



## Wastewater Treatment Facilities: Biorefinery for Biofuels

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## Objectives

- Transform the daily disposal of industrial and domestic sewage into large quantities of lipids using microorganisms
- Integrate the lipid, sugar, and thermochemical platforms for producing JP-Fuels, gasoline, biodiesel and chemicals



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# Evaluation of BioDiesel Production Costs

## Soybean Oil

Note: Feedstock  
represent ~90%  
of total processing costs



**\$4.38/gal feedstock cost**

**\$0.35/gal processing cost**

**\$0.10/gal transportation cost**

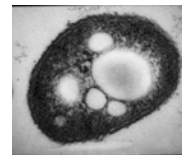
**= \$4.83/gal total cost**



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# Sustainability and Logistical Barriers to Biofuels

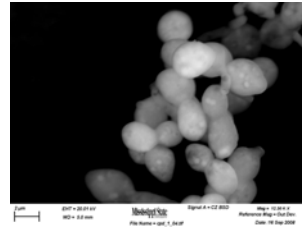
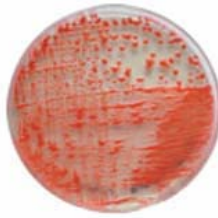
- The US Consumes approximately 300,000,000,000 gal/yr
  - 165,000,000,000 gal/yr gasoline
  - 75,000,000,000 gal/yr diesel
- Ethanol would account for 2%
- Soy Bean oil accounts for 0.33%
- When populations need that for food fuel will lose
- Not Sustainable.
- Single-cell oil produced in a wastewater treatment facility will not have a food market
- Wastewater treatment will always occur and scales with population.



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# The Oleaginous Microorganisms

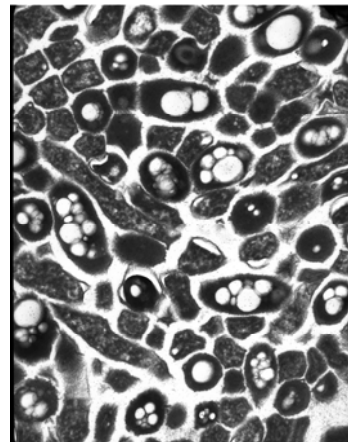
- *Rhodotorula glutinis*
- *Cryptococcus curvatus*
- 11 others



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## COMPARISON OF OIL PRODUCTION FROM FEEDSTOCKS

Sample	% Oil	Time (D)
Soybean	19	105
Canola	33	255
Camelina	36	255
Turnip	36	255
Flax	39	240
Tallow	46	365
Castor	55	195
<i>H. matrisalis</i>	23	2.5
<i>R. glutinis</i>	16-60	2.5
<i>R. opacus</i>	60-80	2.0



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# WASTEWATER AS CARBON SOURCE

- **Wastewater contains:**
  - Carbon
  - Nitrogen
  - Phosphorous
  - Water
  - Micronutrients
- **Approximately 30 million gallons\* of wastewater are produced daily in Tuscaloosa**
  - Residential waste
  - Industrial waste



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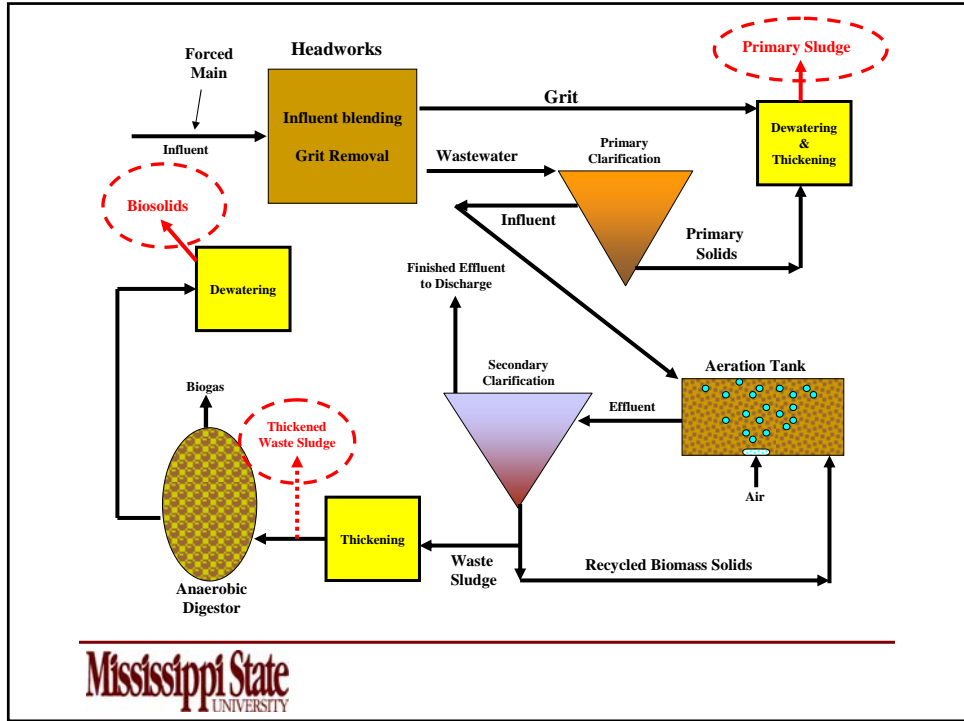
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## 35 Billion Gallons of Municipal Wastewater Generated Daily

