Bioconversion of Biofuel Residues into Aquatic Feed

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bioenergy research group
"working for a sustainable world"

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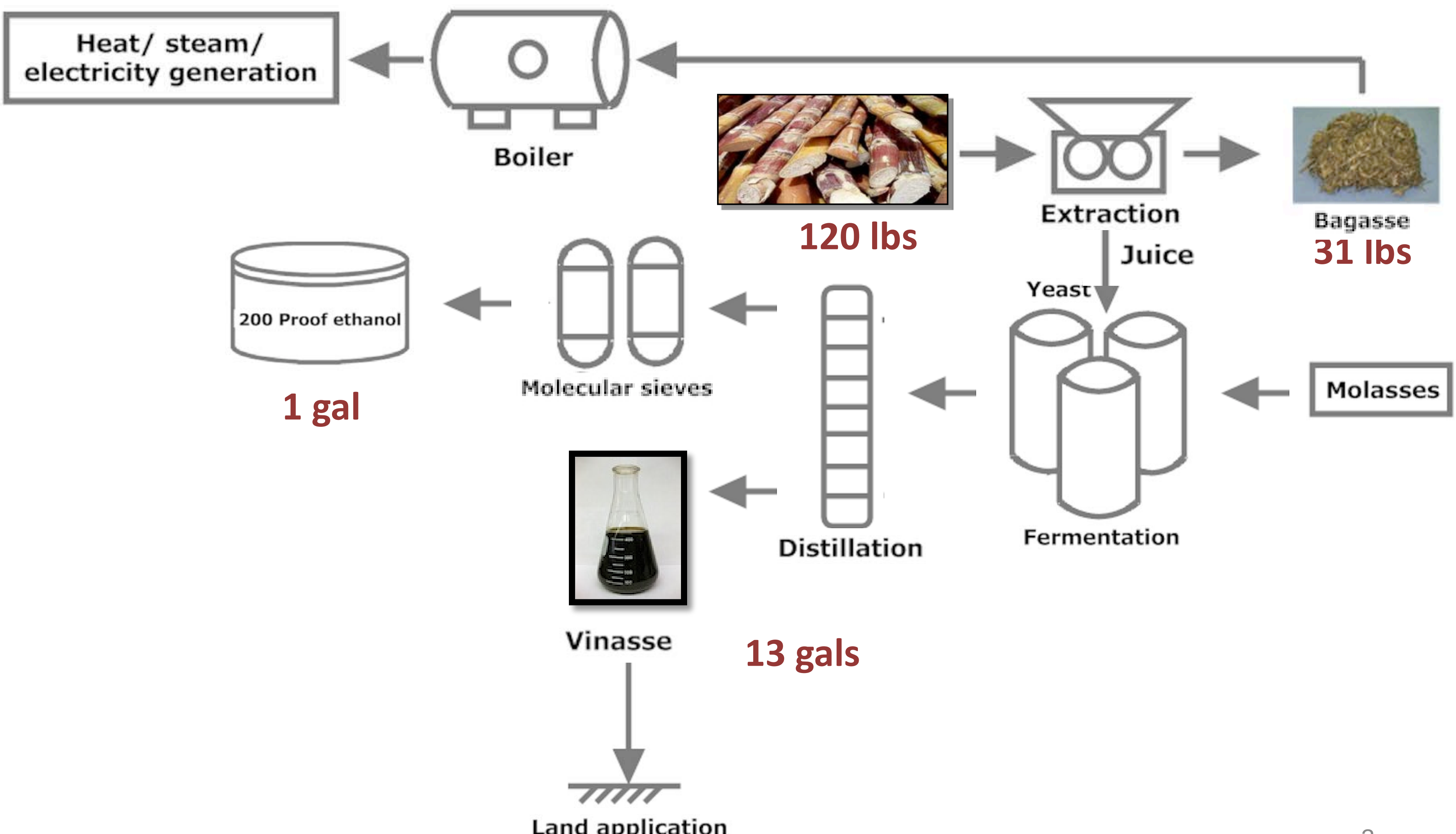
Introduction

