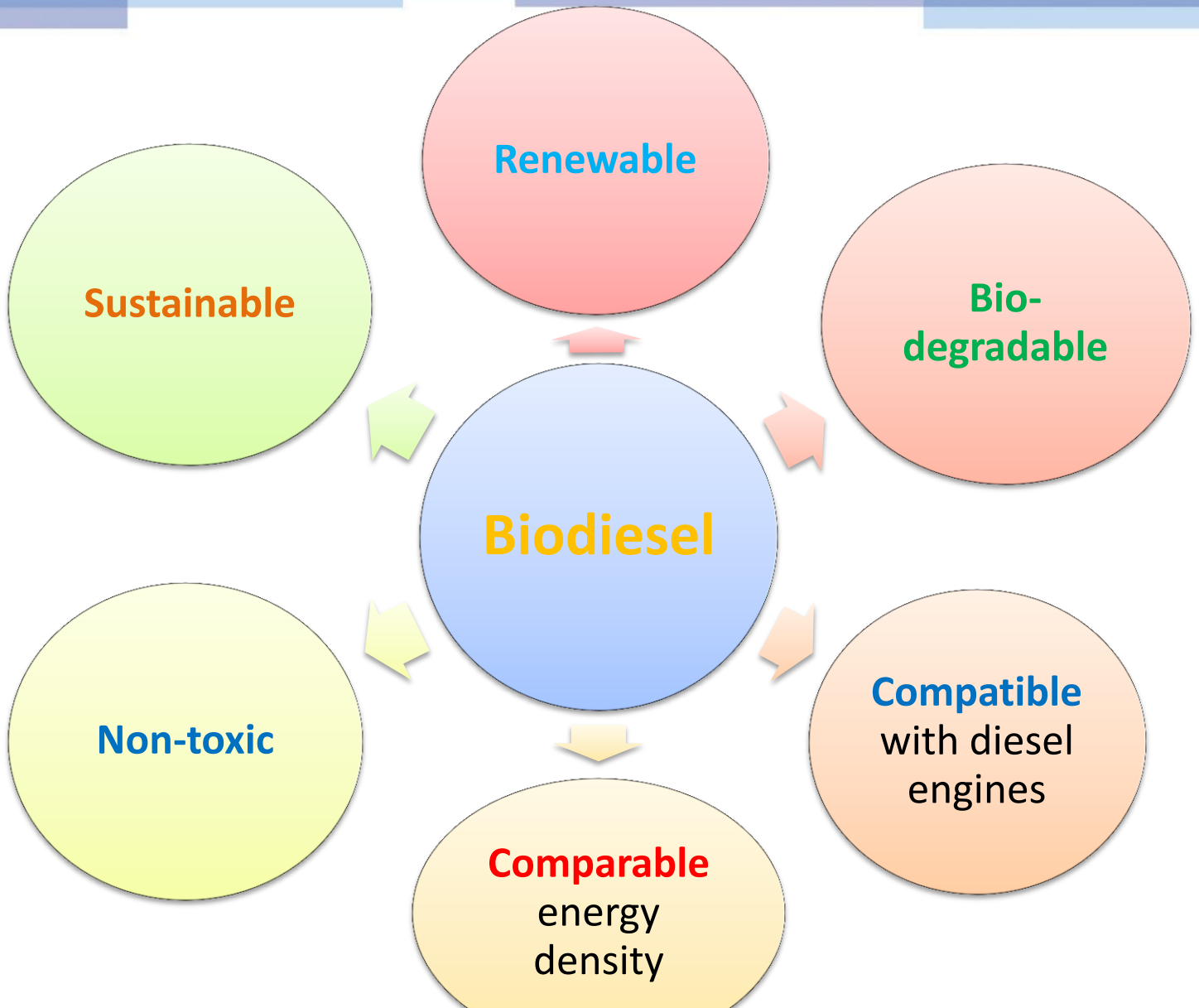

What is biodiesel?

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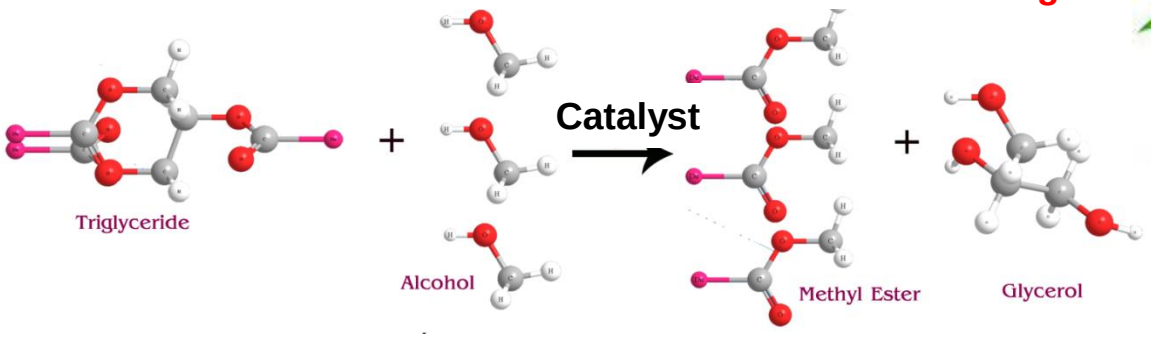
Fatty acid methyl esters

Transesterification



Oil/fat **Alcohol**

Biodiesel (FAMEs) 100 Kg

Glycerol 10Kg

- Alcohol: **methanol** (cheaper)
- Catalyst: **base or acid** (FFA)
- Oil/fat: **vegetable oil/animal fat** (**expensive**) and **waste oil** (**bad quality**)

Alternatives

Problem of Glycerol?

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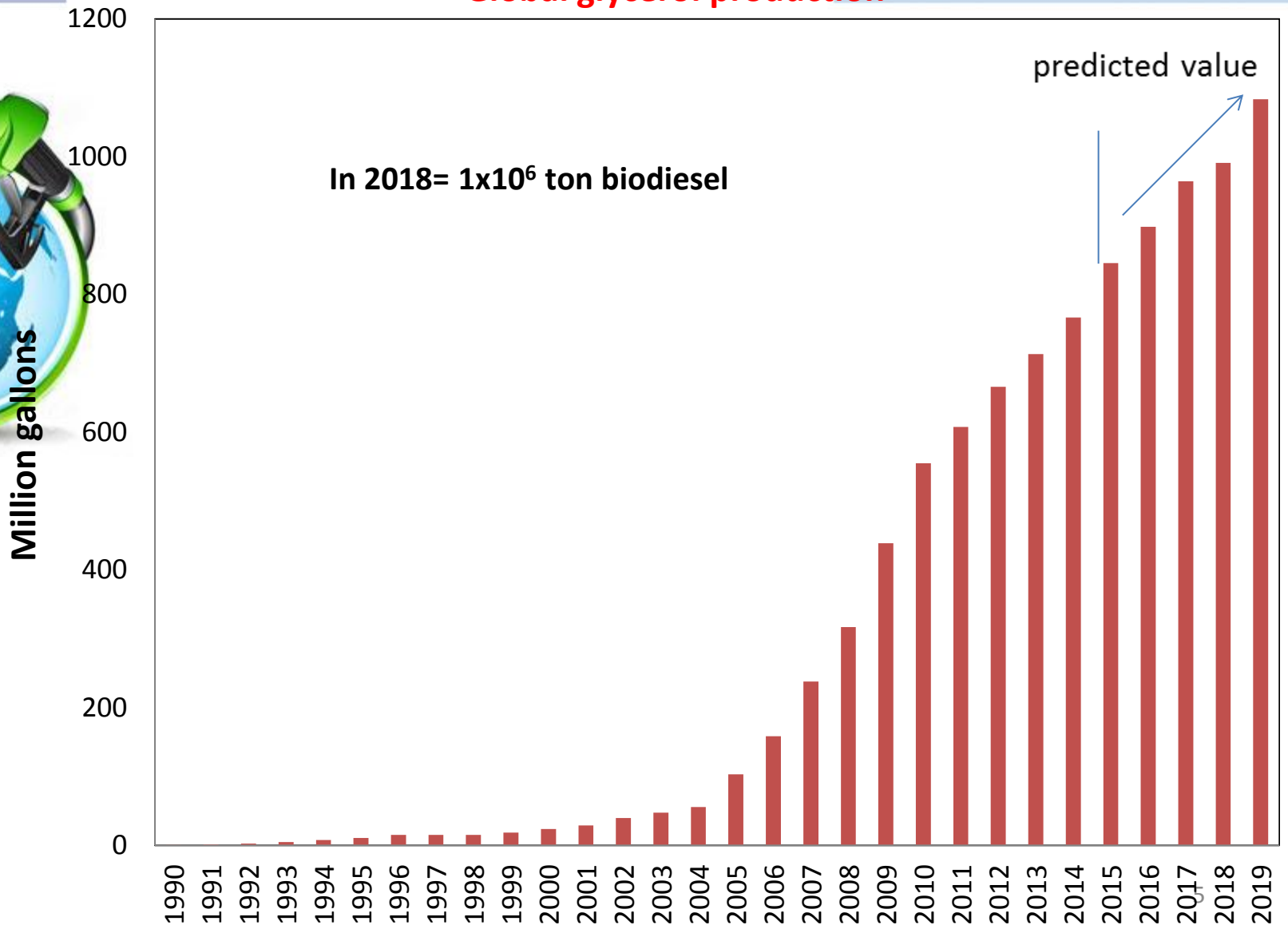
Global glycerol production



