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

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For gifts of enzymes

Genencor (Enzymes)

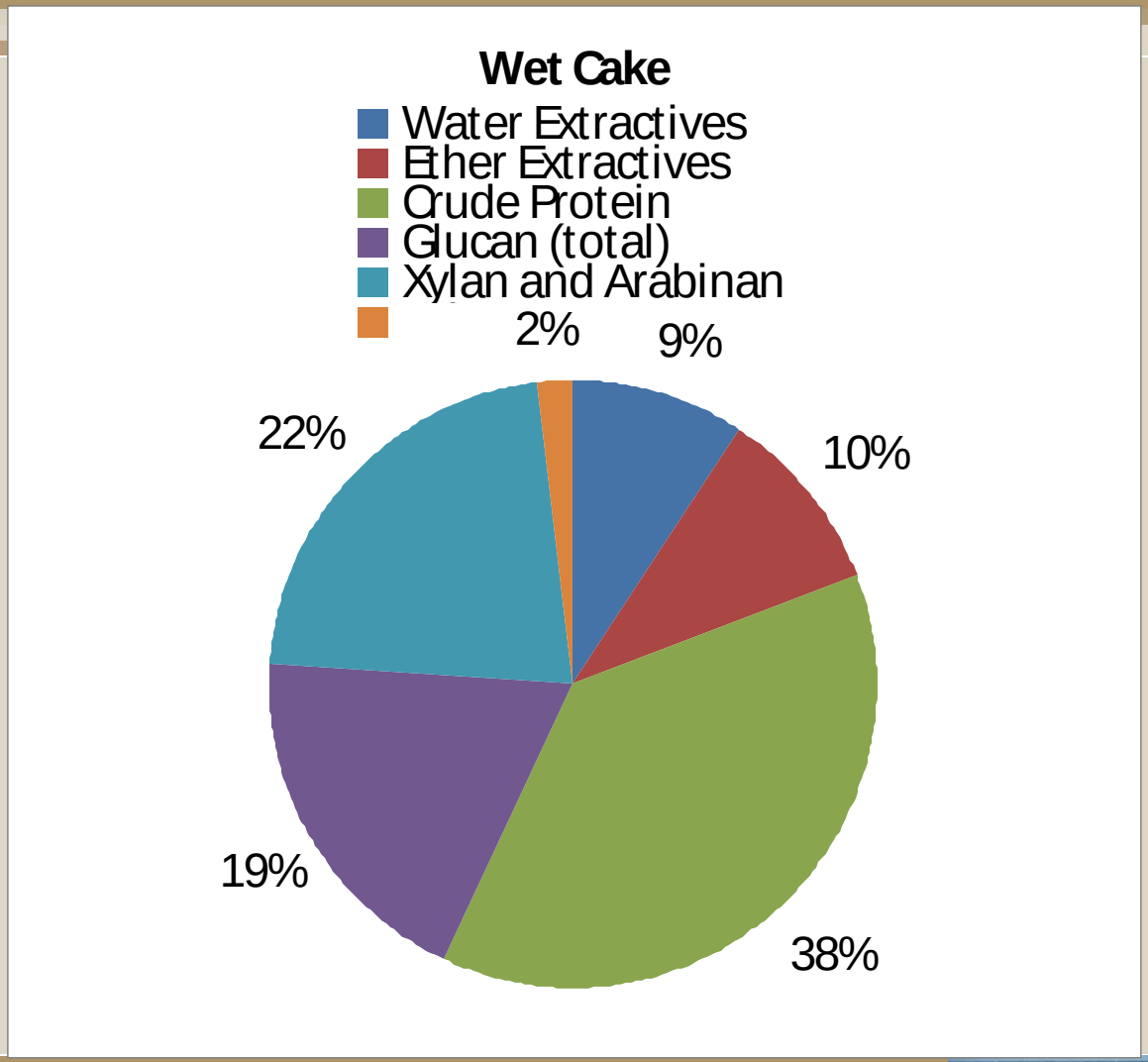
Distillers Grains and Stillage

Big River Resources, LLC.

