

AFEX Pretreatment of and Protein Extraction from DDG

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Acknowledgements

Financial support from the U. S. Department of Energy through the Midwest Consortium for Sustainable Biobased Products and Bioenergy Award # DE-FG36-04GO14220.

Our collaborators at NCAUR for help with protein extraction



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Project Goals

1. Integrate institutional capabilities of the Midwest Consortium to add value to Distillers Grains (DG)
2. Carry out research to process DG
 - Additional fermentable sugars and ethanol
 - Obtain a protein enriched solid residue
3. Contribute directly to the DOE's multi-year plan as relates to the sugar platform and product
 - Help to ensure that the DOE meets targets to establish biomass as a significant source of sustainable fuels in the US



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MSU Goals

- Determine AFEX conditions necessary for optimal sugar yields
 - Temperature
 - Ammonia Loading
 - Moisture Content
- Understand effect of AFEX on DDGS
- Evaluate possibility of protein extraction



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Experiments

- AFEX Optimization
 - Temperature
 - Ammonia Loading
 - Both low (11.5% twb) and high (60% twb) moisture
- Xylanase Addition
- Amylase Addition
- Analysis of AFEX treated grain
 - SEM Imaging
 - FTIR Imaging
- Protein Extraction



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AFEX vs Untreated

AFEX – Low Moisture

Untreated

AFEX – High Moisture



AFEX

Untreated



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Temperature Effect

Constants

