



Process Simulation of Modified Dry Grind Ethanol Plant with Recycle of Pretreated and Enzymatically Hydrolyzed Distillers' Grains

Youngmi Kim, Nathan S. Mosier, and Michael R. Ladisch
LORRE, Purdue University

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For gifts of enzymes

Genencor (Enzymes)

Distillers Grains and Stillage

Big River Resources, LLC.



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Outline

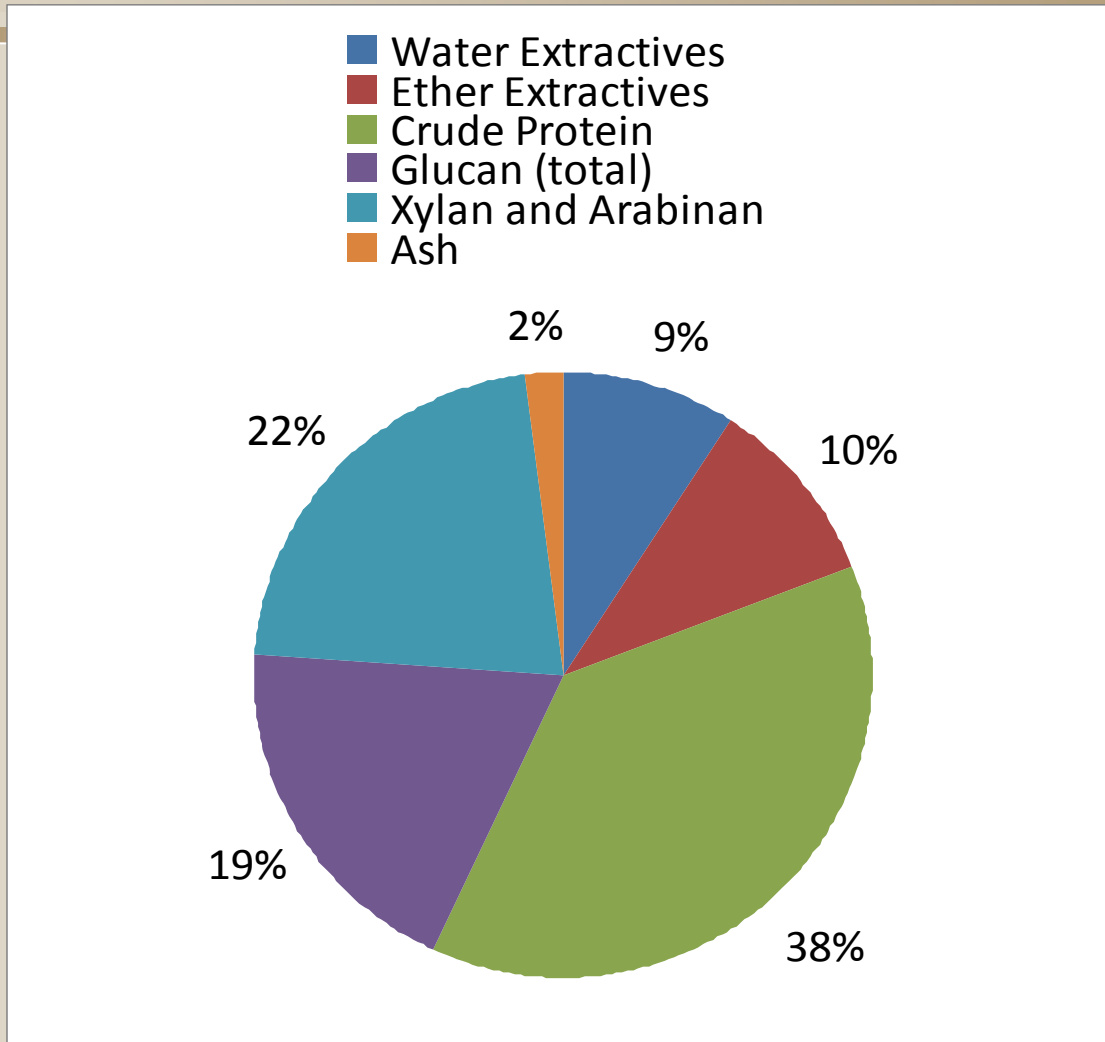
- Composition of distiller's grains
- Modified dry grind processes
- Impacts of the modified dry grind processes
 - Ethanol yield
 - Fermentable sugar and ethanol concentrations
 - Accumulation of fermentation inhibitors
 - Water balance
- Composition of enhanced DDGS
- Summary and conclusions