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 usage
- Composition of enhanced DDGS
- Summary and conclusions

Composition of Distiller's Grains



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Modified Dry Grind Process (Case 3)

Milling

Liquefaction

Saccharification

Fermentation

Distillation/
Dehydration

Ethanol

Evaporation

Thin
Stillage

Centrifugation

Pretreatment

Saccharification

Fermentation

Centrifugation

Syrup

Dryer

Wet Cake

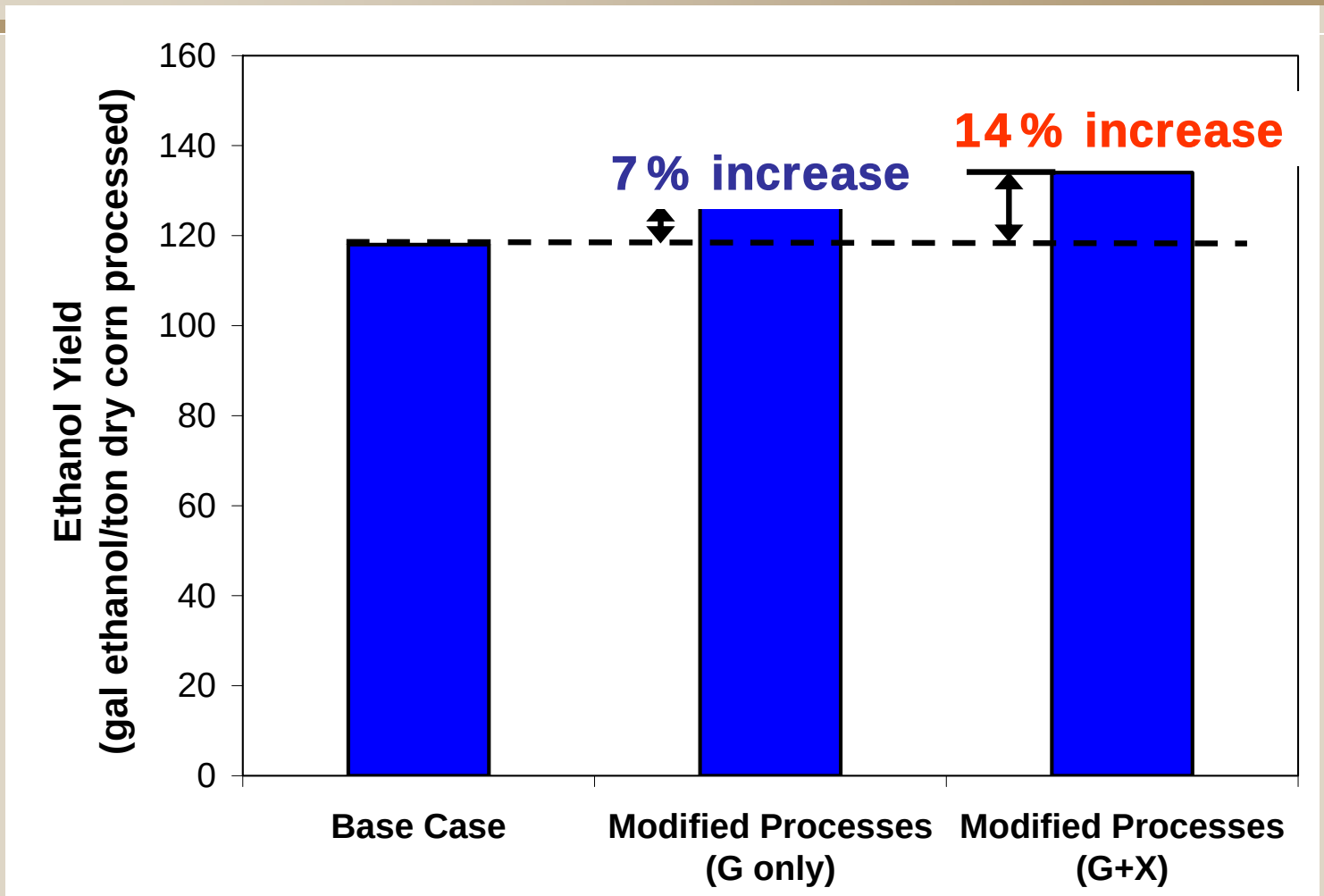
DDGS

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 usage ?**

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)