Alternative feedstock

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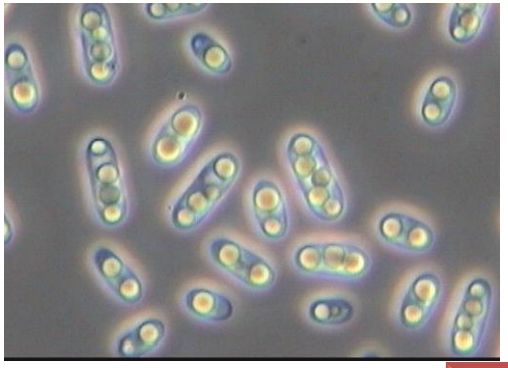

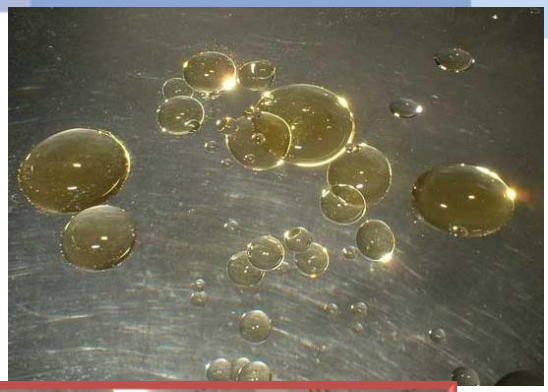

Microbial oils:

- Accumulate high lipid

(80% w/w)

- Rapid growth rate
- Easy to control
- Does Not require arable land

Problem

High RM cost – 70% cost

Affordable substrates

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Wastewater Sludge:

- Naturally produced
- Cost free (waste)
- Rich in C & nutrients
- Disposal problem

Oil

Soap

Glycerol

Crude glycerol:

- By-product of biodiesel production
- Cost low (0.15 US$/kg) or can be free
- Simple Carbon

Process

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Sterilization
121^{0}C, 30 min

Sludge

Sludge+crude glycerol

Oleaginous microbes

Fermenter

Biomass

Extraction

Transesterification

Glycerol + Biodiesel

Process (fermentation)

Higher SS was obtained with washed sludge (31 g/L) than unwashed sludge (23 g/L).

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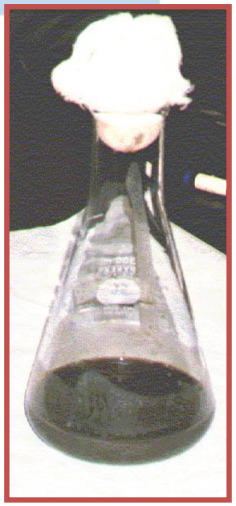
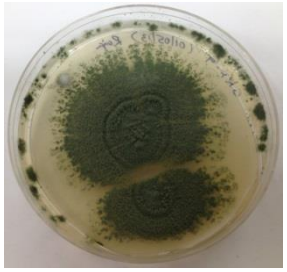
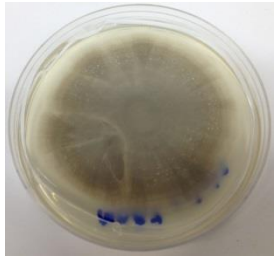
Sterilization
121^{0}C, 30 min

Sludge →
Sludge+crude glycerol →



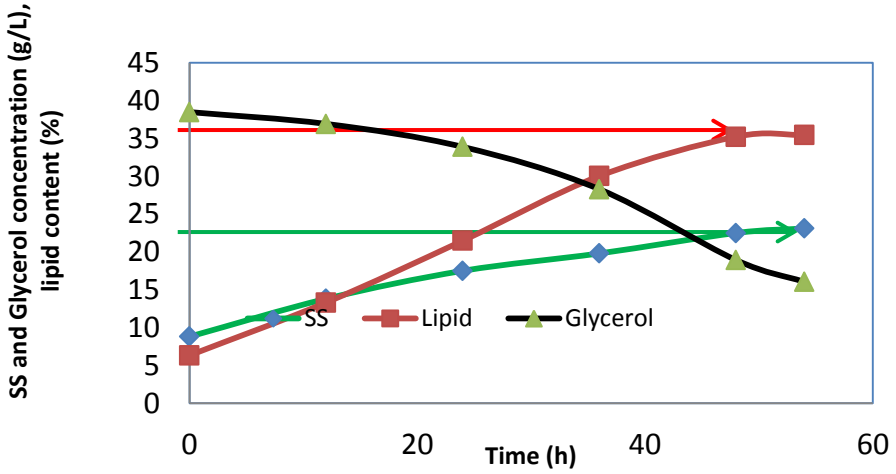




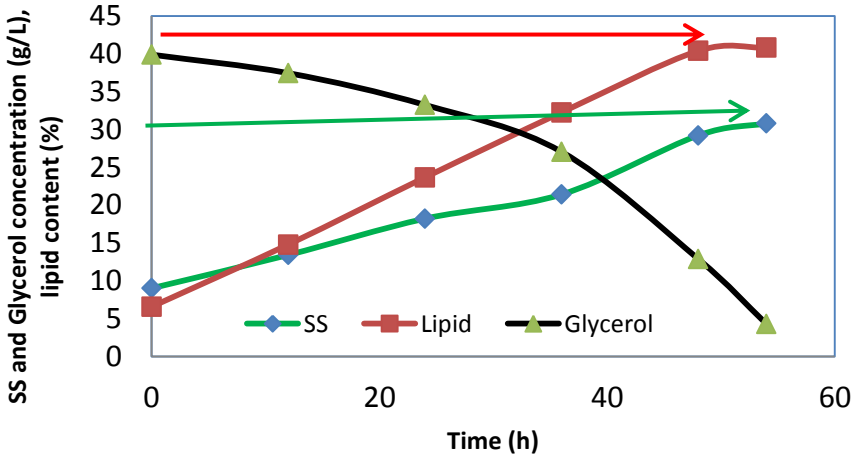
Fermenter

Oleaginous microbes

Unwashed sludge+40 g/L glycerol



Washed sludge+40 g/L glycerol



Sludge effect on lipid accumulation

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Initial conditions: sludge SS=30 g/L; Alkaline thermal treated ; 10% innoculation

SS_0	Pre-tretmant	Glucose (g/L)	Glycerol (g/L)	Washed	Unwashed	SS_f	Lipid (%w/w)	Lipid (g/L)
30	AT	-	-	-	UW	21.1	28	5.9
30	AT	-	25	-	UW	29.2	32	9.3
30	AT	25	-	-	UW	31.9	35	11.2
30	AT	-	50	-	UW	30.2	33.6	10.1
30	AT	-	100	-	UW	27.2	33.3	9.1
30	AT	-	150	-	UW	27.2	33.1	9.0
30	AT		40	W	-	29.2	40.4	11.8
30	AT	-	40		UW	22.5	35.2	7.9
35	AT	-	-	W	-	22.7	35	8
35	AT	-	40	W	-	48.0	40	19.2
MOR1			70			10.68	75.8	8.1

Process

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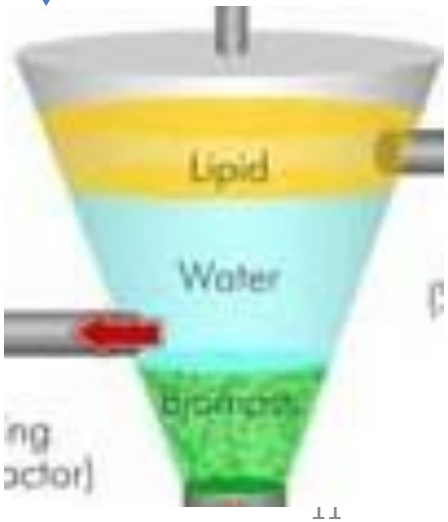
Sludge