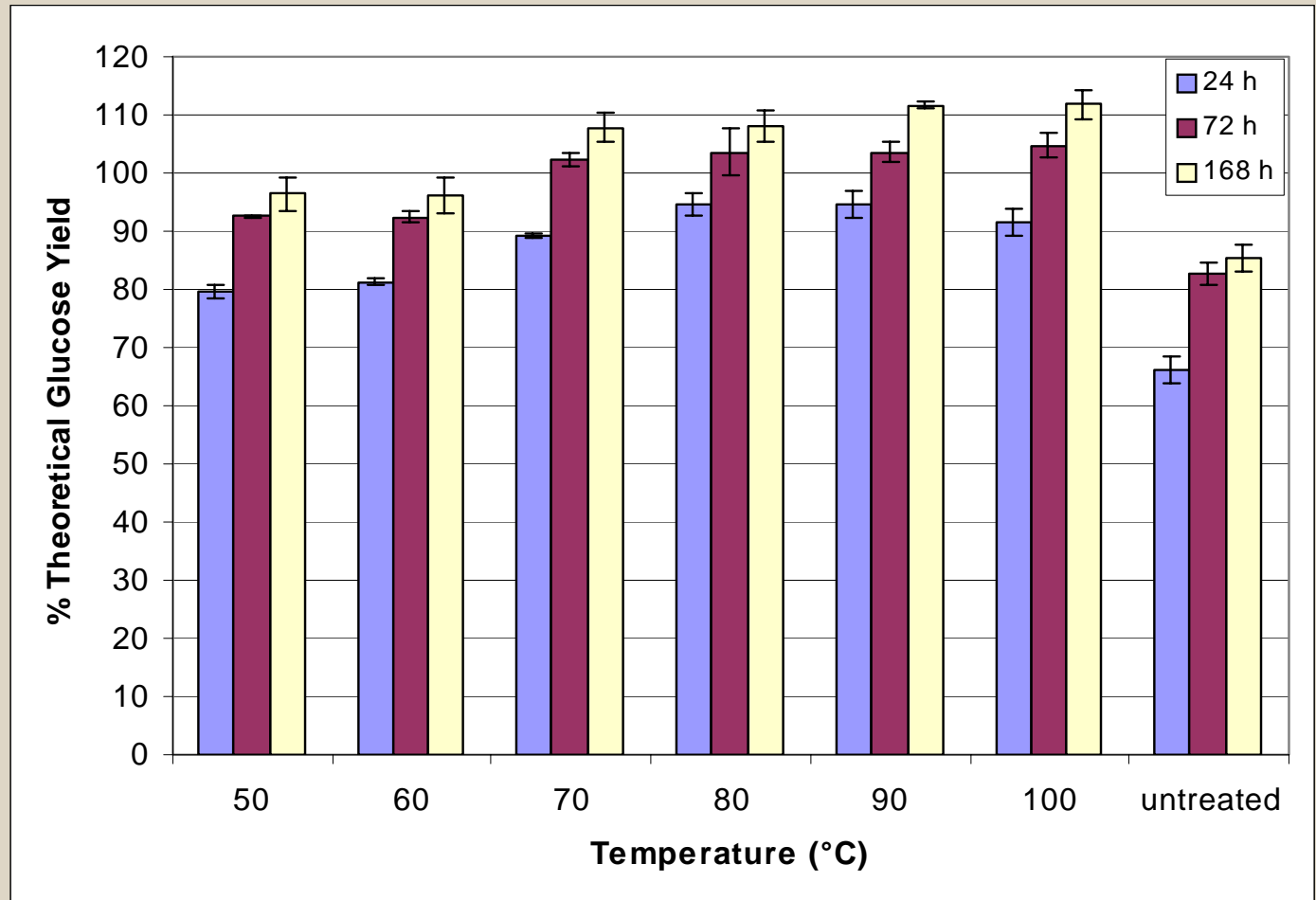
MC: 11.5%

1:1 NH3

5 minute
residence time

Spezyme CP –
16.6 FPU/g
cellulose

Assumed 16.0%
Cellulose



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Ammonia Loading Effect

Constants

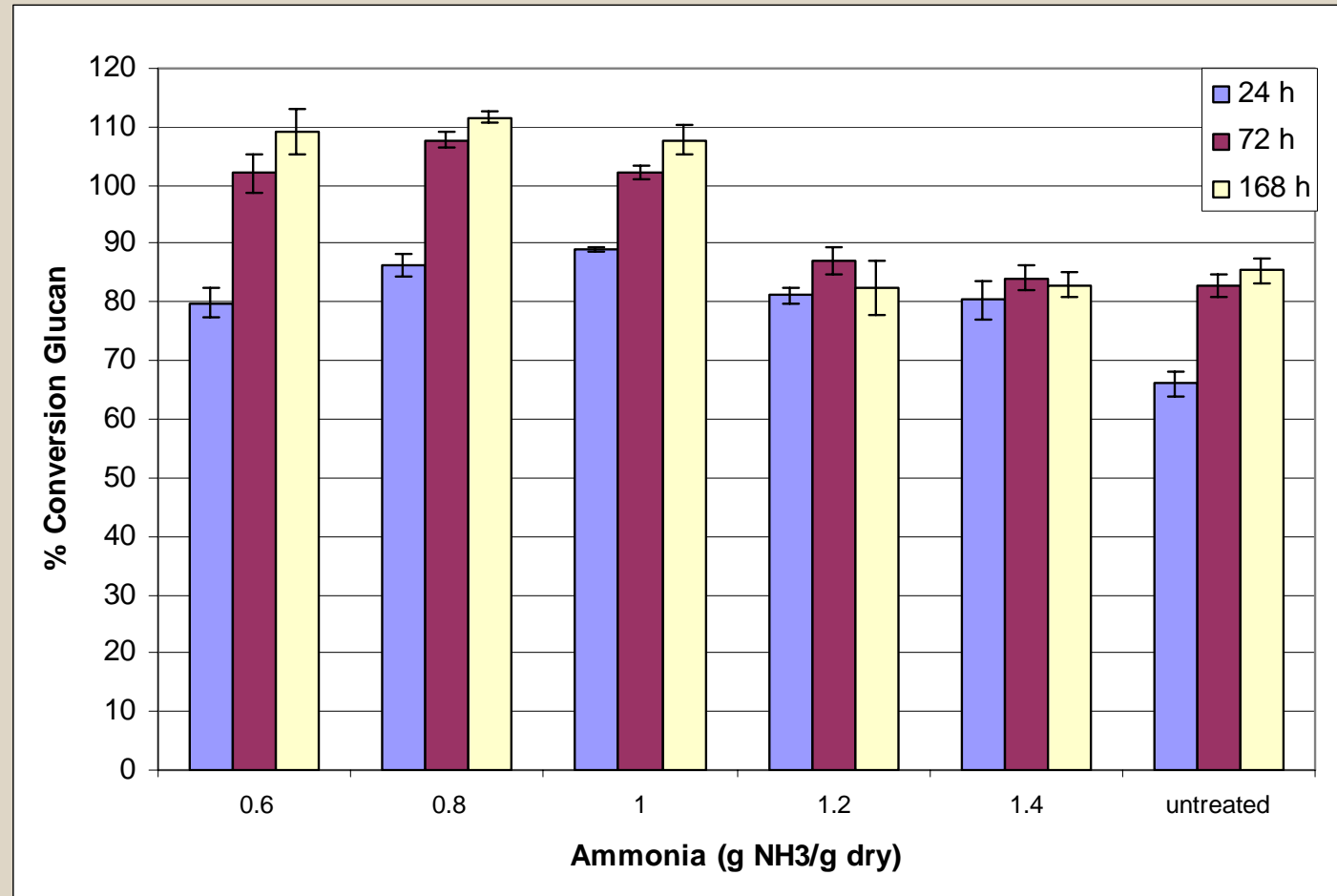
MC: 11.5%

70°C

5 minute
residence time

16.6 FPU/g
cellulose

Assumed 16.0%
cellulose



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Moisture Content

Constants

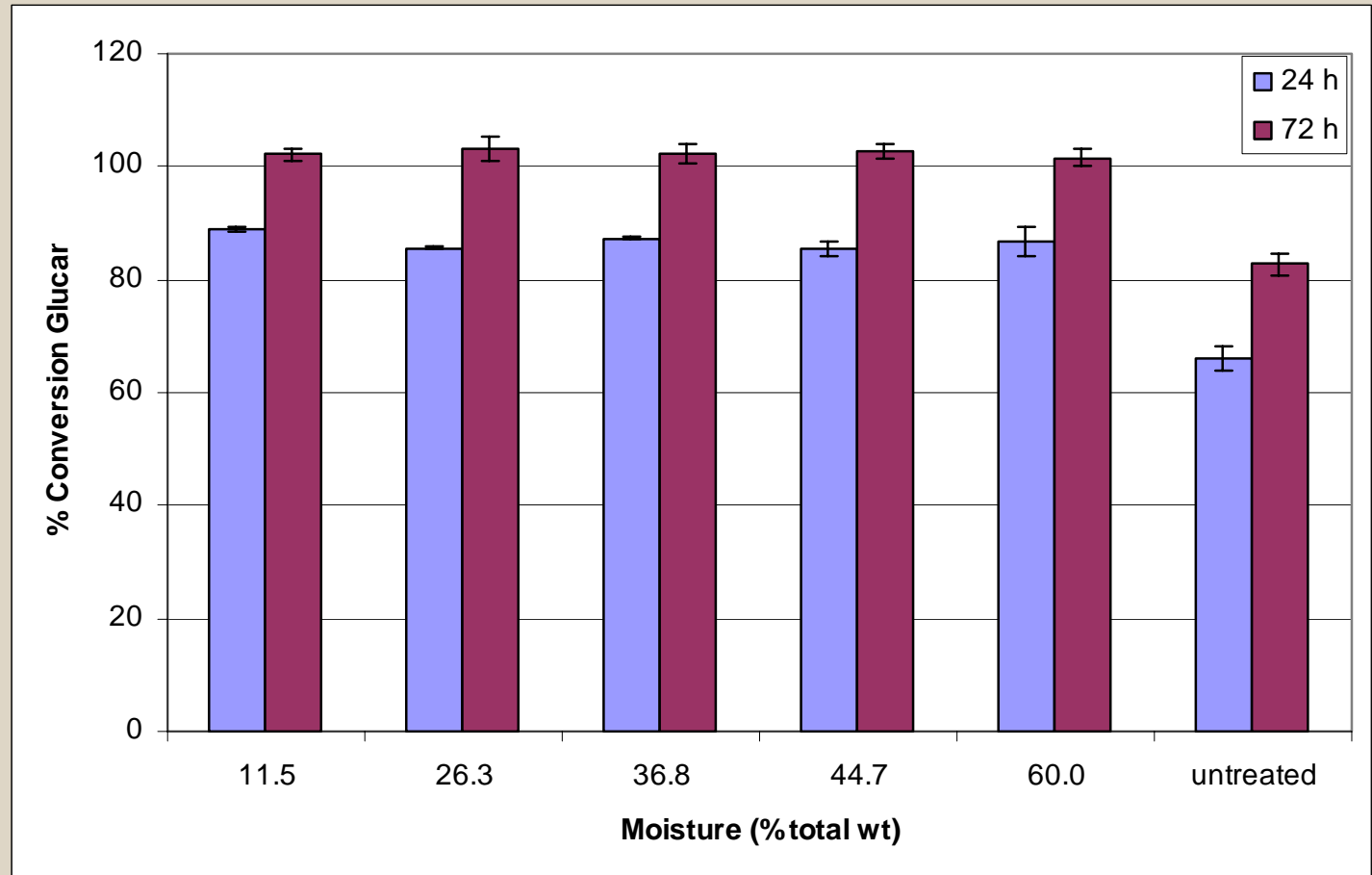
1:1 NH₃

70°C

5 minute
residence time

16.6 FPU/g
cellulose

Assumed 16.0%
cellulose



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High MC - Temperature

Constants

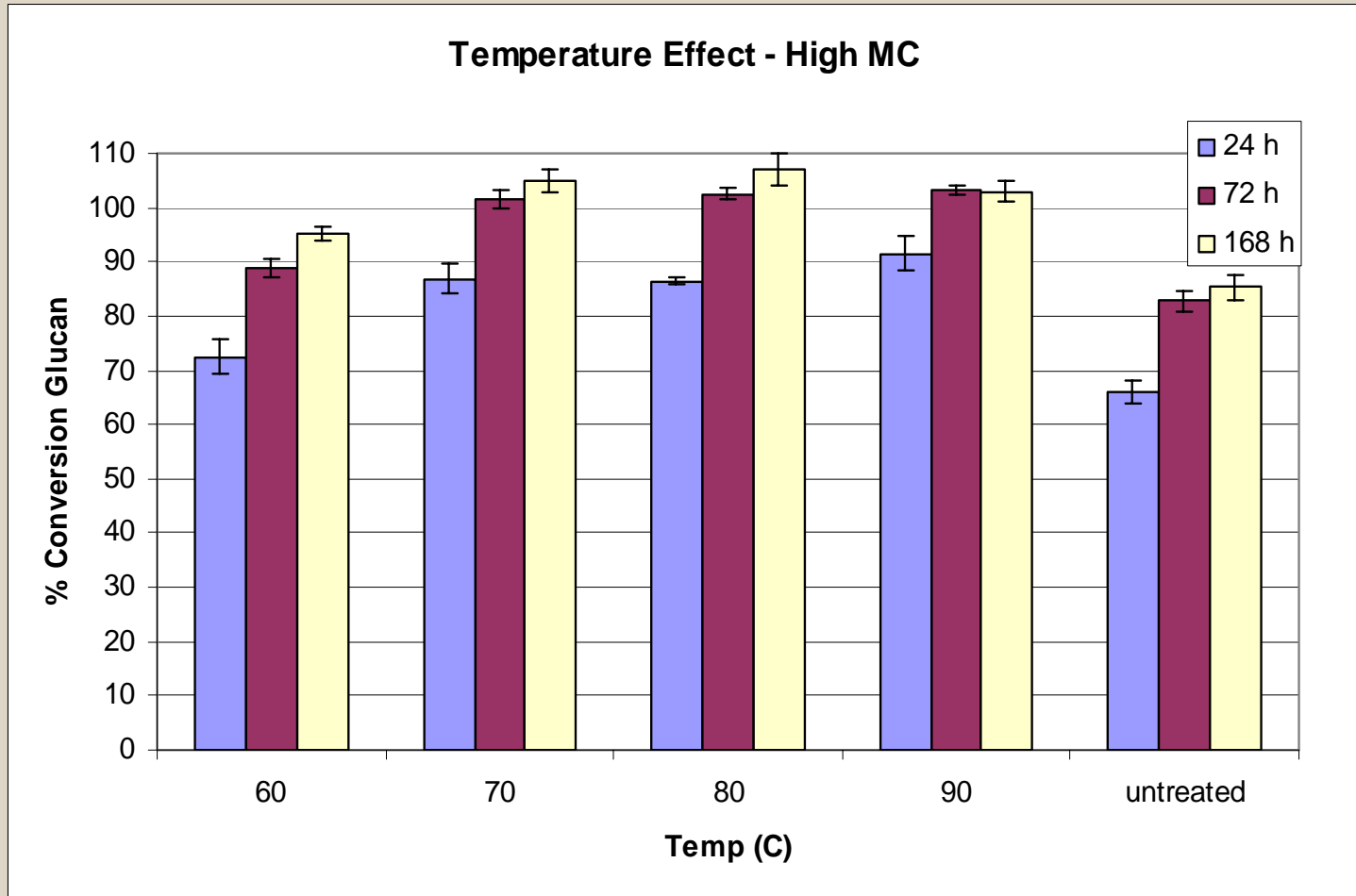
MC: 60%

1:1 NH₃

5 minute
residence time

Spezyme CP –
16.6 FPU/g
cellulose

Assumed 16.0%
cellulose



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High MC - Ammonia