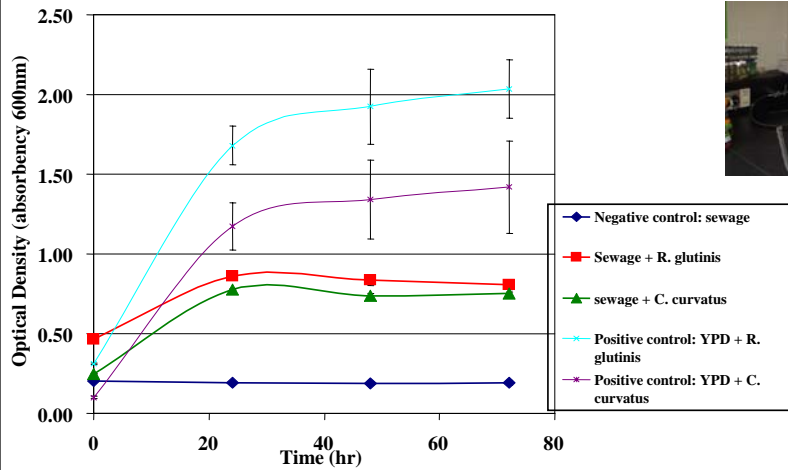


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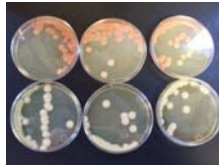
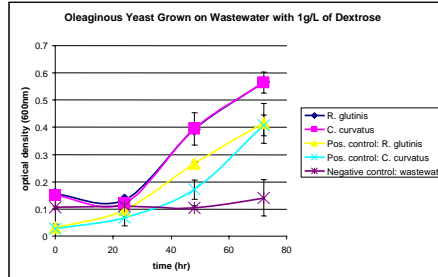
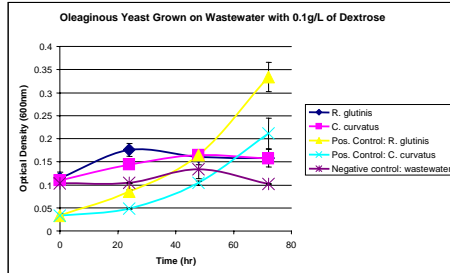
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## Growth of *R. glutinis* and *C. curvatus* on Sewage from YPD

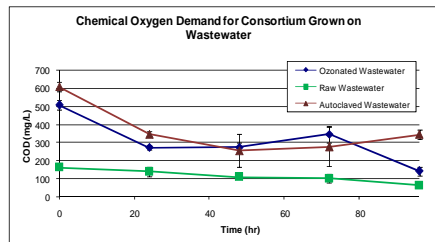


# COMPARISON OF GROWTH CURVES

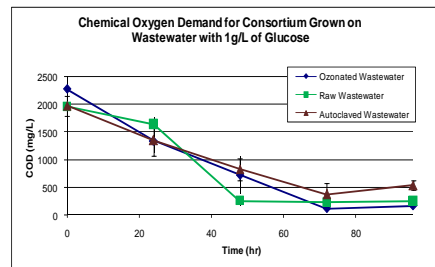


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# CHEMICAL OXYGEN DEMAND



Sugar	Sample	% Reduction
0	C O	72.26
	R W	61.25
	C A	43.49



Sugar	Sample	% Reduction
1g/L	C O	92.70
	R W	87.27
	C A	72.83

10% Oil Content

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Andrew Ford and Jaclyn Hall IOP 5