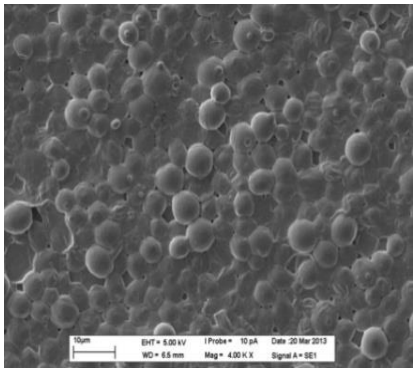
Sludge+crude glycerol

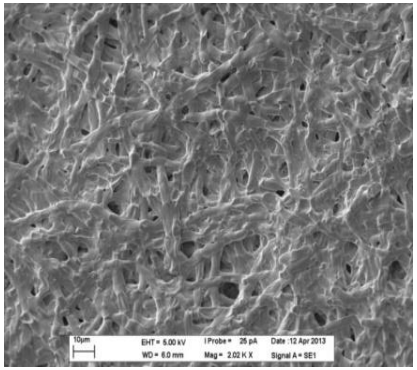
Biomass

Extraction

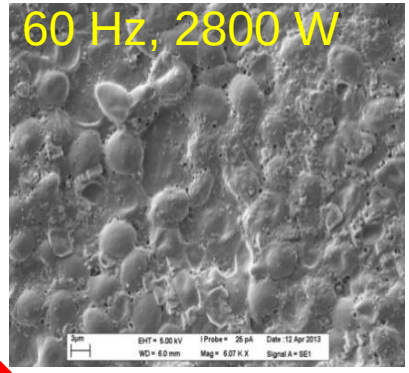


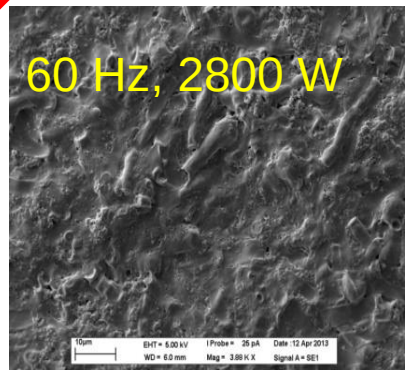
T. oleaginous





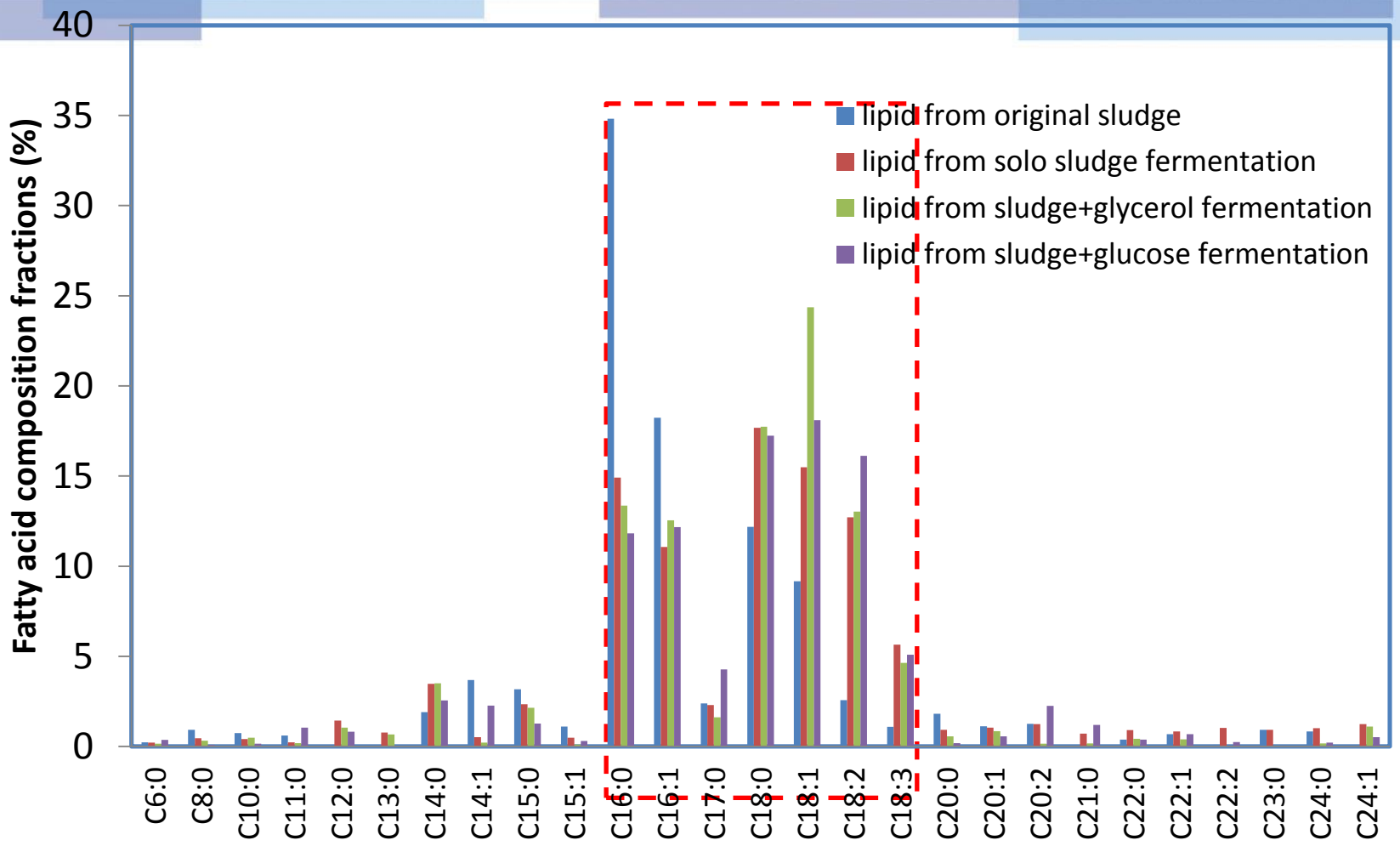
Ultrasonication





Fungi-SK5

Profile of biodiesel



Major:
C16 and **C18**
(similar as plant seed oil)