Accumulation of Fermentation Inhibitors

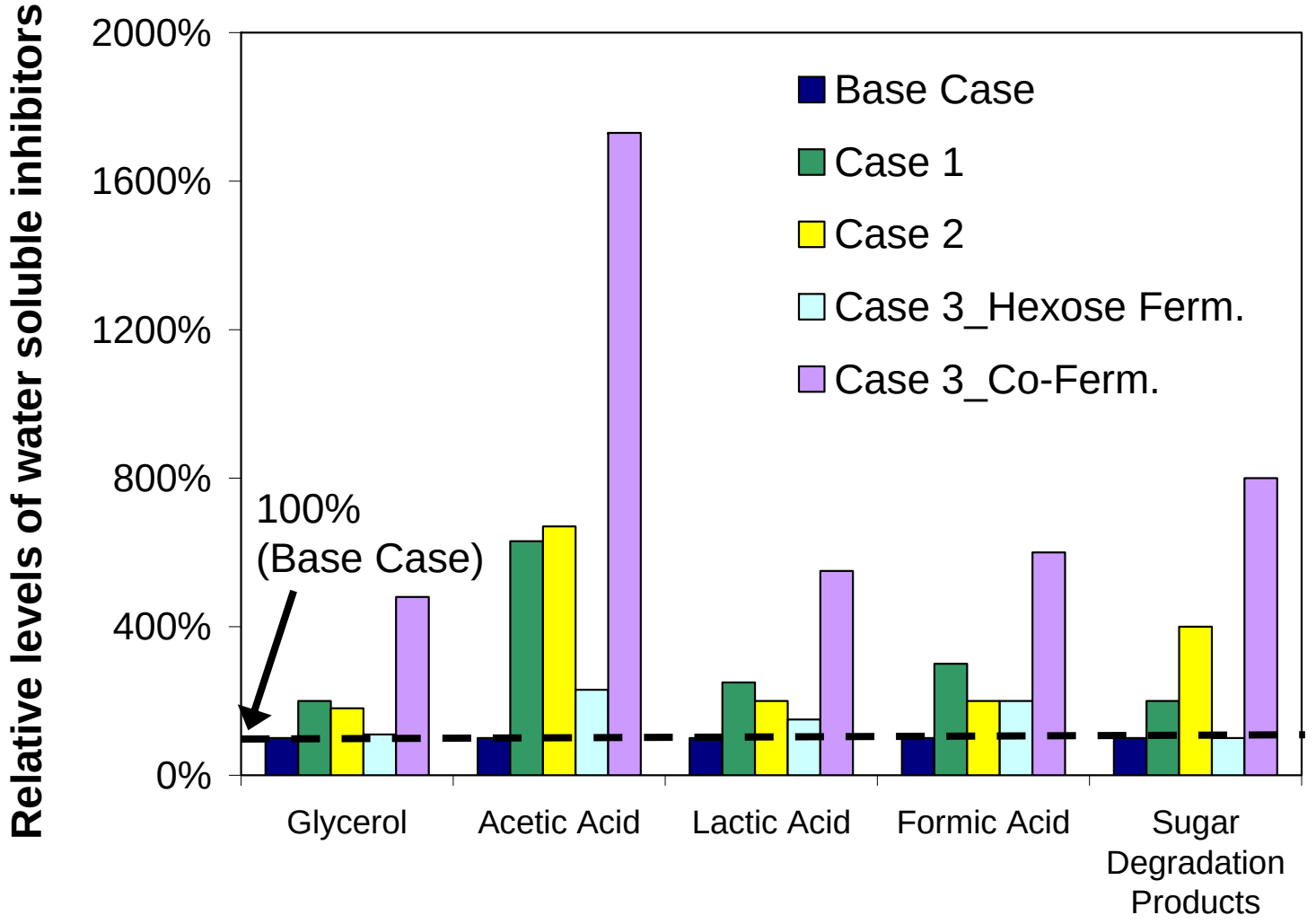
- Recycle of stillage (backset) and recirculation of the process water cause build-up of inhibitory components, both volatiles and non-volatiles.