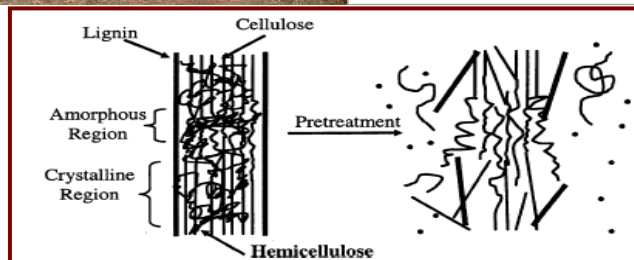
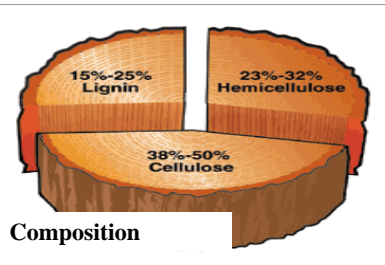
## Carbon Sources Supporting Growth of Oleaginous Microorganisms

- **Sugars**
  - Glucose
  - Xylose
  - Ribose
  - N-acetyl glucosamine
- **Glycerol**
- **Flour**



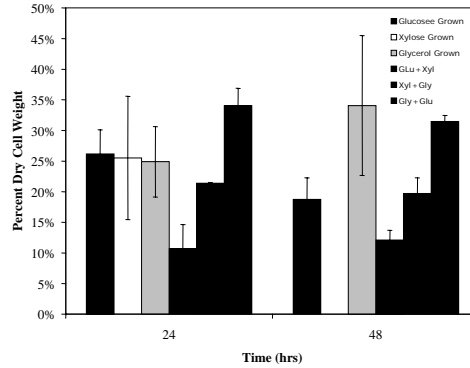
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## Lignocellulosic Biomass



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# Conversion of Lignocellulosic Biomass to Microbial Oil

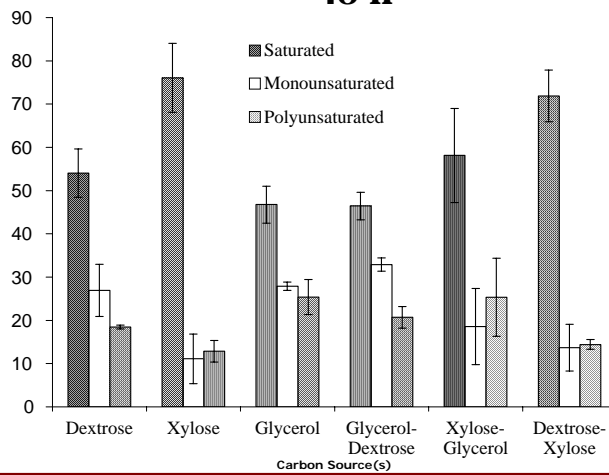


Bioresour Technol. 2009 Jan;100(1):356-361.



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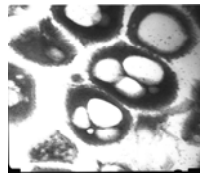
## The Effect of Carbon Source on the Saturation of Fatty Acids Produced by *R. glutinis* 48 h



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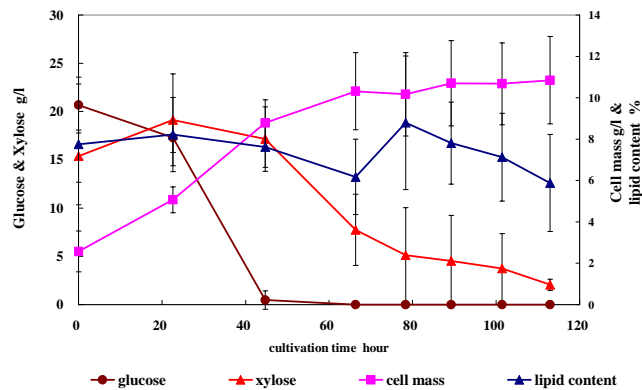
# Conversion of Lignocellulosic Biomass to Microbial Oil

Sugar	Cell mass concentration in culture g/L	Total Lipid production. % dry wt.
Xylose	15	40
Dextrose	20	60
Artificial acid hydrolysate	16	35
Switch Grass Hydrolysates	2.63	26