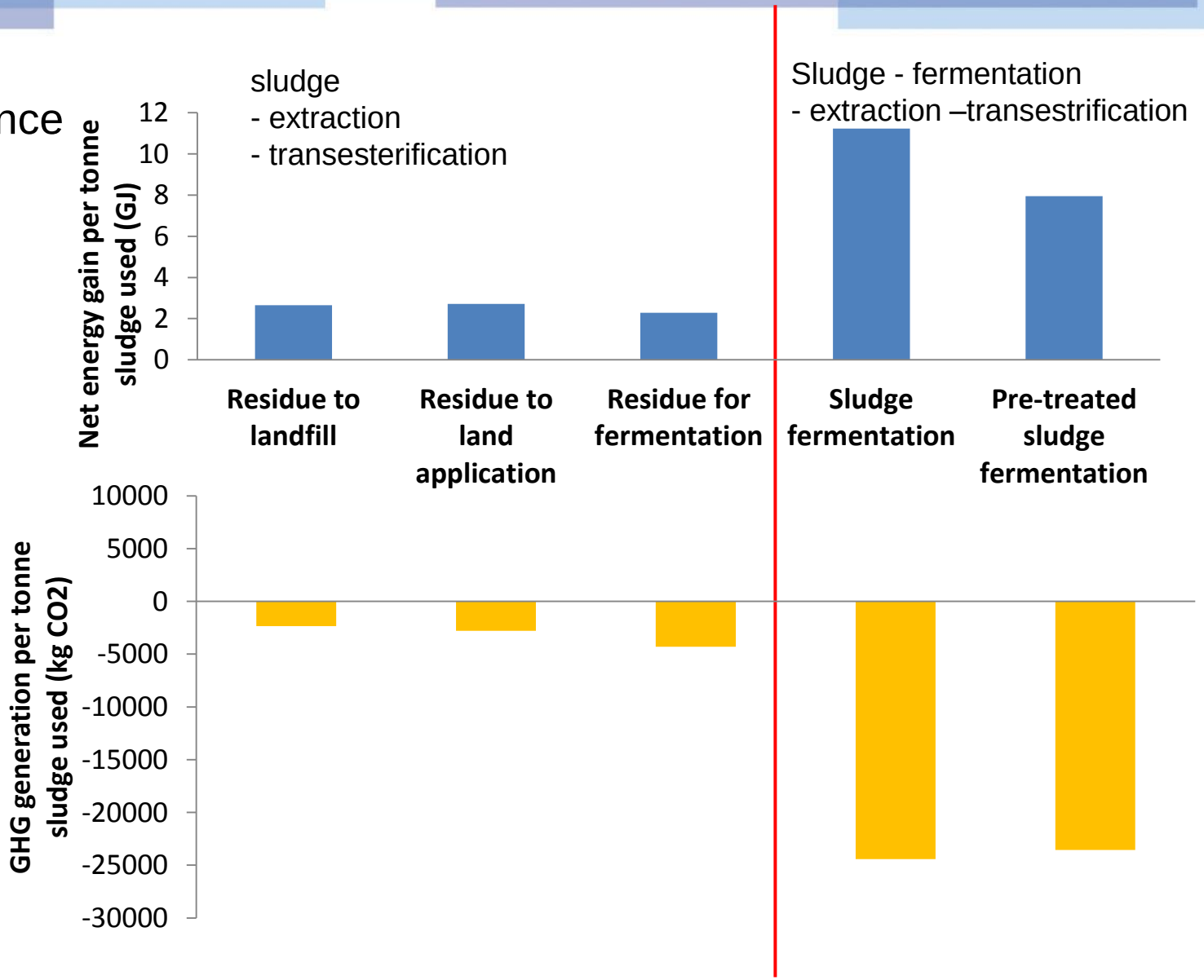
Suitable for biodiesel production

Energy balance and Greenhouse Gas Emissions

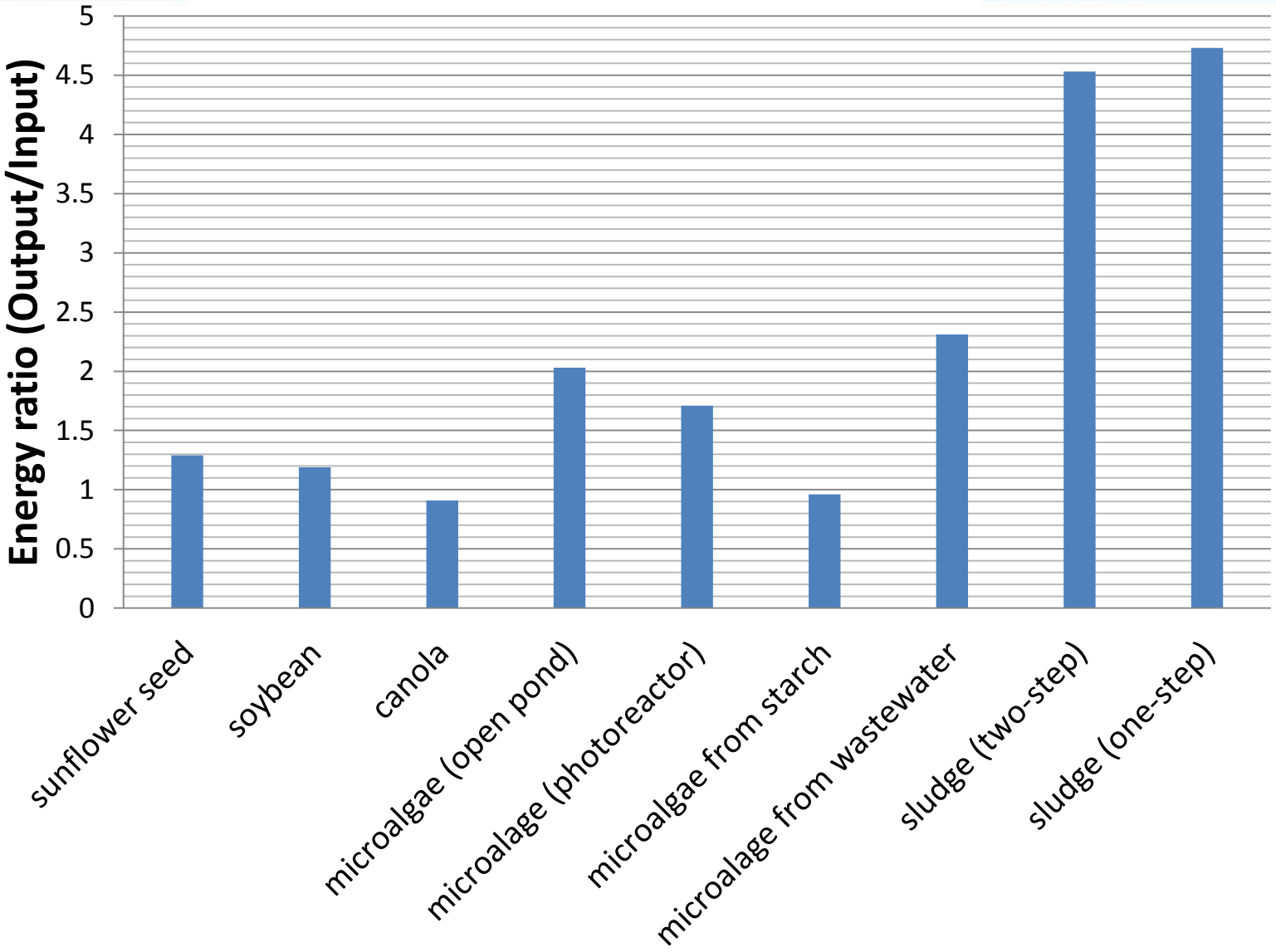
(1 tonne sludge utilized)