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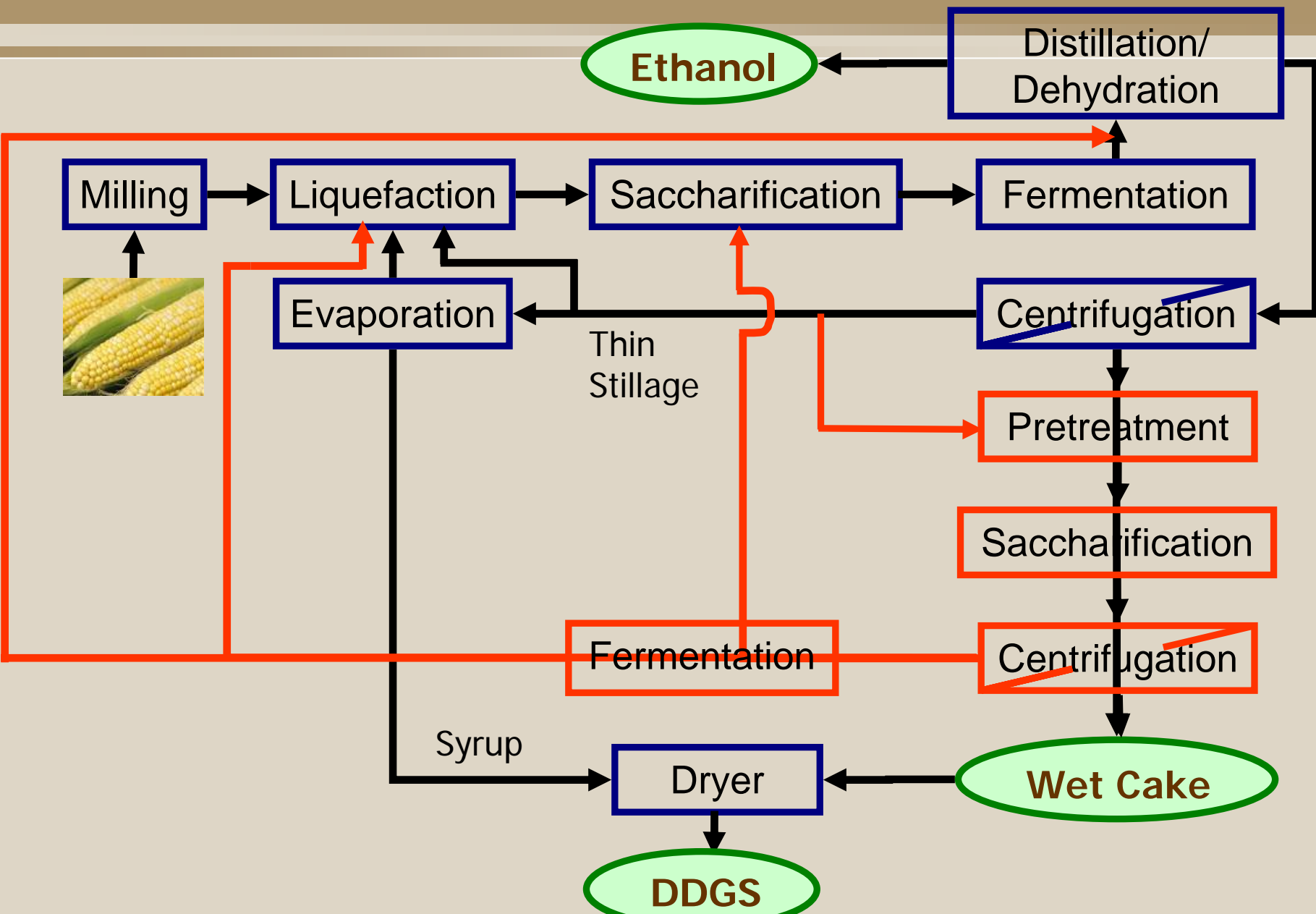
Composition of Distiller's Grains



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Con Modified Dry Grind Process (Case 3)