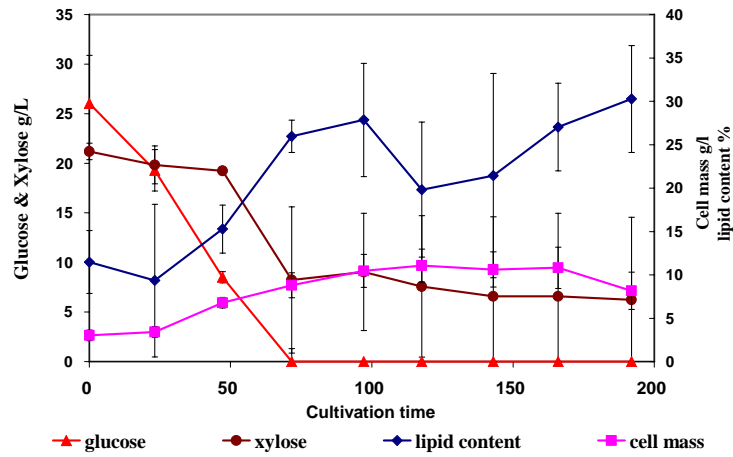
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## Conversion of 30 g/L Acid Hydrolysate by Oleaginous Microbes



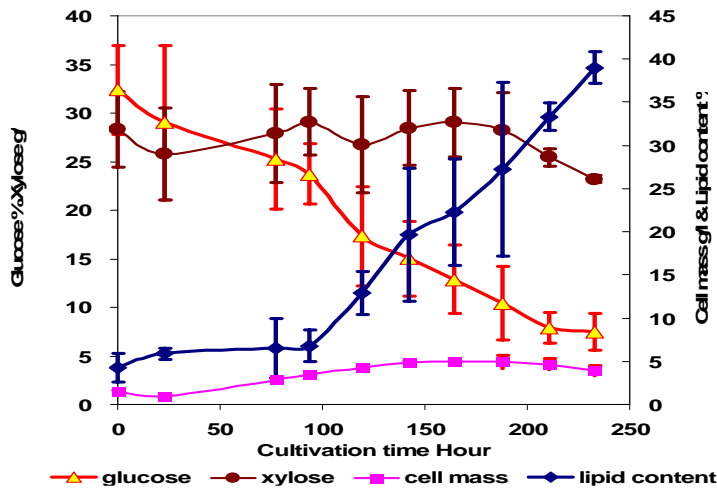
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## Conversion of 45 g/L Acid Hydrolysate by Oleaginous Microbes



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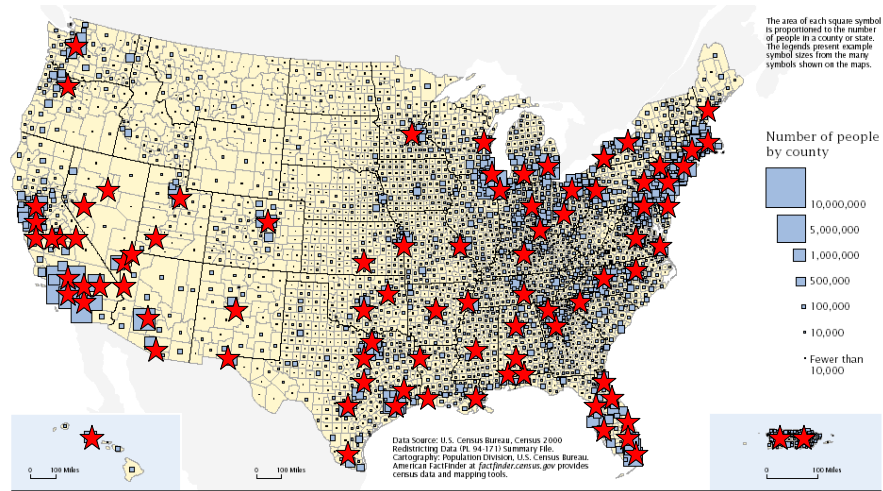
## Lipid accumulation by *R. glutinis* growing on acid hydrolysate with 60 g/l of total sugar at 30 °C



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# Example Biorefinery Locations



## ACKNOWLEDGEMENTS

- Department of Energy
- Environmental Protection Agency
- MS/AL Sea Grant
- 23 students



**Thank You**