Constants

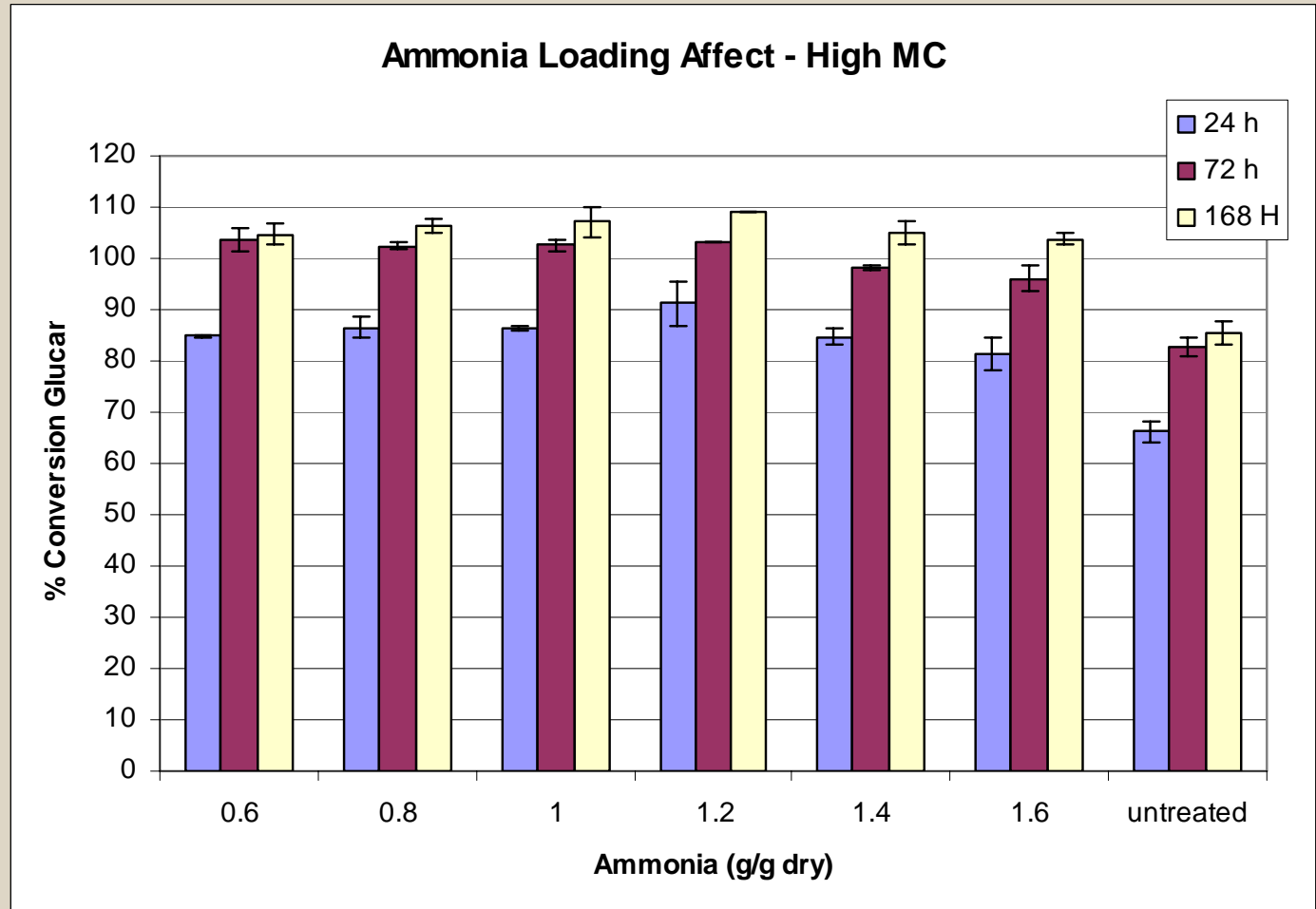
MC: 60%

80°C

5 minute
residence time

16.6 FPU/g
cellulose

Assumed 16.0%
cellulose



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Summary of Results

- Optimal conditions

	Temp	NH3	72h yield
11.5% MC	70°C	0.8:1 kg/kg dry	108%
60% MC	80°C	0.6:1 kg/kg dry	103%

- Milder than other types of biomass
- Very low xylose yields (<10% after 168h)
- 65% grain solubilized



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Xylanase Addition

- Multifect Xylanase + Spezyme CP + β -Glucosidase
 - Loading ranged from 10-50 mass % loading compared to cellulase (ie, 10-50 μ g xylanase protein per 100 μ g Spezyme protein added)
- Less than 20% conversion after 168h
 - Xylose not detected
- Glucose yields decreased with 50 mass % loading