Impacts

What would be the impacts of the modified dry grind processes on

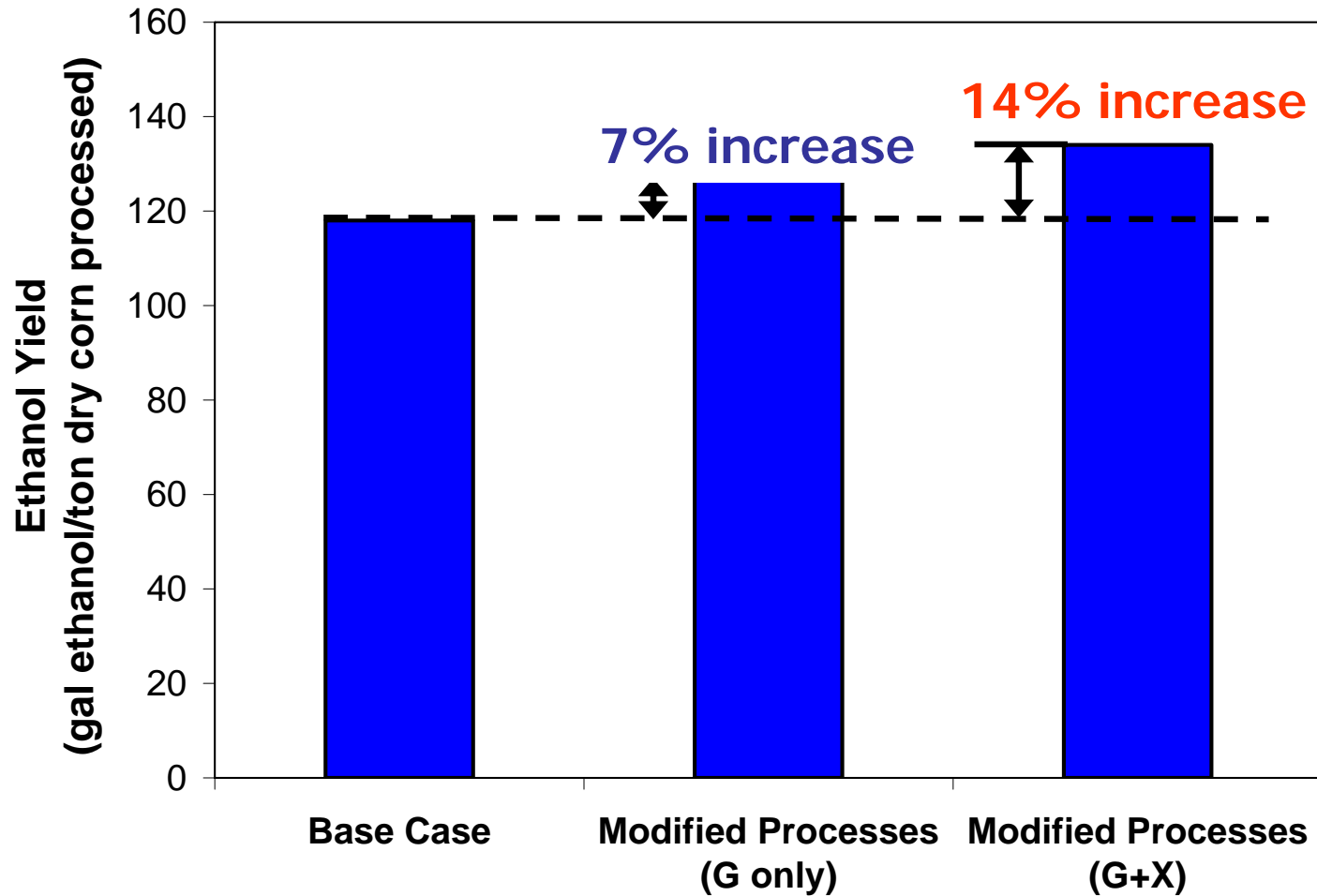
- **Overall ethanol yield ?**
- **Fermentable sugar and ethanol concentrations ?**
- **Accumulation of inhibitors ?**
- **Water balance ?**



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Ethanol Yields



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Fermentable sugar and ethanol concentrations in the fermentor

	Base Case	Case 1	Case 2	Case 3	
	Hexose Only	Co-Ferm.	Co-Ferm.	Hexose Only	Co-Ferm.
Fermentable sugar conc. (wt/vol)	33.5%	27.0%	37.9%	33.3%	12.0%
Ethanol conc. * (wt/vol)	15.4%	12.4%	17.4%	15.4%	5.3%

* concentrations at the end of fermentation. **Best case scenarios**

USDA's Ethanol Cost-of-Production Survey (2002):

12-18% (by v/v, equivalent to 9-14% by w/v)



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Accumulation of Fermentation Inhibitors