Energy balance

GHG emissions



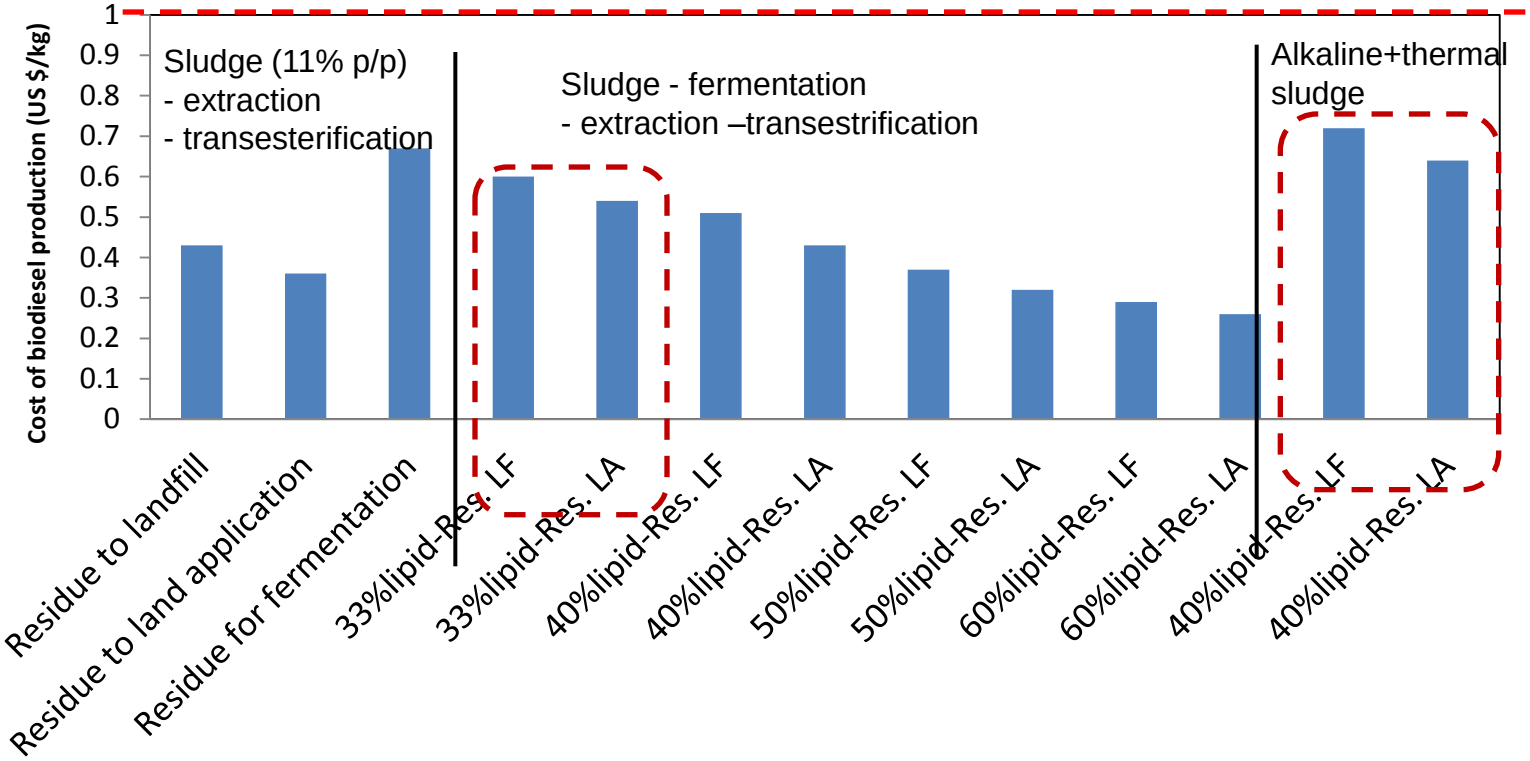
Comparison of Energy Ratio



Cost of biodiesel production from sludge

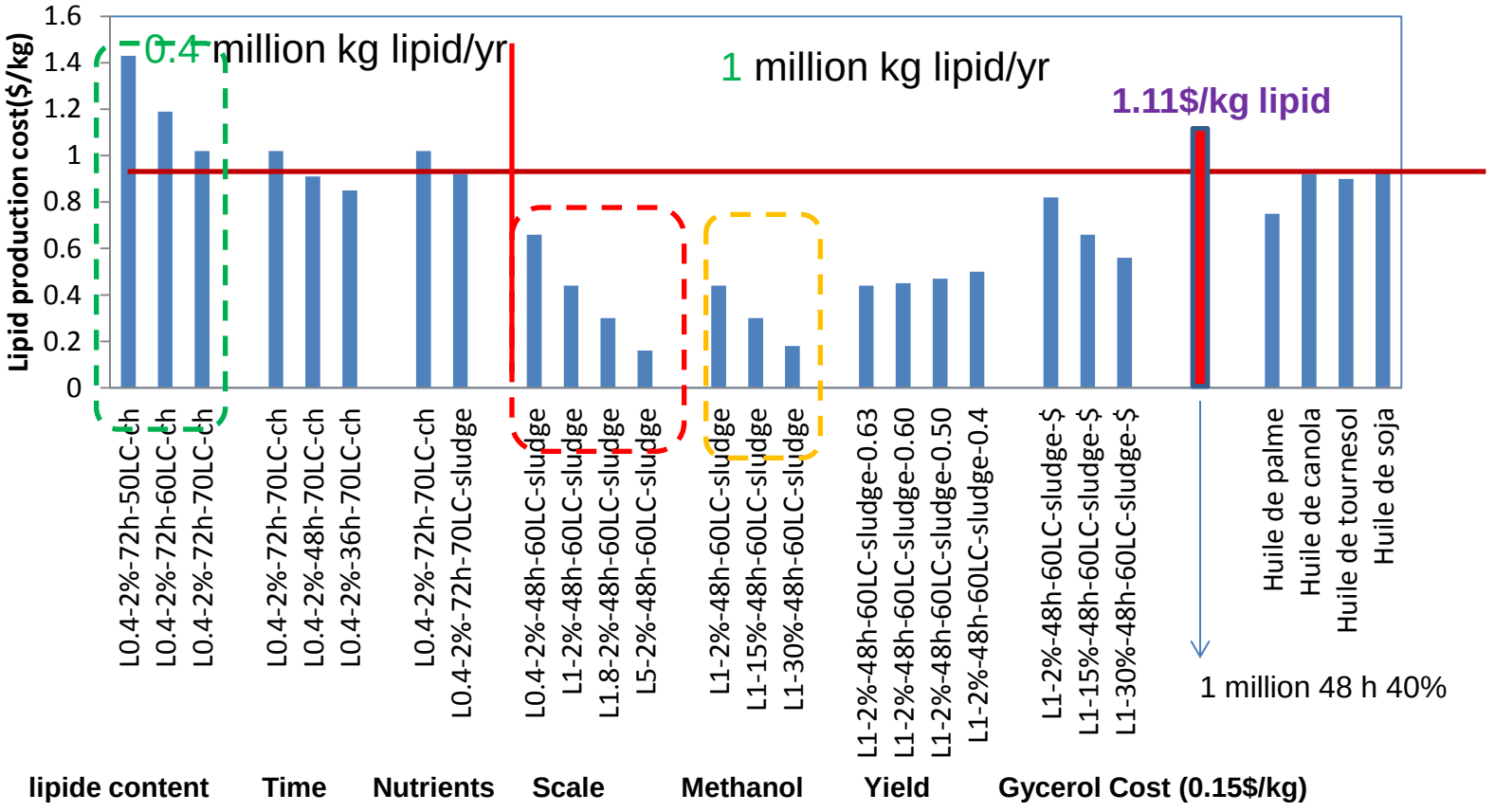
260 tonnes sludge per day

1.0 US $/kg: Cost of biodiesel production



LF= landfill
LA=land application

Cost estimation of crude glycerol for biodiesel production



Conclusions

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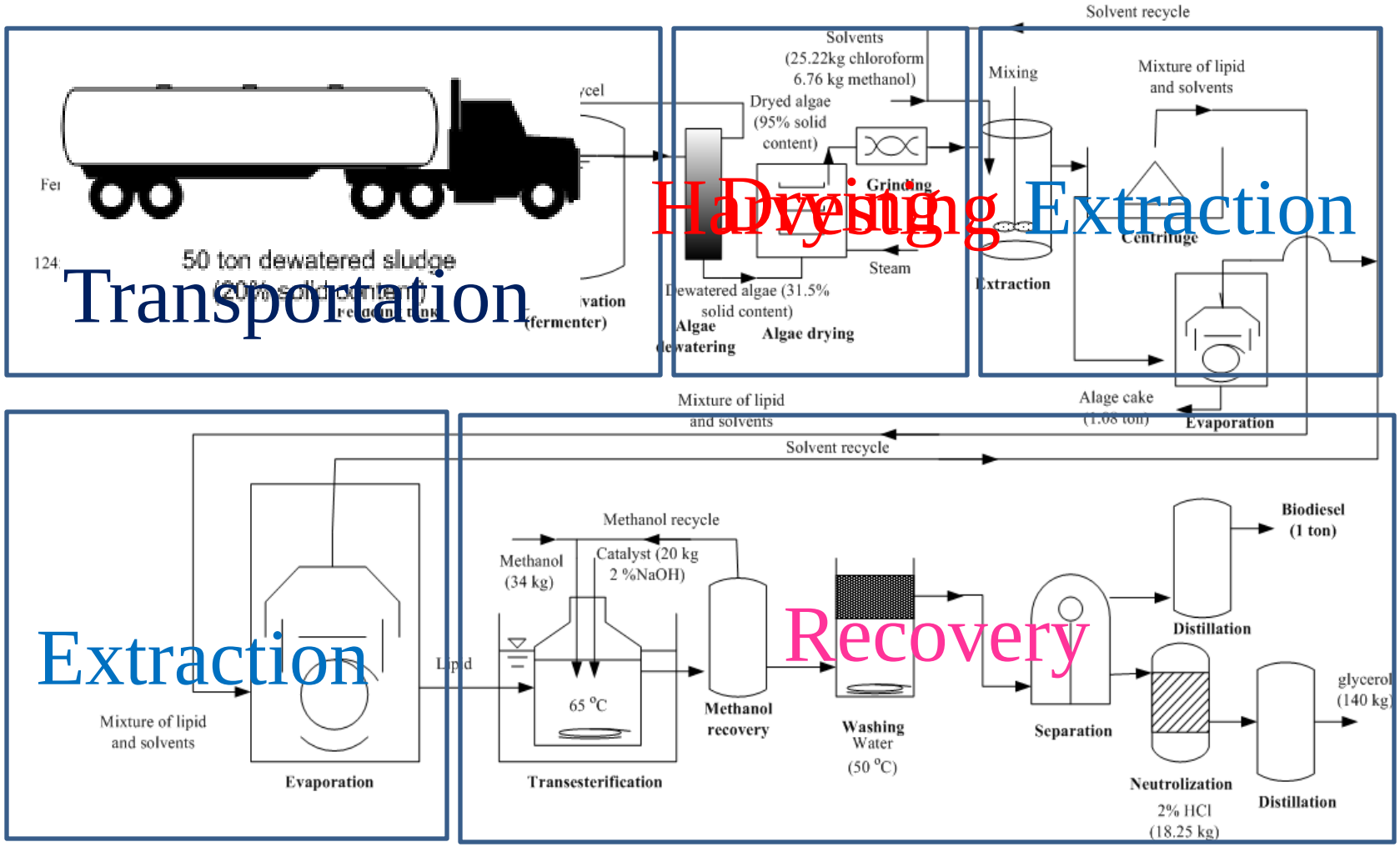
Medium	Sludge	Glycerol	Sludge +glycerol	Washed sludge +glycerol
Quantity used	1 tonne sludge	1 tonne	1 tonne sludge + 1.3 tonne Glycerol	1 tonne sludge + 1.3 tonne Glycerol
Biodiesel (product)	198 kg	220Kg	263 kg	411 kg
Glycerol (by-product)	20 kg	22Kg	26 kg	41 kg

Merci beaucoup

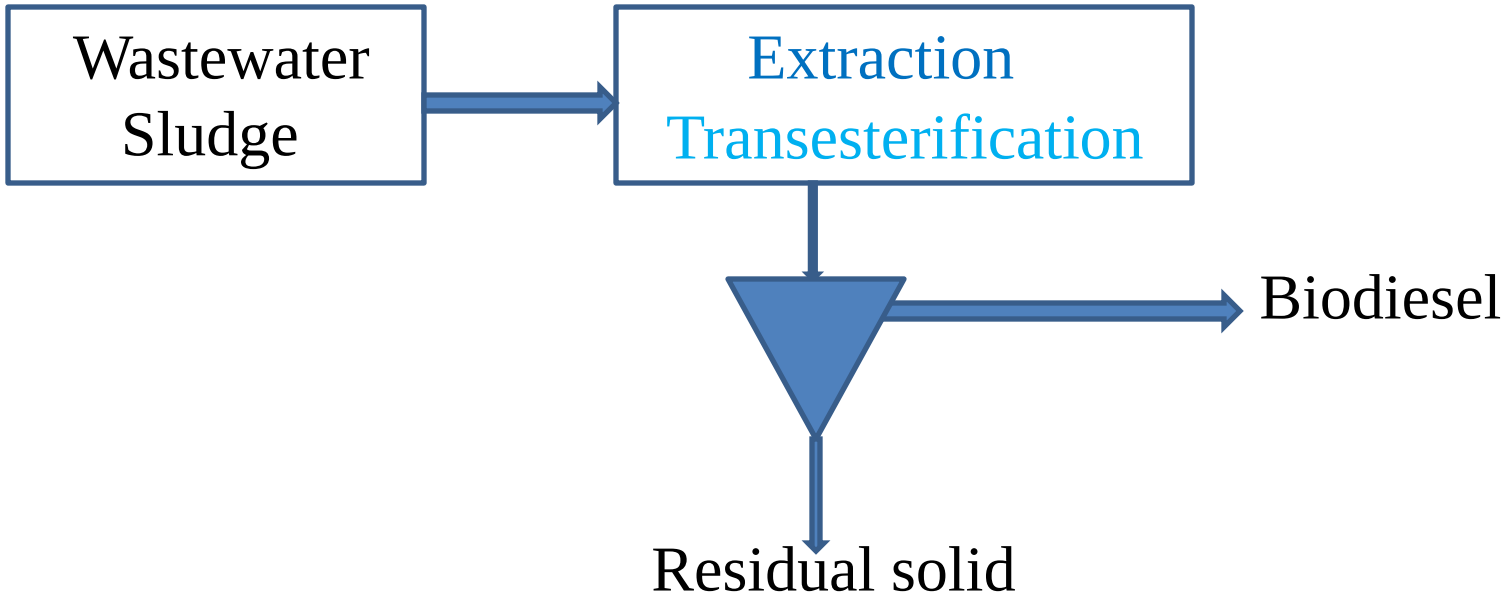
Energy balance of biodiesel production

(heterotrophic microalage)