- 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.

- Non-volatile compounds may cause severe toxic effects on fermentation and moderate effects on the enzymatic hydrolysis (Palmqvist et al., 1996).

Relative levels of water soluble fermentation inhibitors during fermentation



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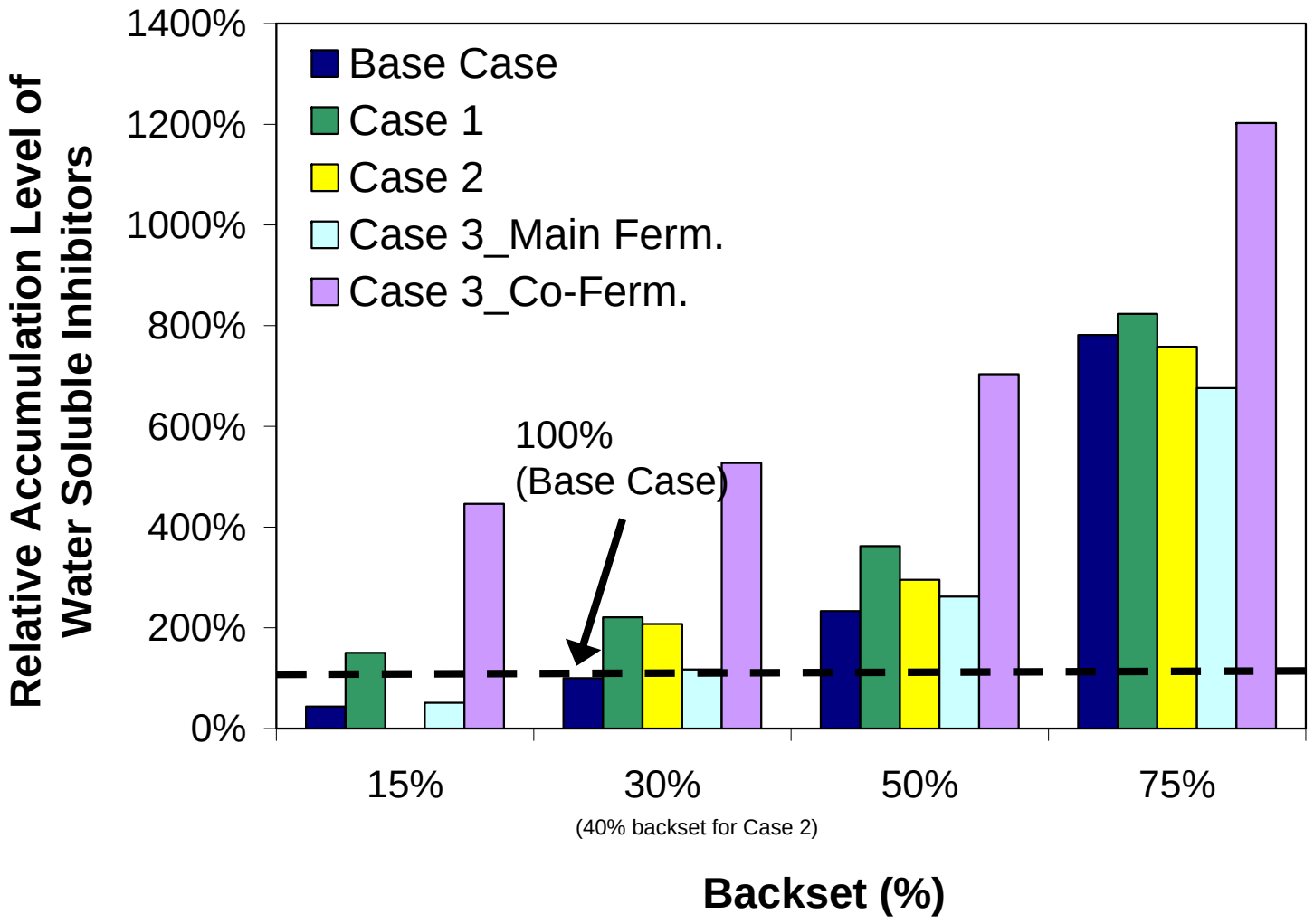
Effect of levels of backset in the process on relative water soluble inhibitors in fermentation mash