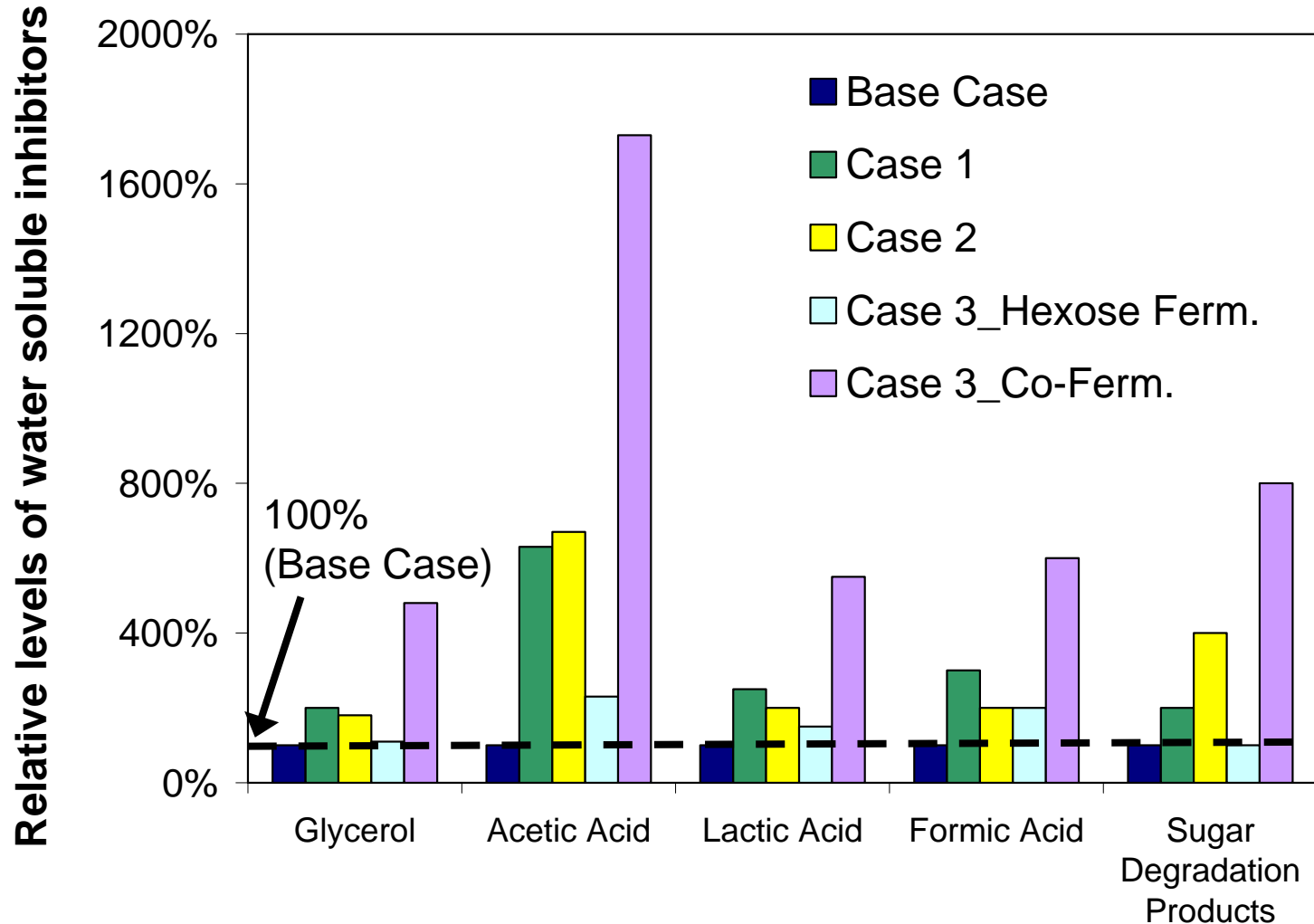
- Recycle of stillage (backset) and recirculation of the process water cause build-up of inhibitory components, both volatiles and non-volatiles.
- Recirculated molecules accumulate at 5-20 times higher concentrations than concentration without recycle (Galbe and Zacchi (1992, 1994)).
- Inhibitory compounds
 - Released from biomass - acetic acid, lignin derivatives
 - Sugar degradation - furfural, HMF
 - By-products or contamination during fermentation
 - acetic acid, lactic acid, glycerol, etc.