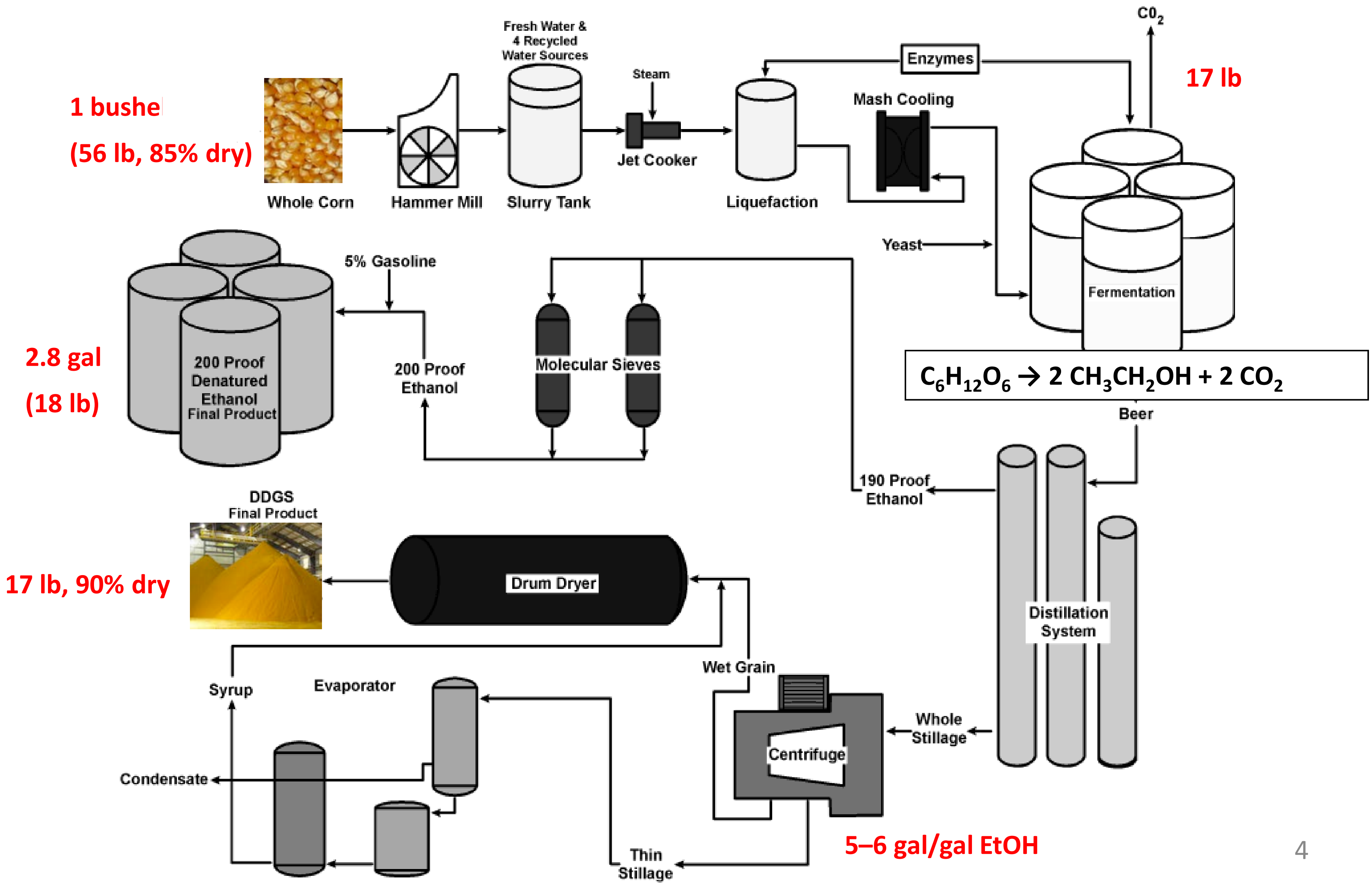
Biofuels

- **Bioethanol**
  - Sugar-based feedstock
  - Starch-based feedstock
  - Lignocellulosic-based feedstock
- **Biodiesel**
  - Vegetable oil
  - Animal fat
  - Waste oil
  - Algal oil
  - *Jatropha* oil