Biodiesel produced from microalage cultivated in wastewater



Biodiesel production from sludge (one-step)



SEM images after ultrasonication (glycerol medium)

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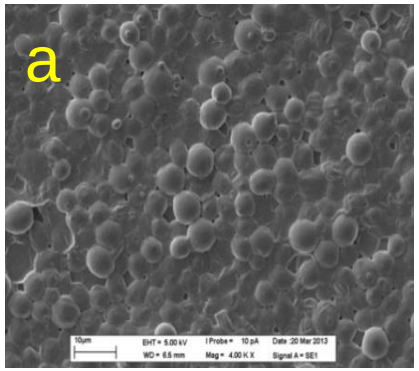
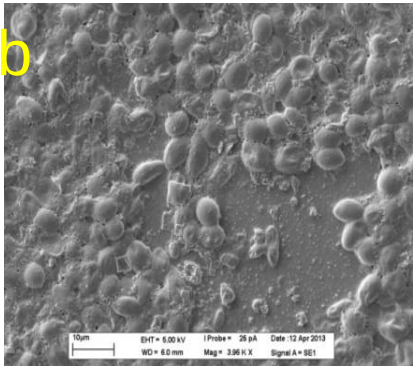
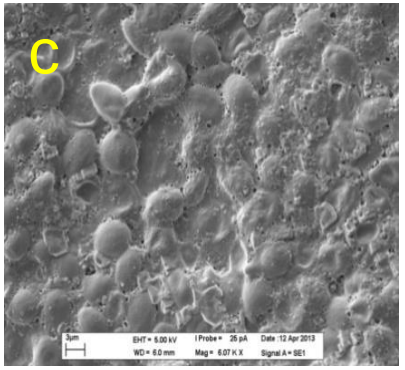
Trichosporon oleaginosus



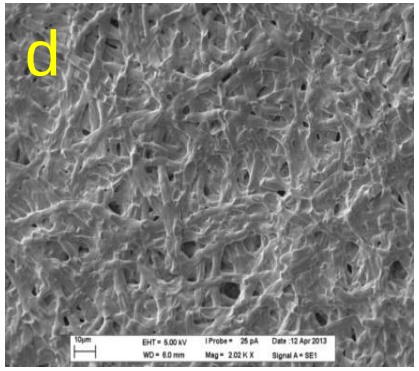
Ultrasonication →



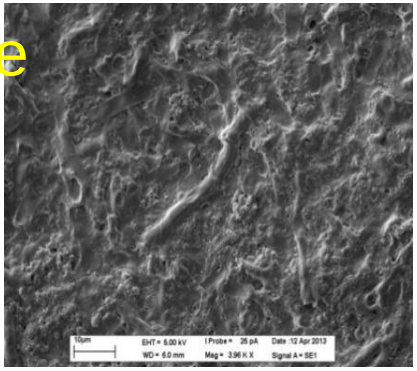


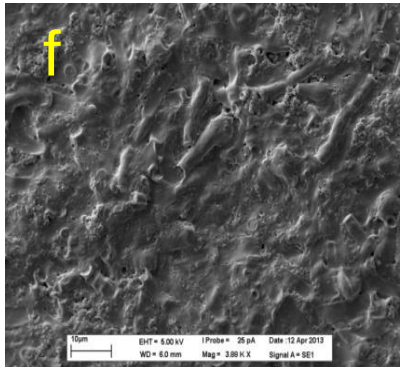
Before | 520 kHz, 40 W | 60 Hz, 2800 W

SKF-5



Ultrasonication →





Before | 520 kHz, 40 W | 60 Hz, 2800 W

Energy balance and Greenhouse Gas Emissions

(1 tonne biodiesel produced)

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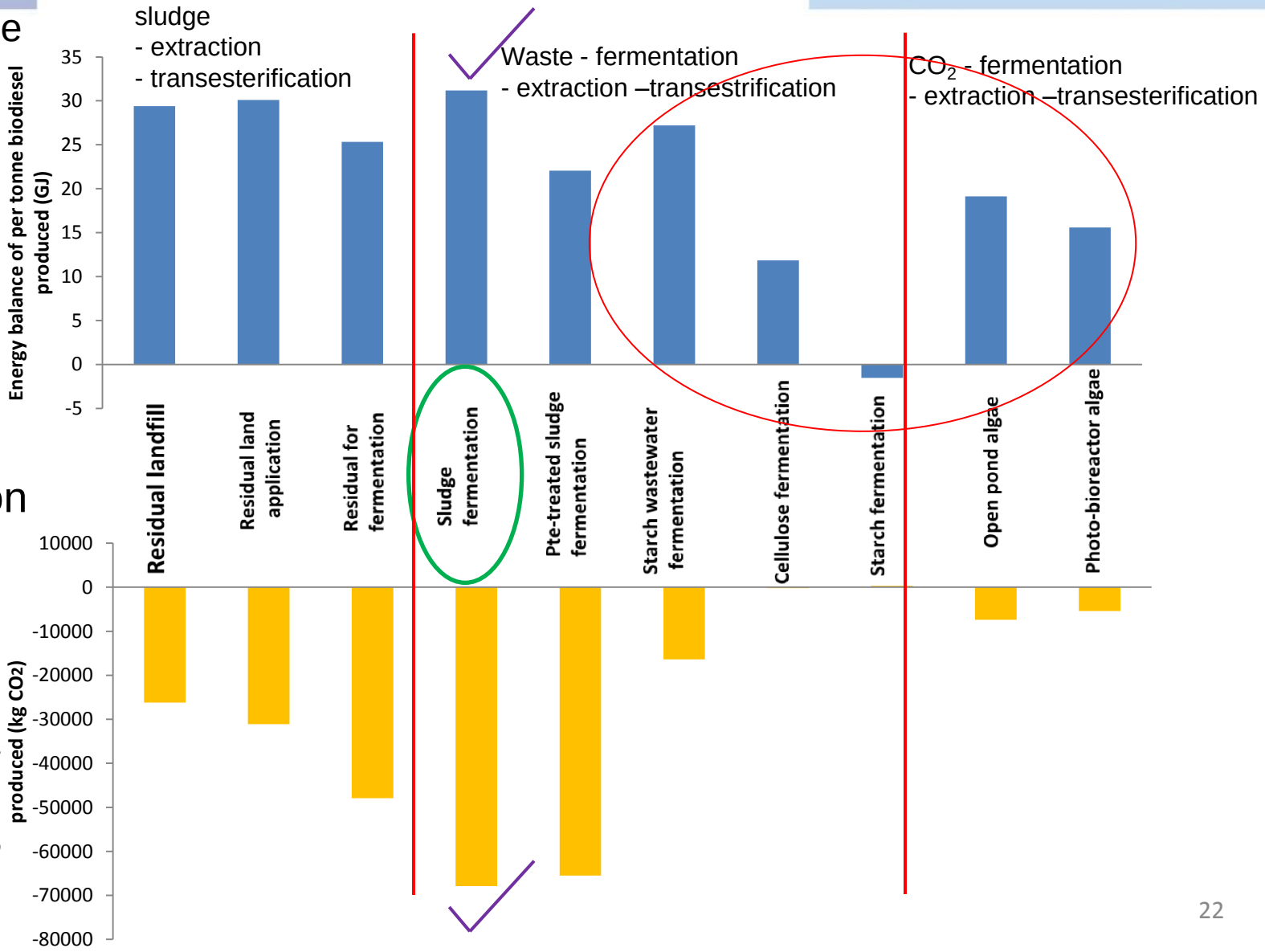
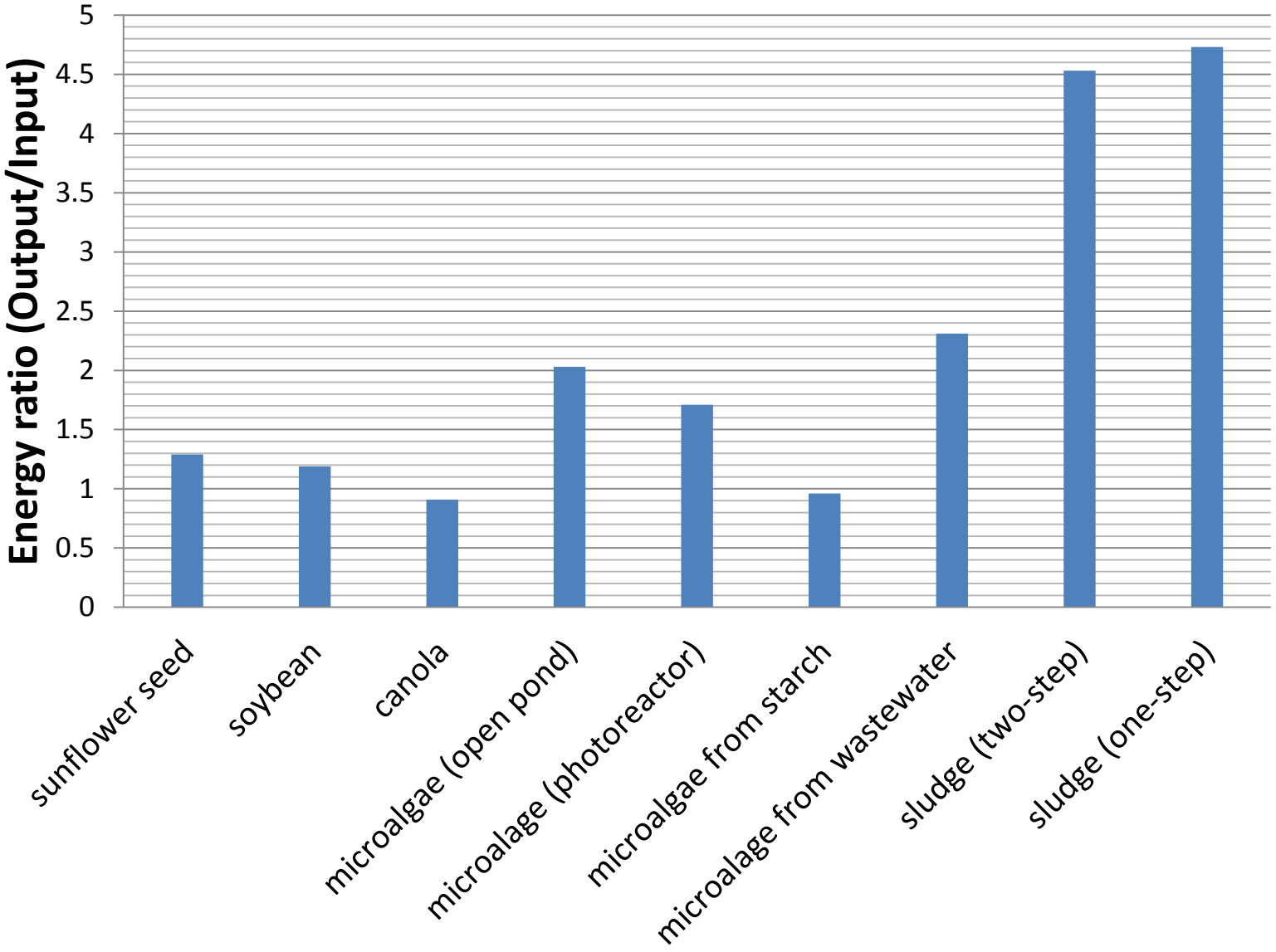
Energy balance