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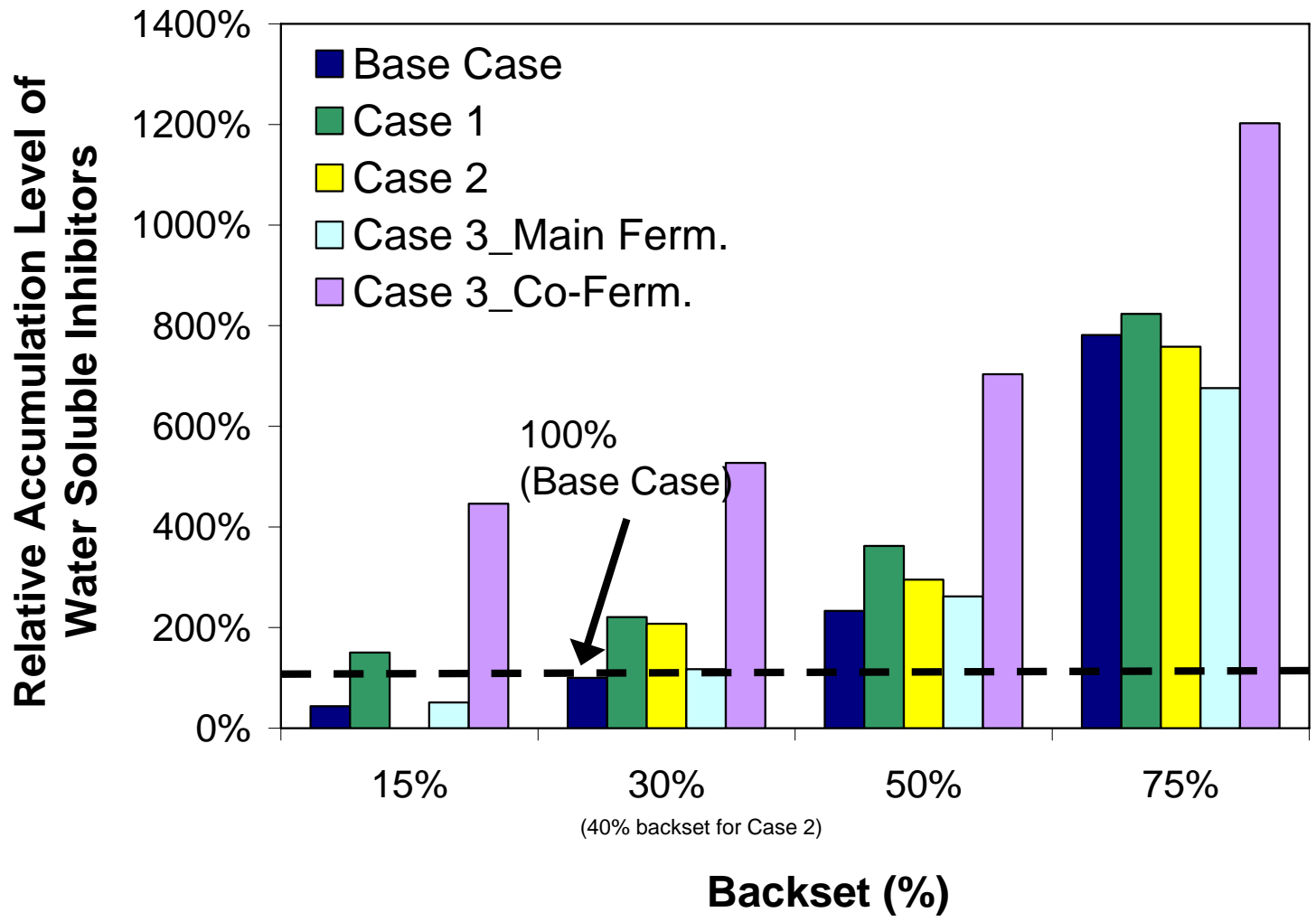
Relative levels of water soluble fermentation inhibitors during fermentation



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Effect of levels of backset in the process on relative water soluble inhibitors in fermentation mash



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Water Balance

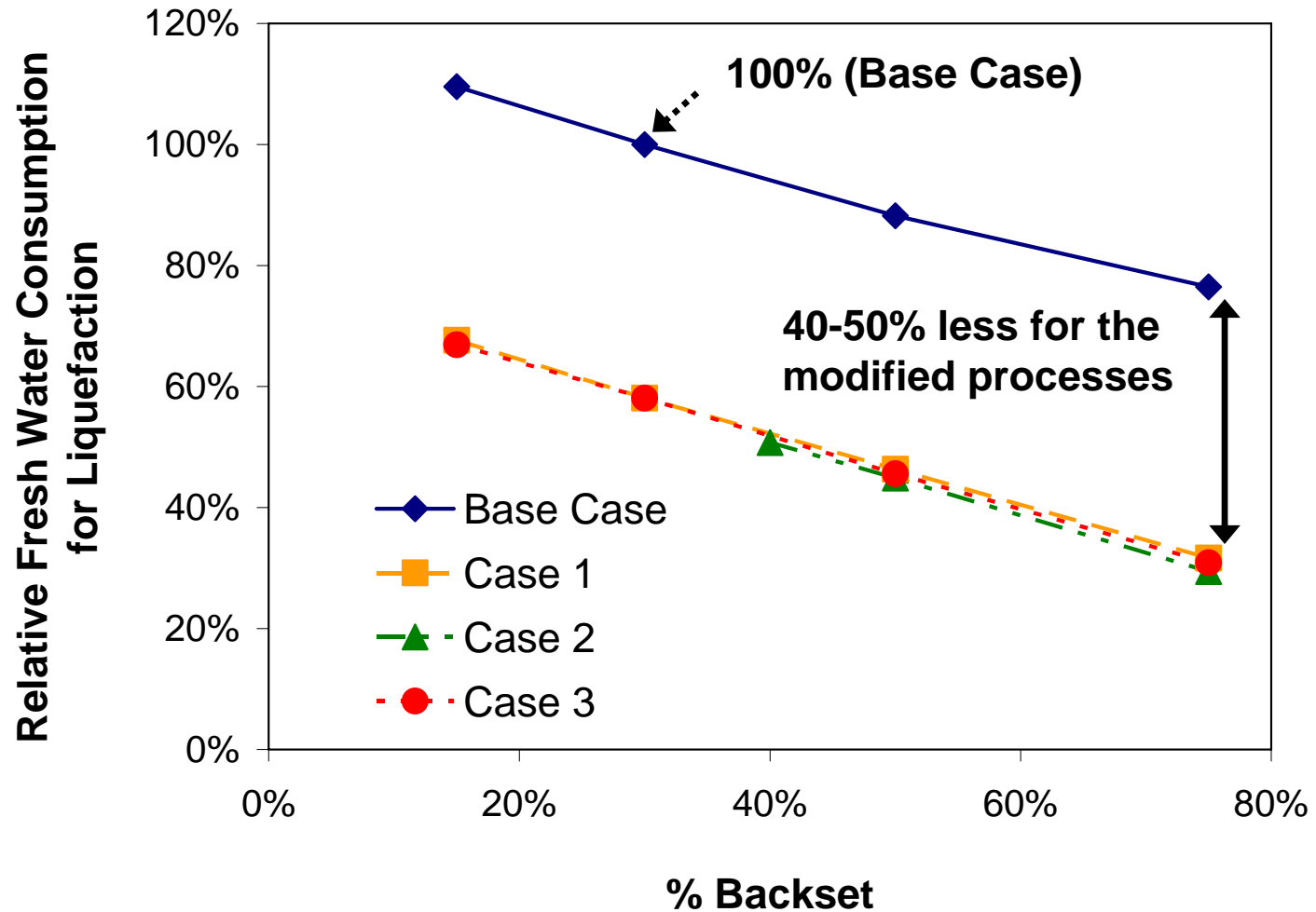
- Reducing water consumption and minimizing waste water discharge are of major concerns in fuel ethanol plants.
- Backset may reduce quantity of water required in the process.
- Fresh water input is needed depends on levels of the backset available, concentrations of inhibitory compounds re-introduced into the process, and heating (steam) or cooling water requirements of the process.