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Amylase Addition

Constants

0.8:1 NH₃

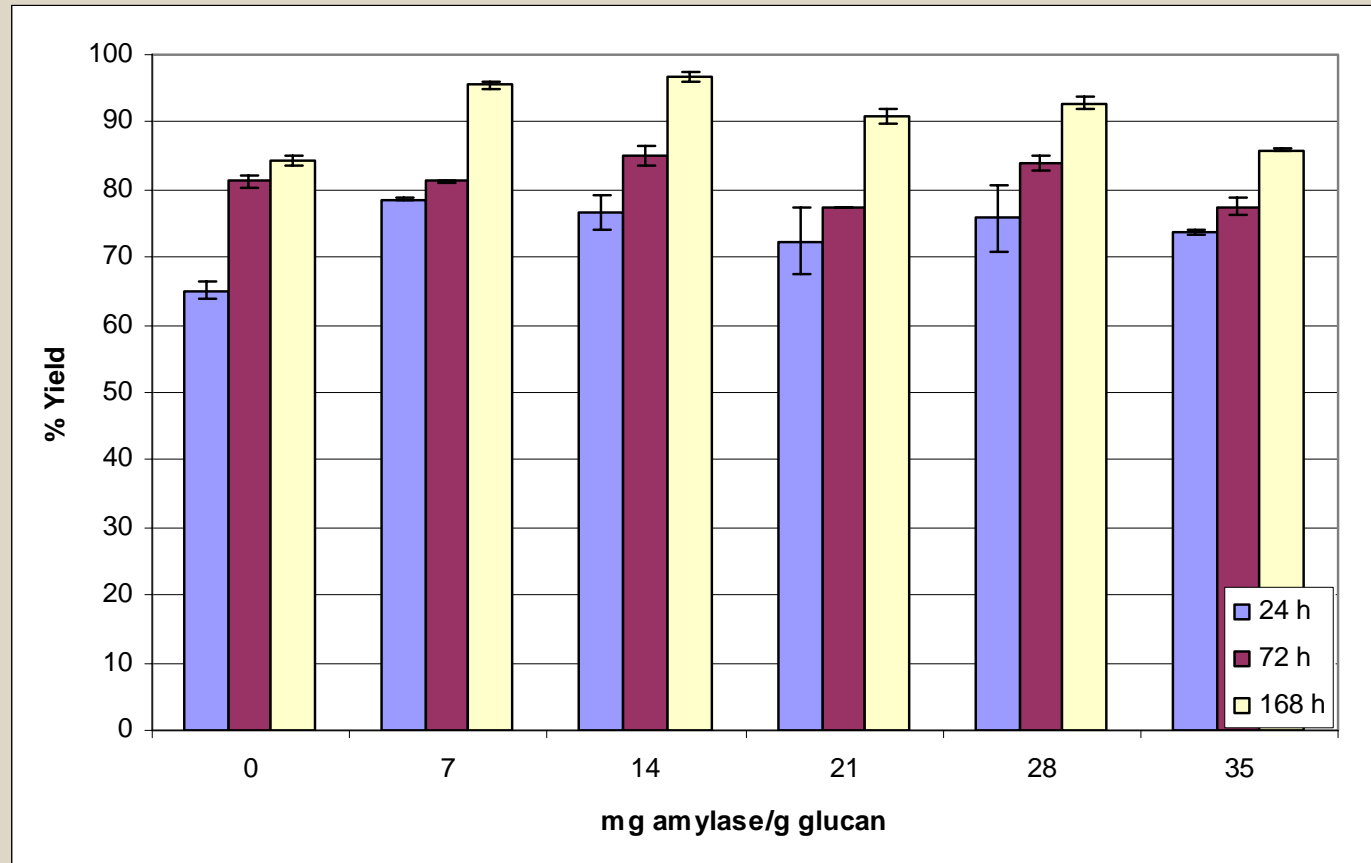
70°C

11.5% MC