Comparaison of Energy Ratio



Biodiesel from Algae

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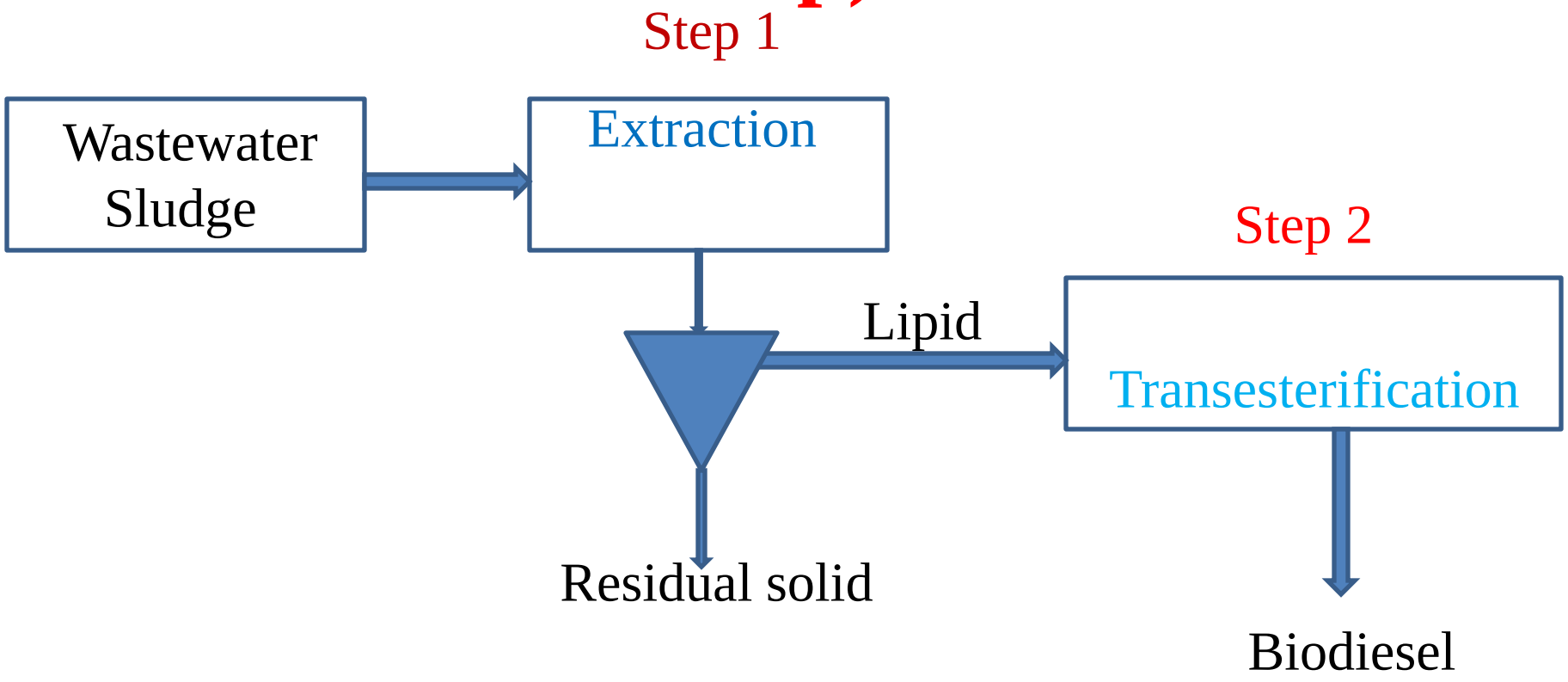
Biodiesel production from sludge (two-step)



Different medium effect on lipid accumulation

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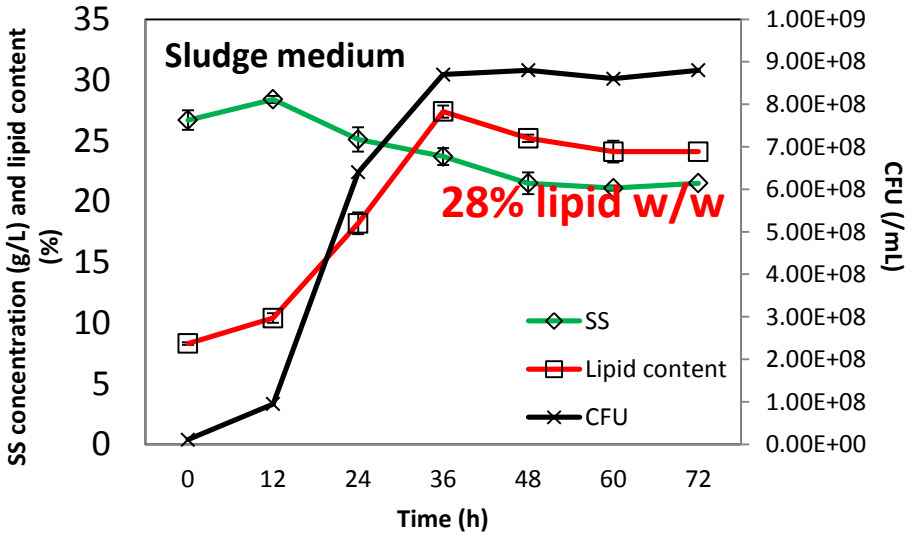
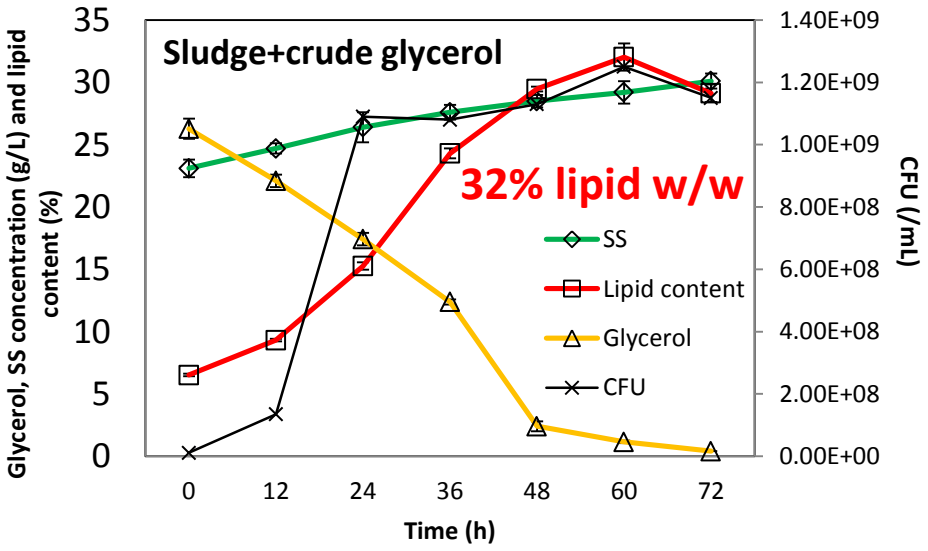
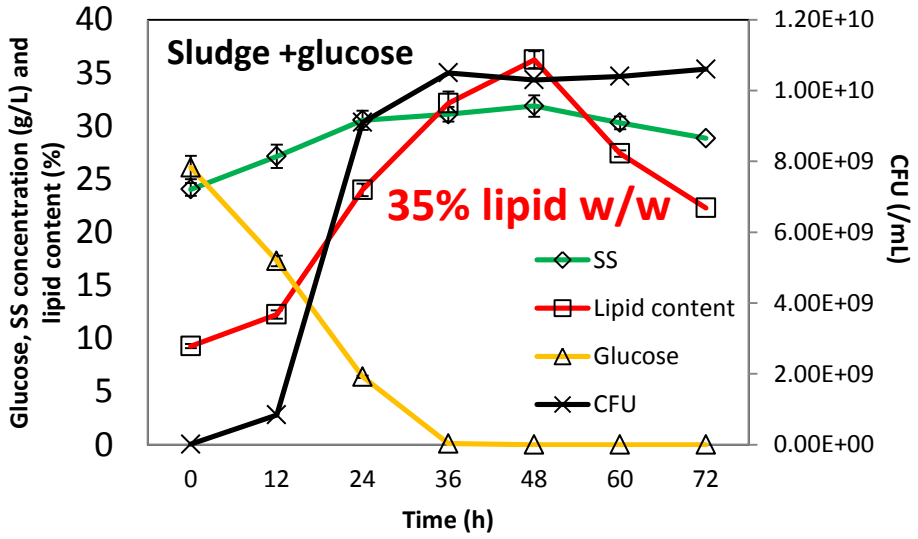
Initial conditions: sludge SS=30 g/L; Alkaline treated; Glucose/glycerol conc.=25 g/L; 10% innocul.