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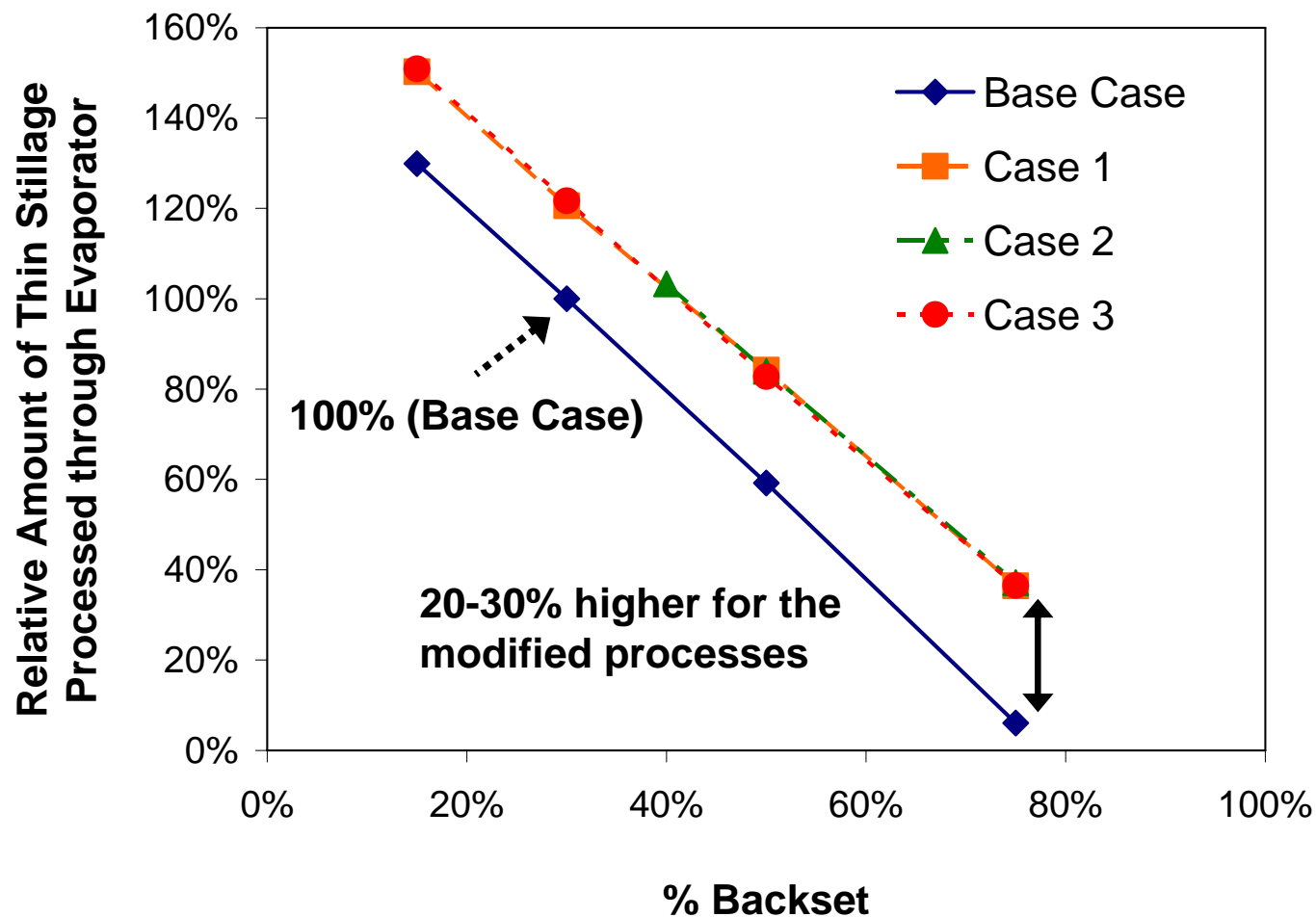
Fresh Water Consumption for Liquefaction