Spezyme CP -
16.6 FPU/g
cellulose

Stargen enzyme
~350 mg/ml

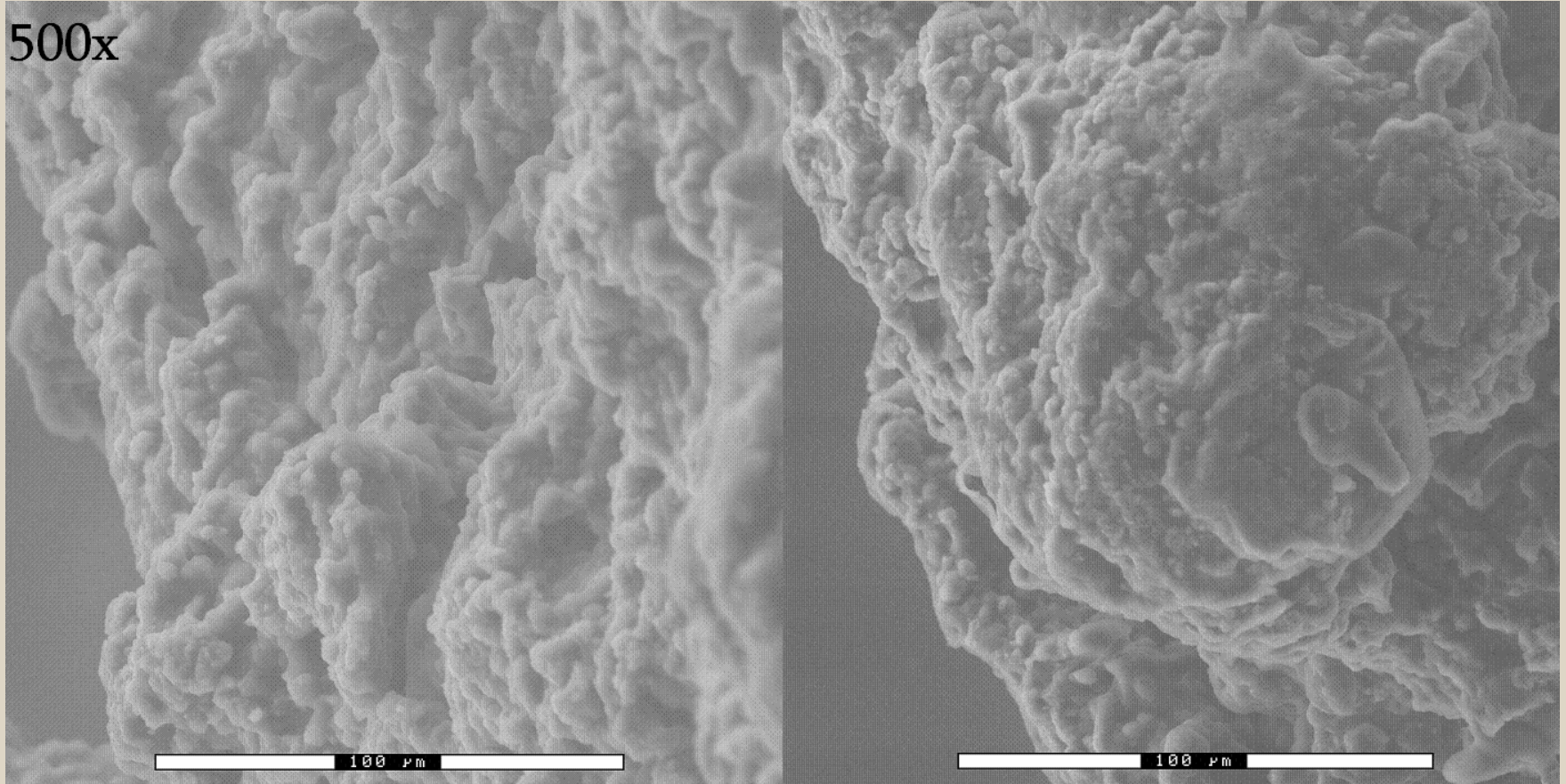
Assumed 21.2%
glucan (16.0%
cellulose + 5.2%
starch)