Curde glycerol for lipid accumulation is comparable with glucose

Glycerol concentration effect on lipid accumulation

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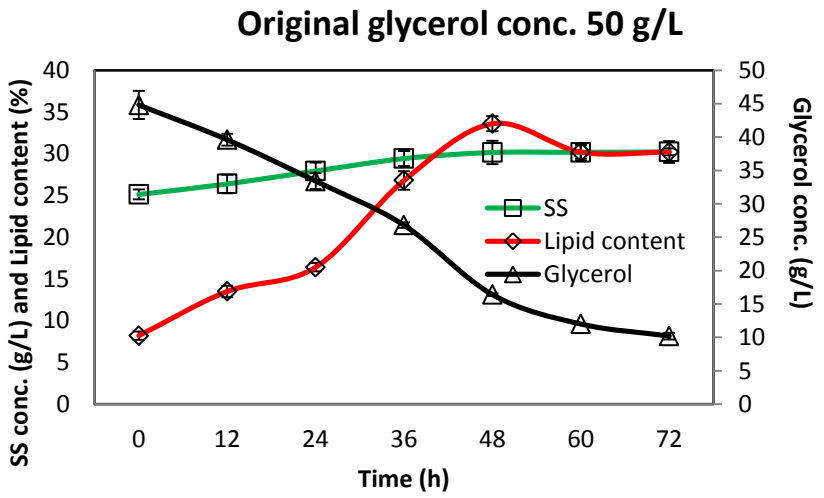
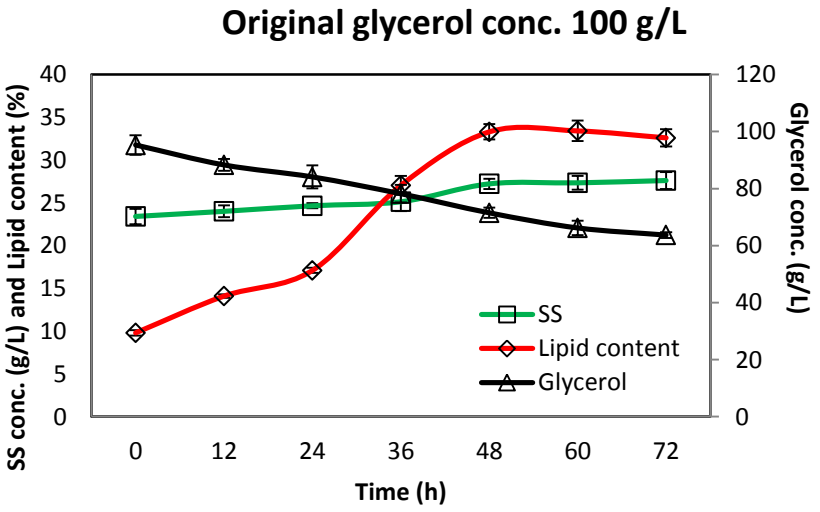
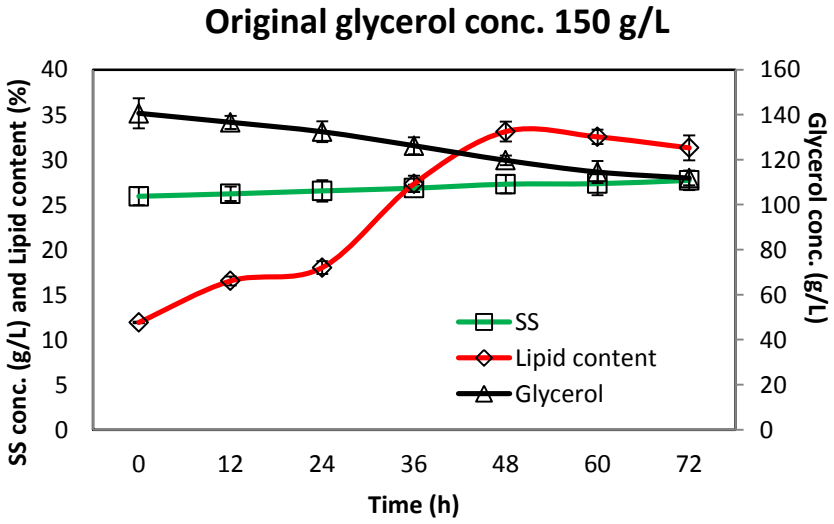
Initial conditions: sludge SS=30 g/L; Alkaline treated; 10% innoculation

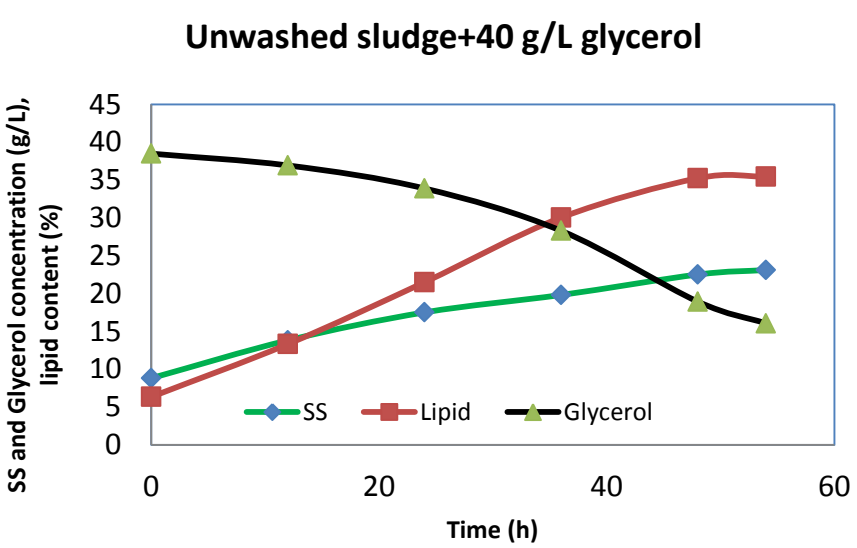


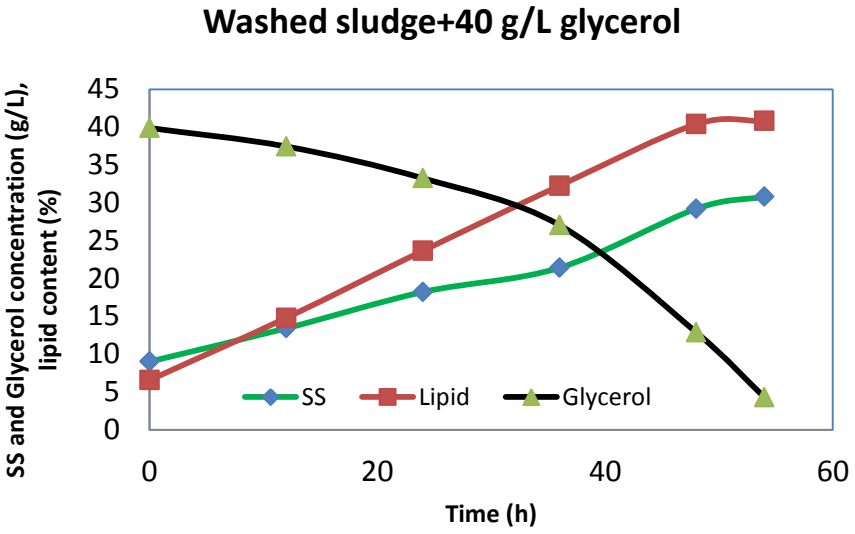




Sludge effect on lipid accumulation

Initial conditions: sludge SS=30 g/L; Alkaline treated ; 10% innoculation





Higher SS was obtained with washed sludge (31 g/L) than unwashed sludge (23 g/L).