Sugar-based Ethanol Production and Residues

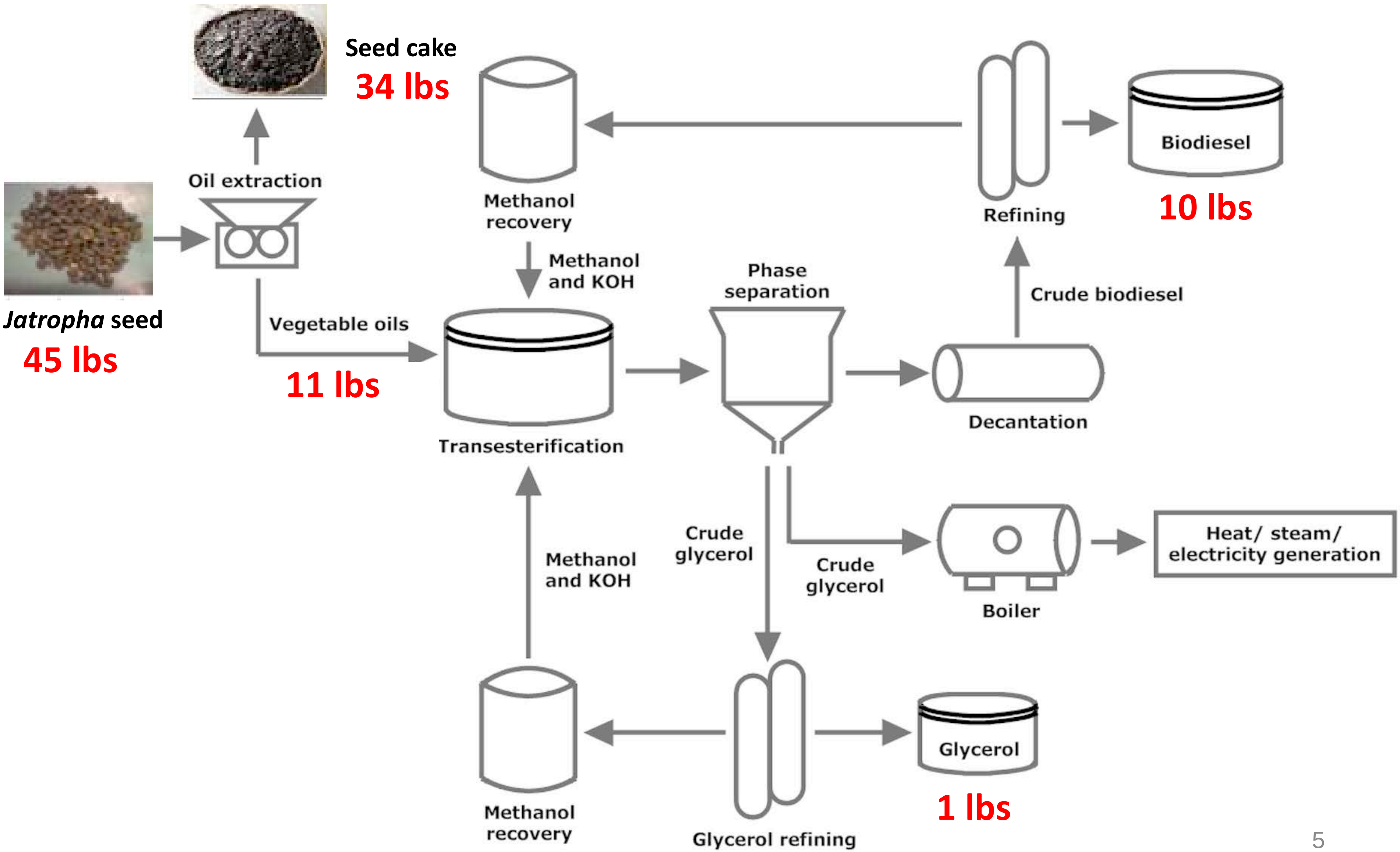


Starch-based Ethanol Production and Residues

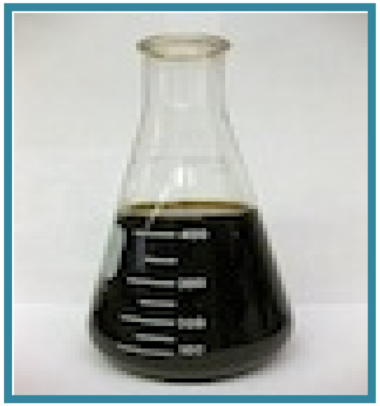


$$C_6H_{12}O_6 \rightarrow 2\ CH_3CH_2OH + 2\ CO_2$$

Jatropha Biodiesel Production and Residues



Fungal Fermentation of Liquid Residues



Vinasse

Crude glycerol

Vinasse

- Extremely high in organic content (100-130 g/L as chemical oxygen demand (COD))
- Requires treatment before disposal
- Increases ethanol production cost
- Raising a concern over a sustainability of sugar-based ethanol plants




Crude Glycerol

- High viscosity
- Extremely high organic content (~540 g_{TOC}/L)

- ~~Food~~
- ~~Cosmetic~~
- ~~Pharmaceutical~~
- ~~Etc.~~




Fungal Processing of Biofuel Residues