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SEM Pictures



AFEX

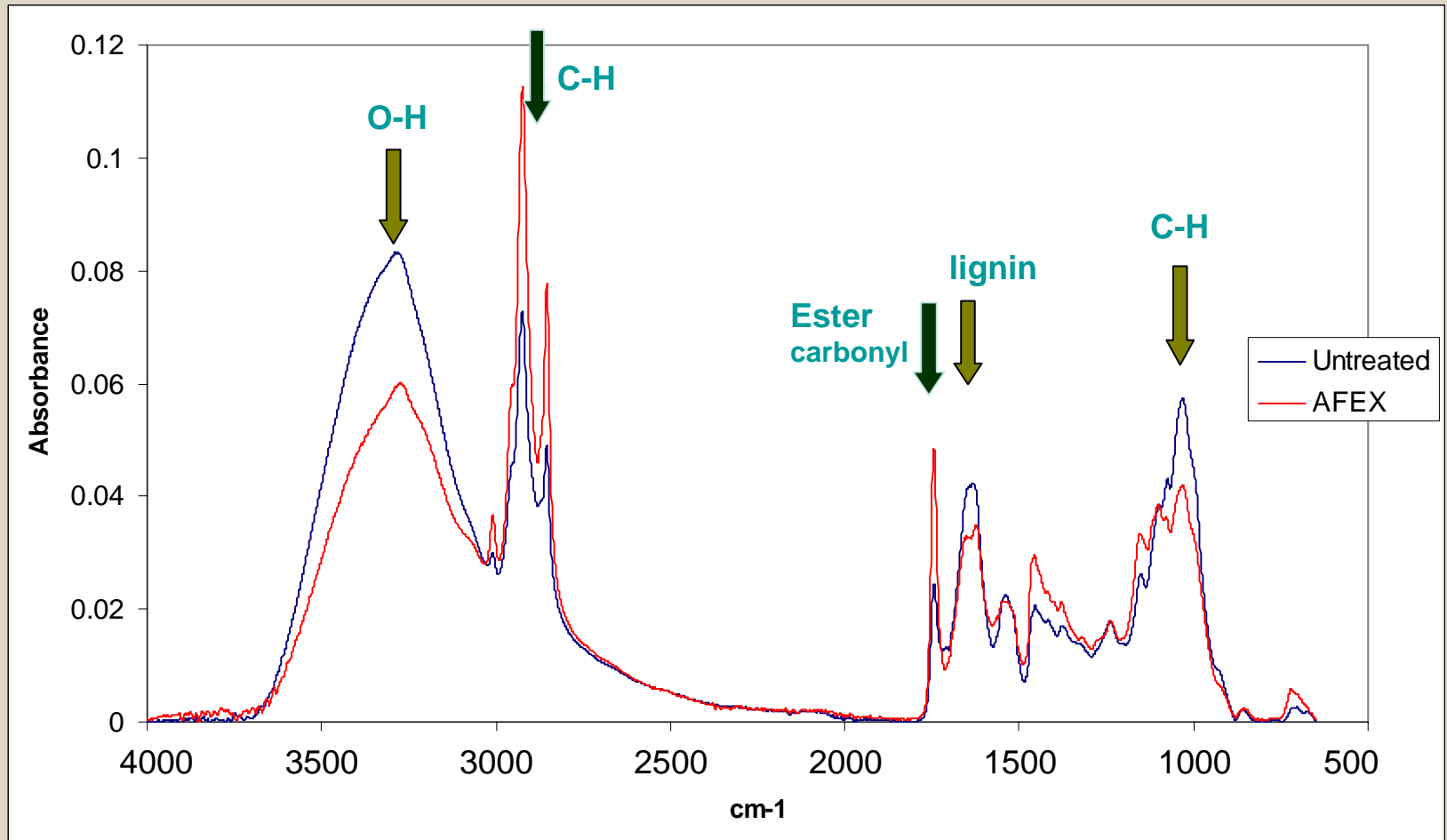
Untreated



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FTIR



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Summary of Analysis

- SEM pictures inconclusive
 - No apparent differences between AFEX and untreated grain
 - Possibly due to low cellulose content
- FTIR Analysis
 - Depolymerization and delignification
 - No apparent hydrolysis of hemicellulose
 - Consistent with hydrolysis results