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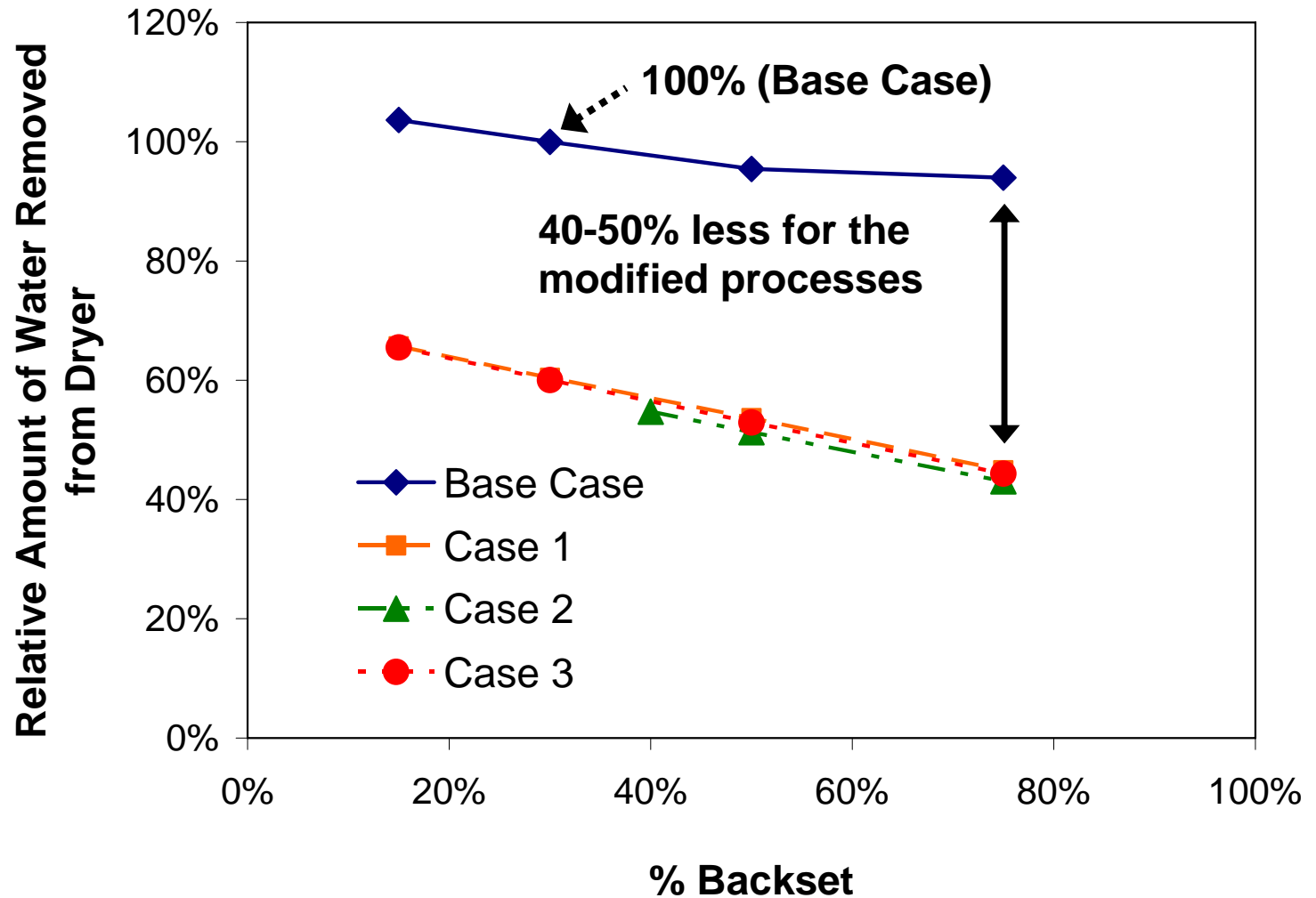
Amount of Thin Stillage Processed through Evaporator