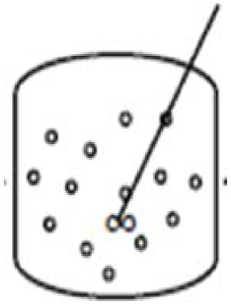
- Simple
  - pH control
  - Mixing
  - Air supply
  - Temperature control
- Requires minimal additional of unit operations
- Generates extra revenue from fungal protein





Fungal Processing of Biofuel Residues

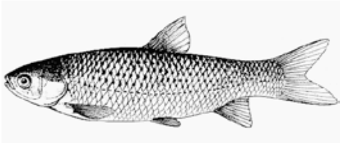
Liquid residues



Fungal processing of residues

$1,190 per dry ton

Fungal biomass



Aquatic feed

Fungal Culture

Rhizopus oligosporus

- An **edible** fungus
- Used for making **Tempeh**

(an Indonesian fermented food)

Overall Goal

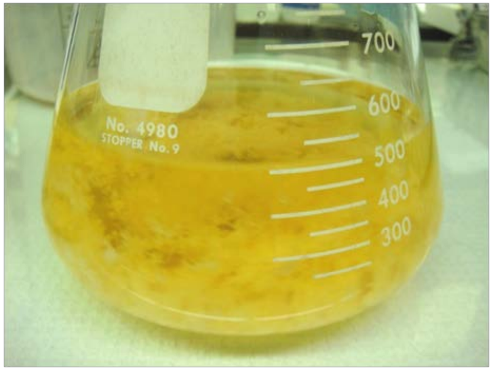
- **To investigate the feasibility of fungal protein production on liquid residues from biofuel production**





Fungal Cultivation on Vinasse

- Food-grade fungus, *Rhizopus oligosporus*, (ATCC # 22959)