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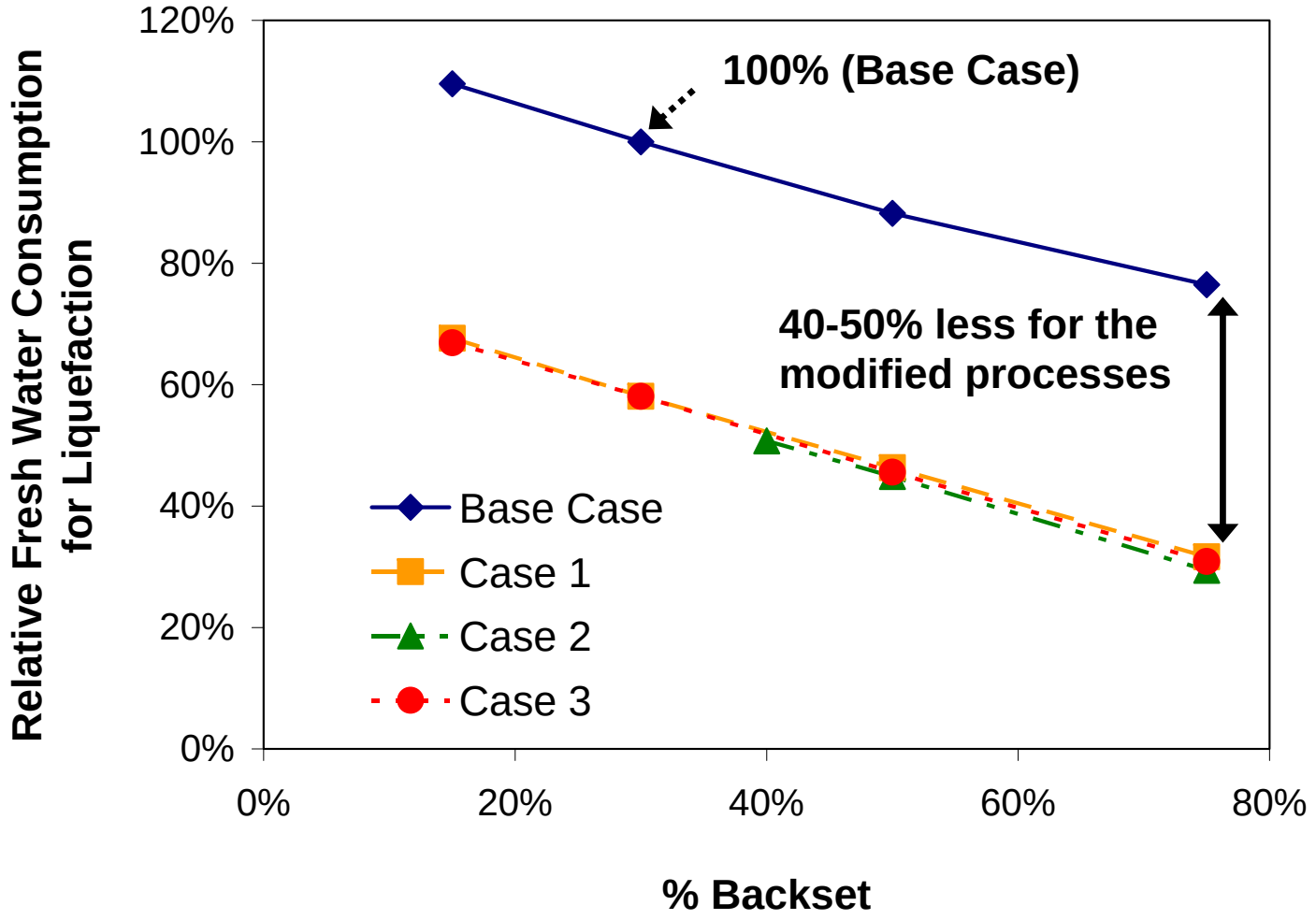
Water Balance

- 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.