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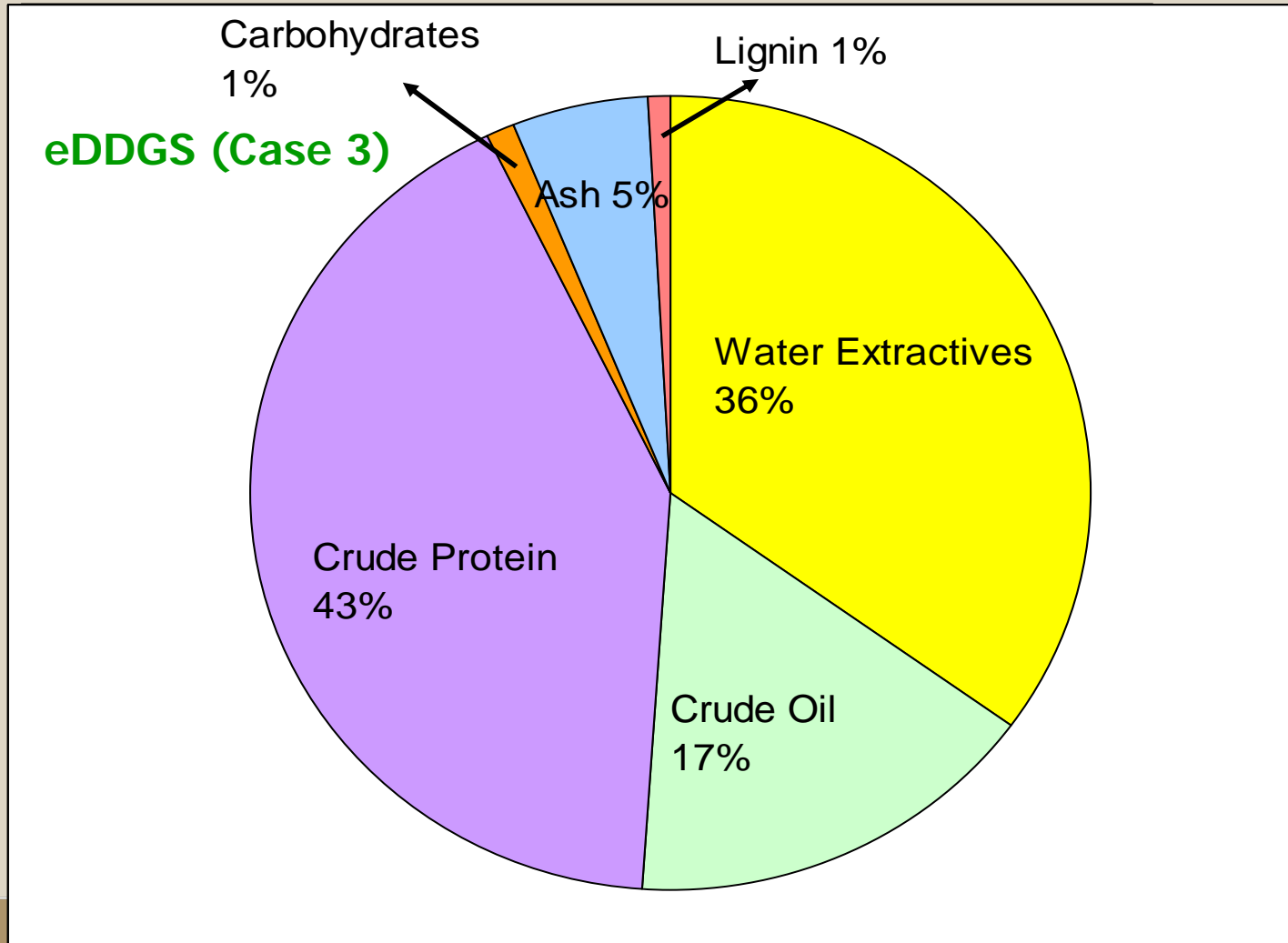
Amount of Water Removed from Dryer



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Composition of eDDGS



Summary and Conclusions

- Simulated material balances show modification of dry grind process enhances ethanol yield by 14% when both glucose and xylose fermented (134 gal ethanol/ton dry corn).
- Build-up of inhibitors due to recycle and its effect on kinetics of enzymatic hydrolysis and fermentation require further investigation to validate the process modifications.
- Proposed processes require less fresh water input for liquefaction than conventional dry grind process. Compensates for increased overall water requirement in a modified process.
- Dryer load for a modified process is less than for conventional dry grind process.
- The final eDDGS (enhanced dried distillers' grains) from the modified processes has 30 to 40% higher protein content than DDGS.



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Thank You



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