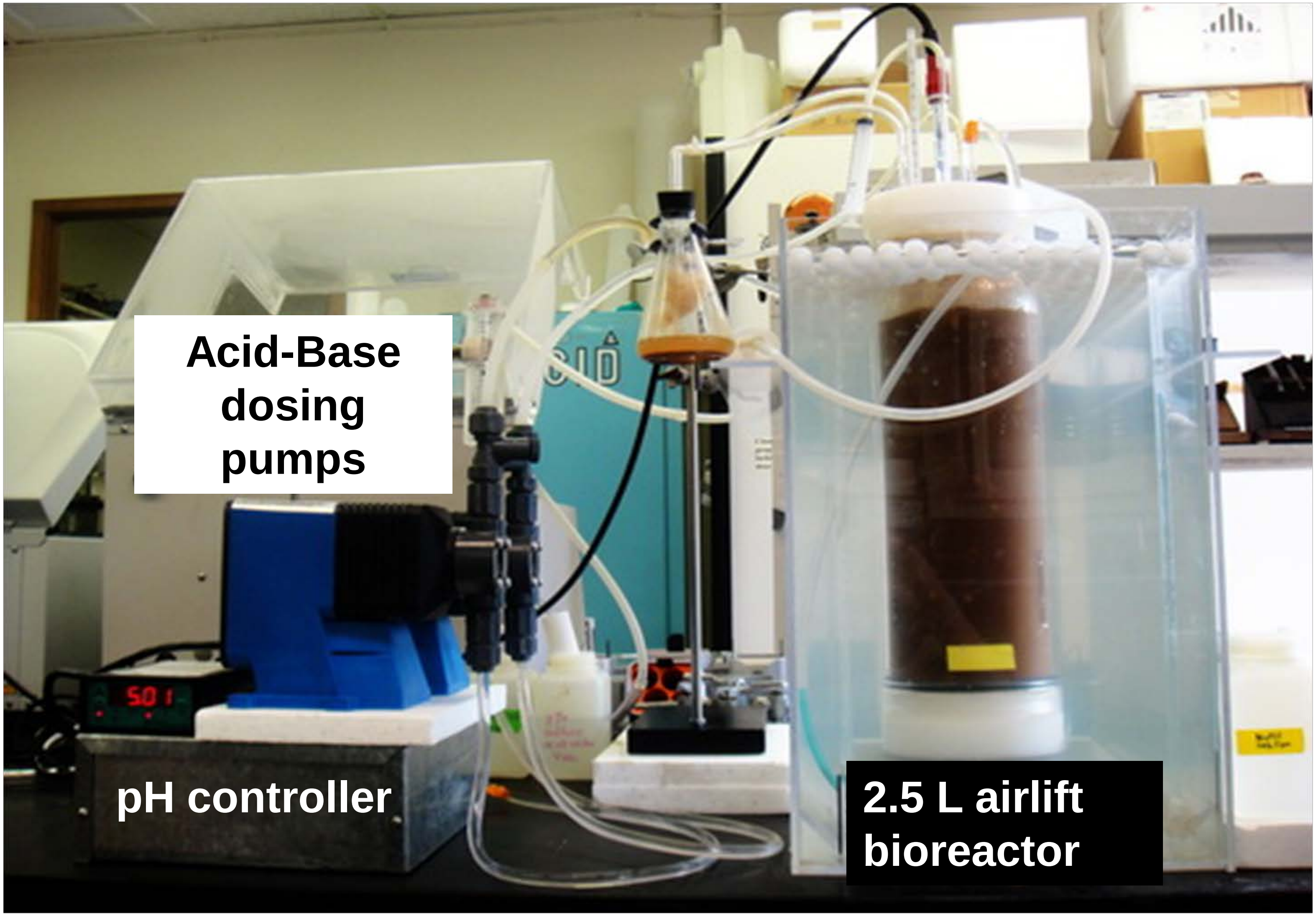


- Vinasse derived from ethanol fermentation of sugarcane syrup





Fungal Cultivation on Vinasse



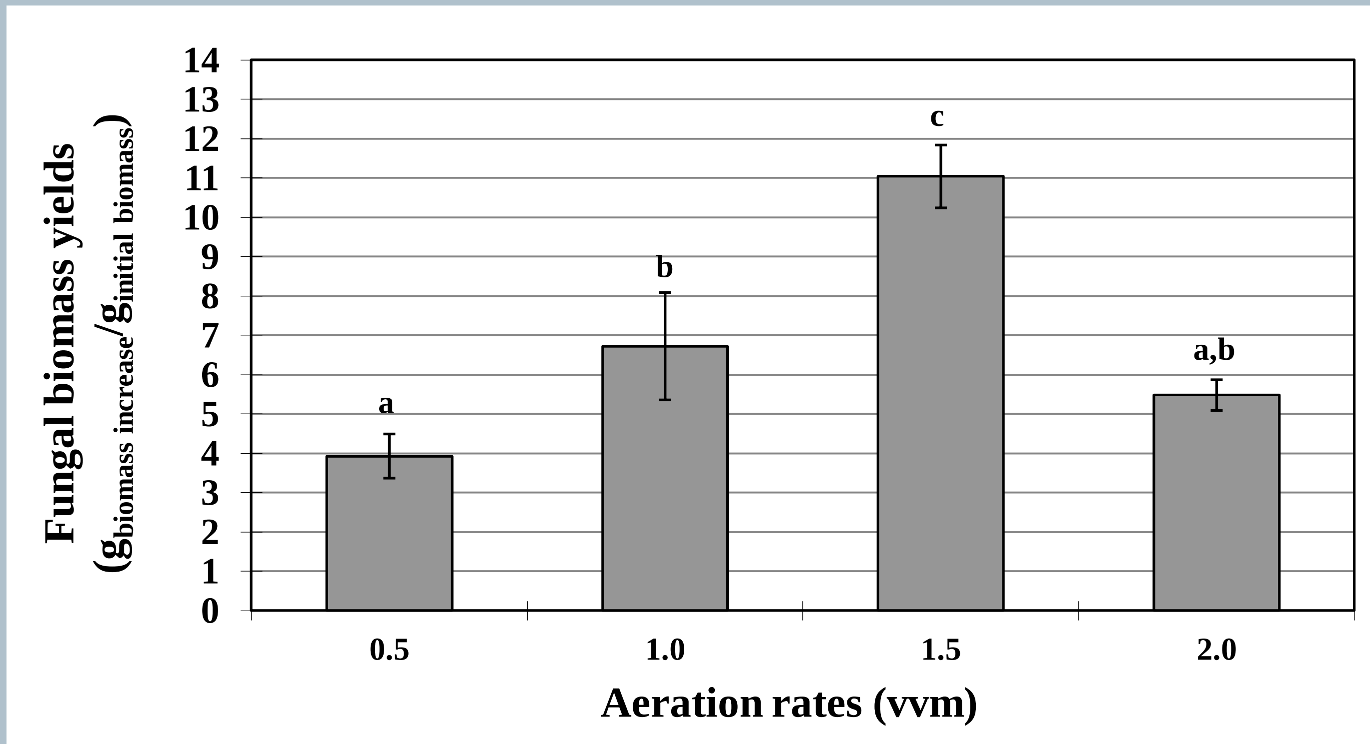
Fungal Cultivation on Vinasse

- Cultivation time: 3 days
- 75% (v/v) vinasse with nutrient supplementation at SCOD:N:P ratio of 100:5:1
- pH: 5.0
- Temperature: 37^{o}C
- Aeration rates: 0.5, 1.0, 1.5, and 2.0 vvm ($volume_{air}/volume_{liq}/min$)

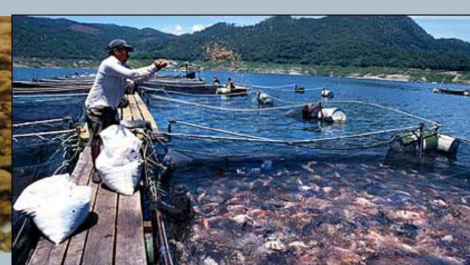
- **Fungal biomass yield = $g_{\text{biomass increase}}/g_{\text{initial biomass}}$**




Results



The optimal aeration rate was 1.5 vvm with the fungal biomass yield of 11.04 0.80 ($g_{\text{biomass increase}}/g_{\text{initial biomass}}$).



Results

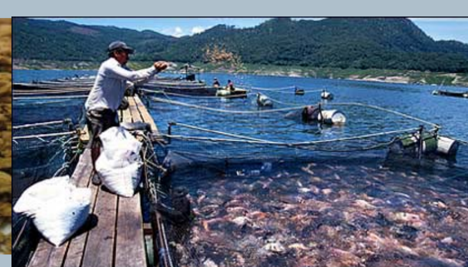
Day 0

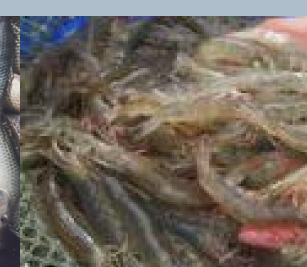
Day 1

Day 2

Day 3

Fungal cultivation on vinasse under 1.5 vvm





Fungal Cultivation on Biodiesel-derived Crude Glycerol

Fungal starter

Crude glycerol (100 g)