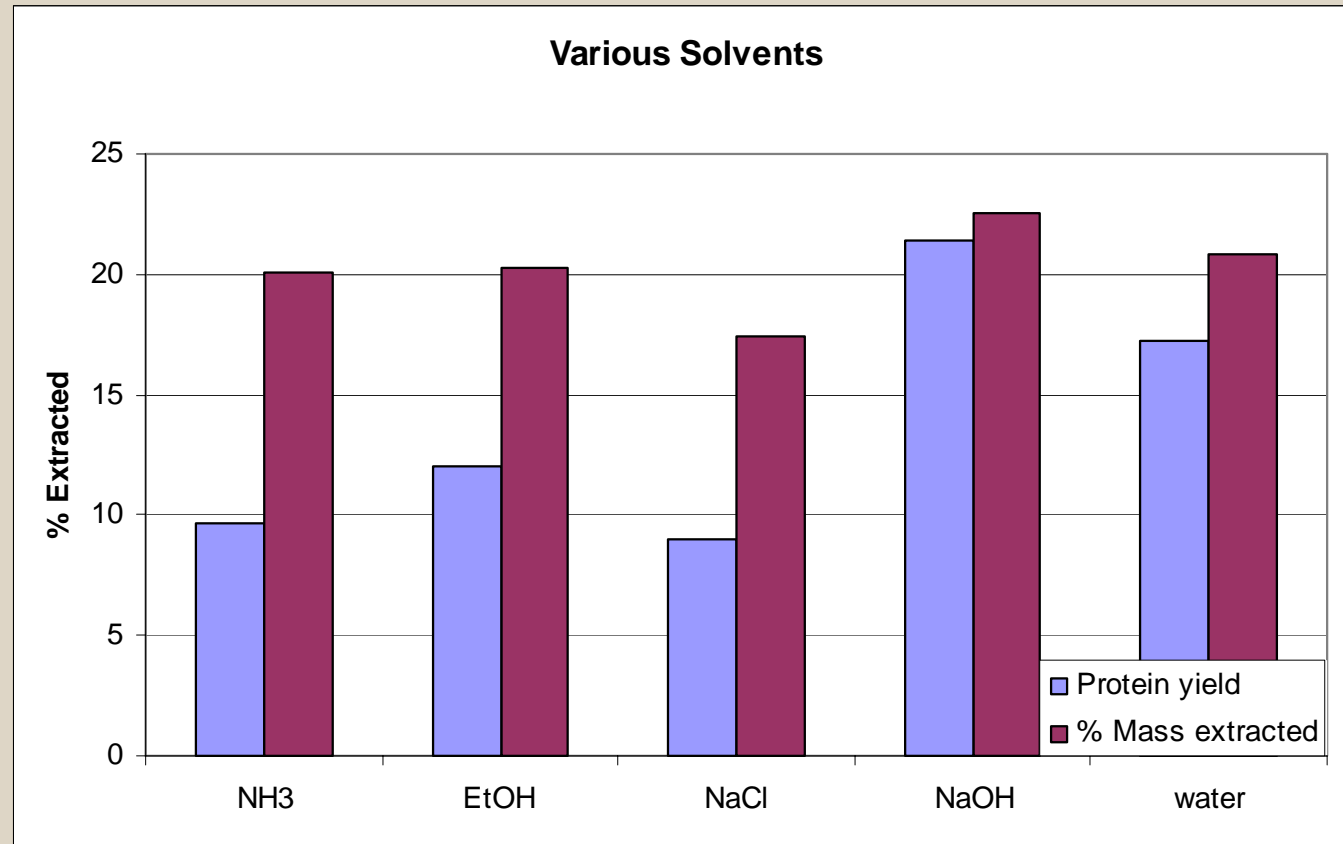


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Protein Extraction

- Solid/Liquid Extraction
- 8:1 Liquid/Solid ratio
- 3 Cycles
- Assume 26.4% protein



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Protein Extraction

- Unlikely to extract more than 25% of total protein using conventional methods
- Options for improving yield
 - AFEX
 - Extraction after hydrolysis
 - Extraction before drying
 - Other pretreatment possibilities



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Conclusions

- AFEX process is an effective pretreatment for both low and high moisture DGS
 - Virtually complete conversion of cellulose in 72 hours
- Xylan conversion negligible
- Amylase addition increases glucose yields after 168 hours of hydrolysis
- Potential for protein extraction
 - Wet DG, hydrolyzed DGS, AFEX-treated



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