Fresh Water Consumption for Liquefaction



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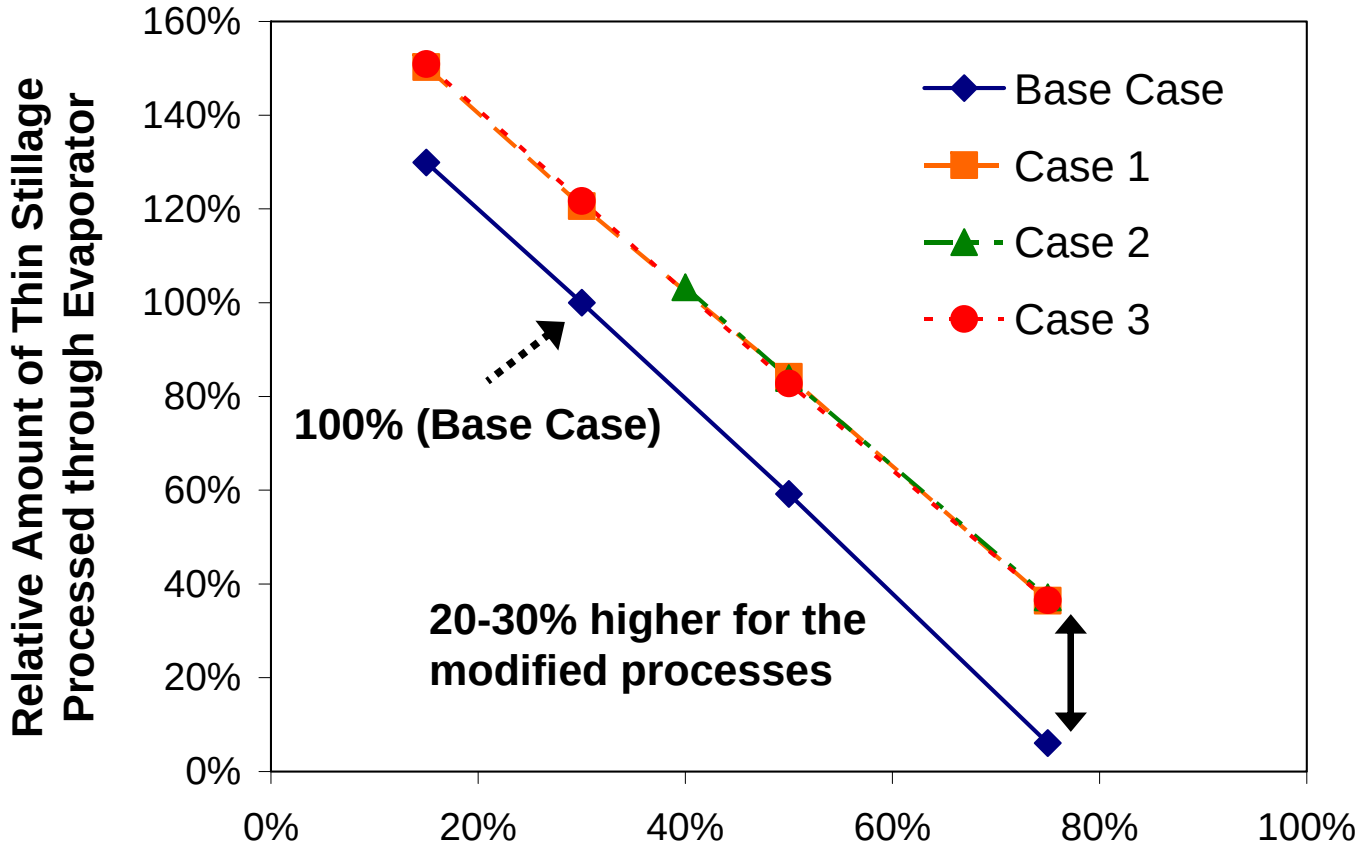
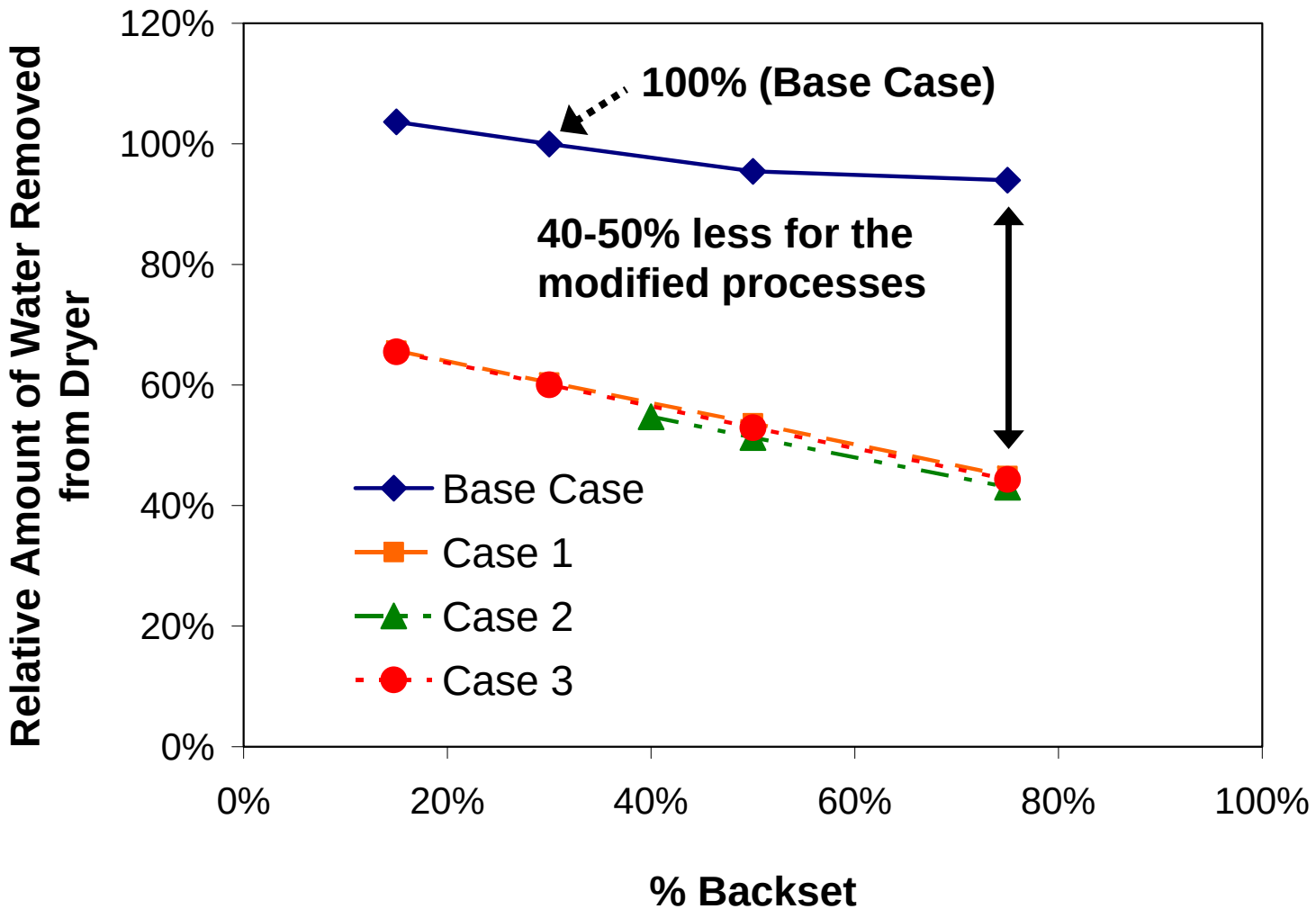
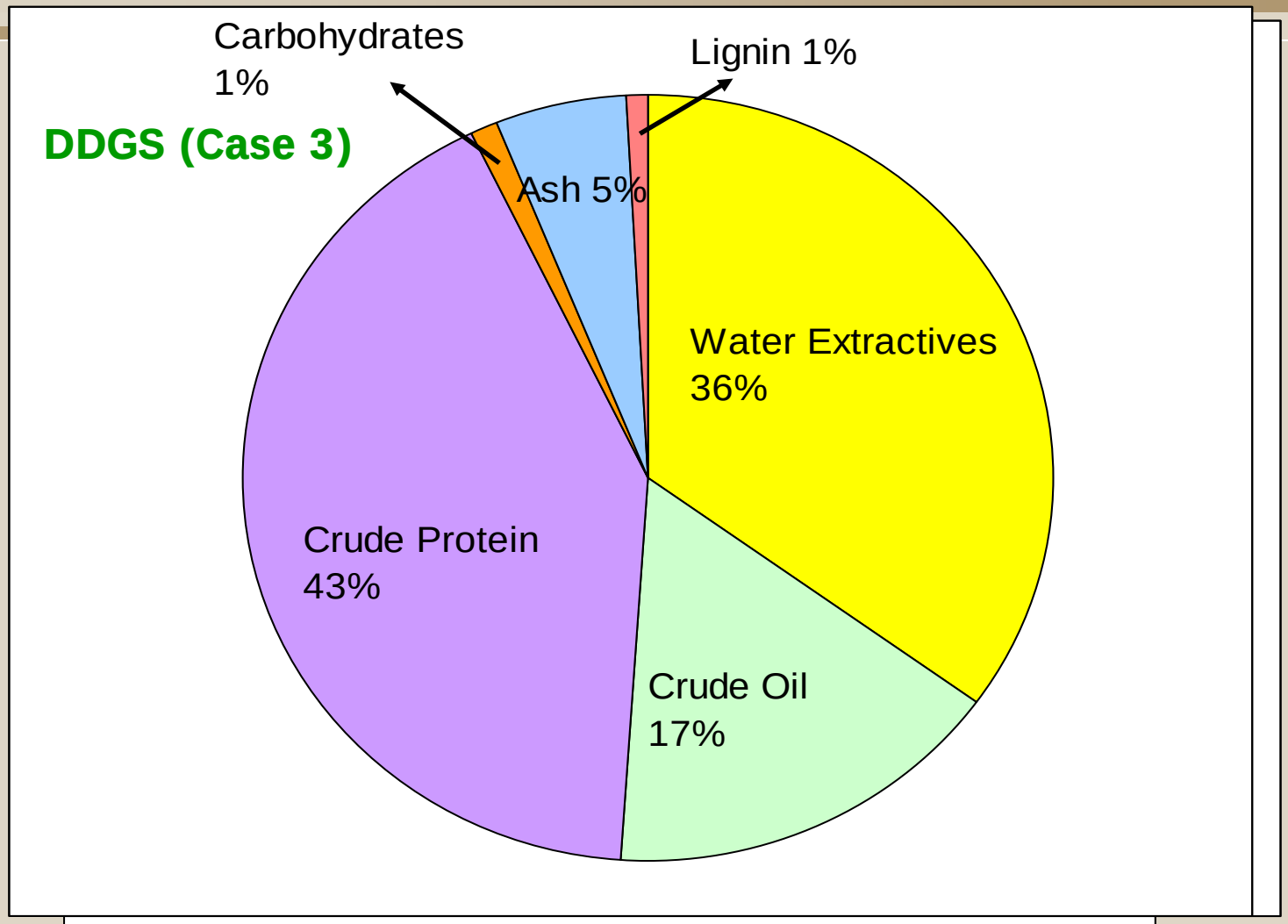
Amount of Thin Stillage Processed through Evaporator



Amount of Water Removed from Dryer



Composition of eDDGS



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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 on inhibitors due to recycle and effect on kinetics of enzymatic hydrolysis and fermentation requires further investigation to validate the process modifications.

- Proposed process requires less fresh water for liquefaction than conventional dry grind processes. Compensates for increased overall water requirement in a modified process.

- Less water mean less drier load.

- The final eDDGS (enhanced dried distillers' grains) from the modified processes has 30 to 40% higher protein content than DDGS.

Thank You

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