@ pH 5.0, 37^{o}C, and 150 rpm
for 3 days

Results

- **Optimal fungal growth condition:**

  75% (w/v) non-sterile crude glycerol with nutrient supplementation and without pH control

- **Fungal biomass yield:**

  0.84 ± 0.03 $(g_{\text{biomass increase}}/g_{\text{initial biomass}})$




Banagrass Juice as a Low-cost Nutrient-rich Solution

Banagrass stalks

(*Pennisetum purpureum*)

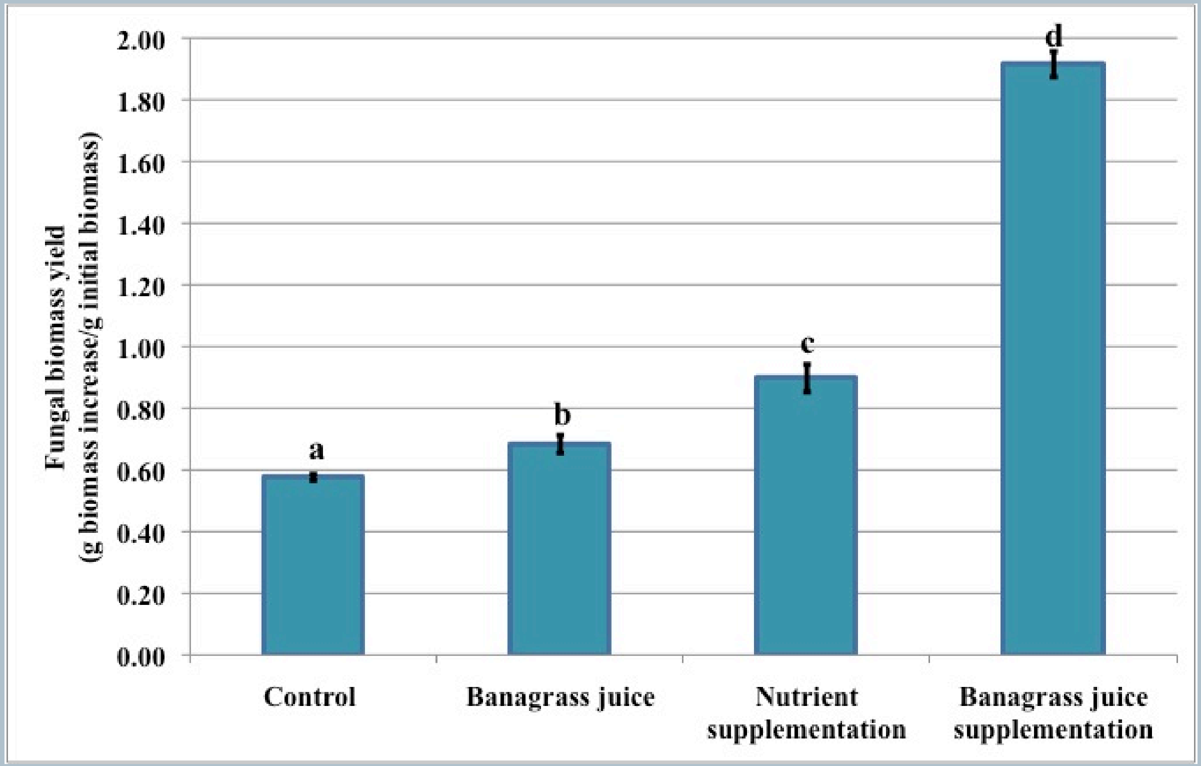
Shredder

Screw press

Banagrass juice

Fibrous biomass for biofuel production

Results



Supplemented crude glycerol with banagrass juice improves fungal biomass yield by 2.3-fold.

Control = 50% glycerol

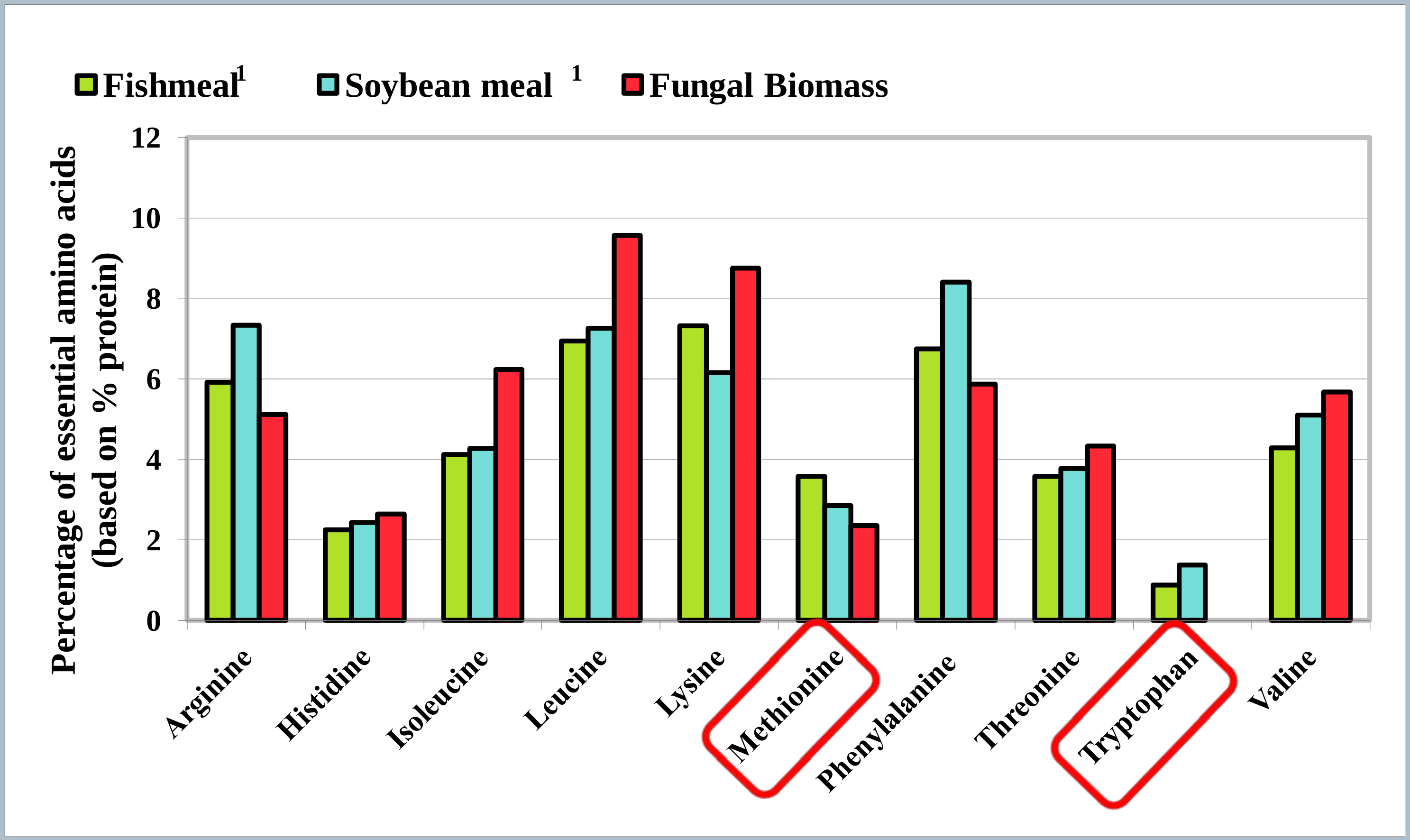
Banagrass juice = 50% banagrass juice

Nutrient supplementation = 50% crude glycerol sample supplemented with nutrient **chemically**

Banagrass juice supplementation = 50% crude glycerol and 50% banagrass juice

Fungal Biomass for Aquatic Feed Application

Fungal biomass contained ~ 45 – 50 % of crude protein (dry weight basis)



Conclusion

- An edible fungal protein can be co-fed with commercial protein sources for aquatic feed application
- An innovative fungal technology provides a sustainable opportunity for sugar-based ethanol plants and biodiesel industries.