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Process for Producing Ethanol from Soybean Hulls(SBH) While Preserving Protein Value

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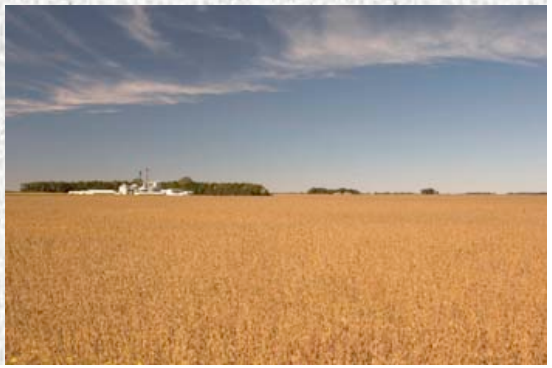


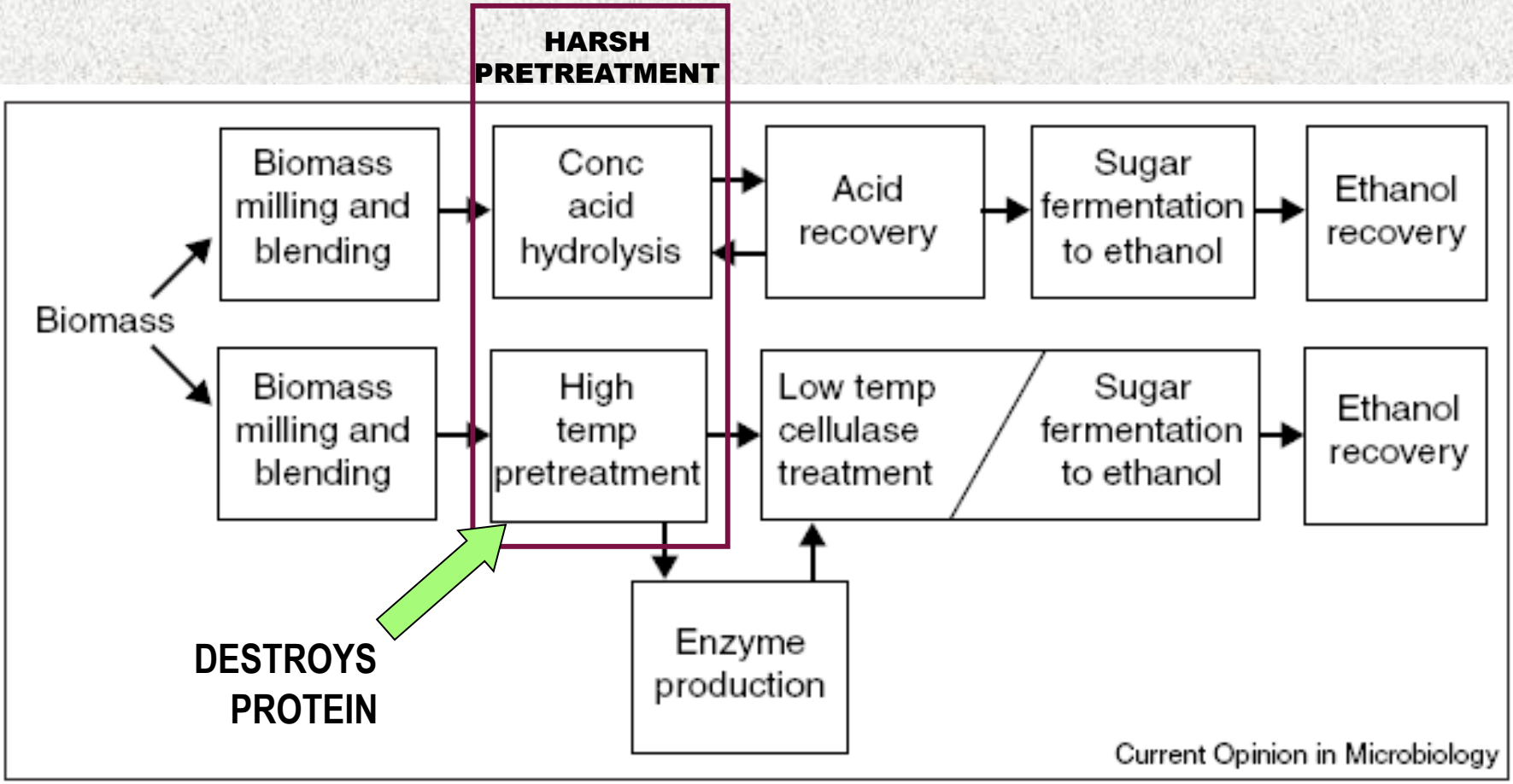
Invention: Value-added Process for Fuel Ethanol and Protein Feed Production

- Soybean Hulls (coat) are an abundant agricultural residue (5-8 million tons) valued by 10% protein level
- ~66% of the hull is polymeric "biomass sugars"
  - Cellulose, hemicellulose, pectin
- Conventional biomass ethanol fermentation processes destroy the protein to liberate the sugars
- Invention: process to produce ethanol from the sugars while preserving the more valuable protein
- Process yields large levels of ethanol and higher value protein concentrate

Soybean Production Agronomy 101

- One of the largest cultivated crops worldwide
- US Crop:75 million acres 95 million tons (2006 USDA)
- Products include soy meal, soy oil, and soybean hulls
- Soybean hulls account for 5-8% of crop
- 5-8 million tons of hulls waste destined for animal feed
  - Contain 9-11% Protein
  - High fiber content limits feeding to only ruminant animals
    - Large pig and poultry market out of luck

Question: Can soybean hull sugars be fermented to ethanol?



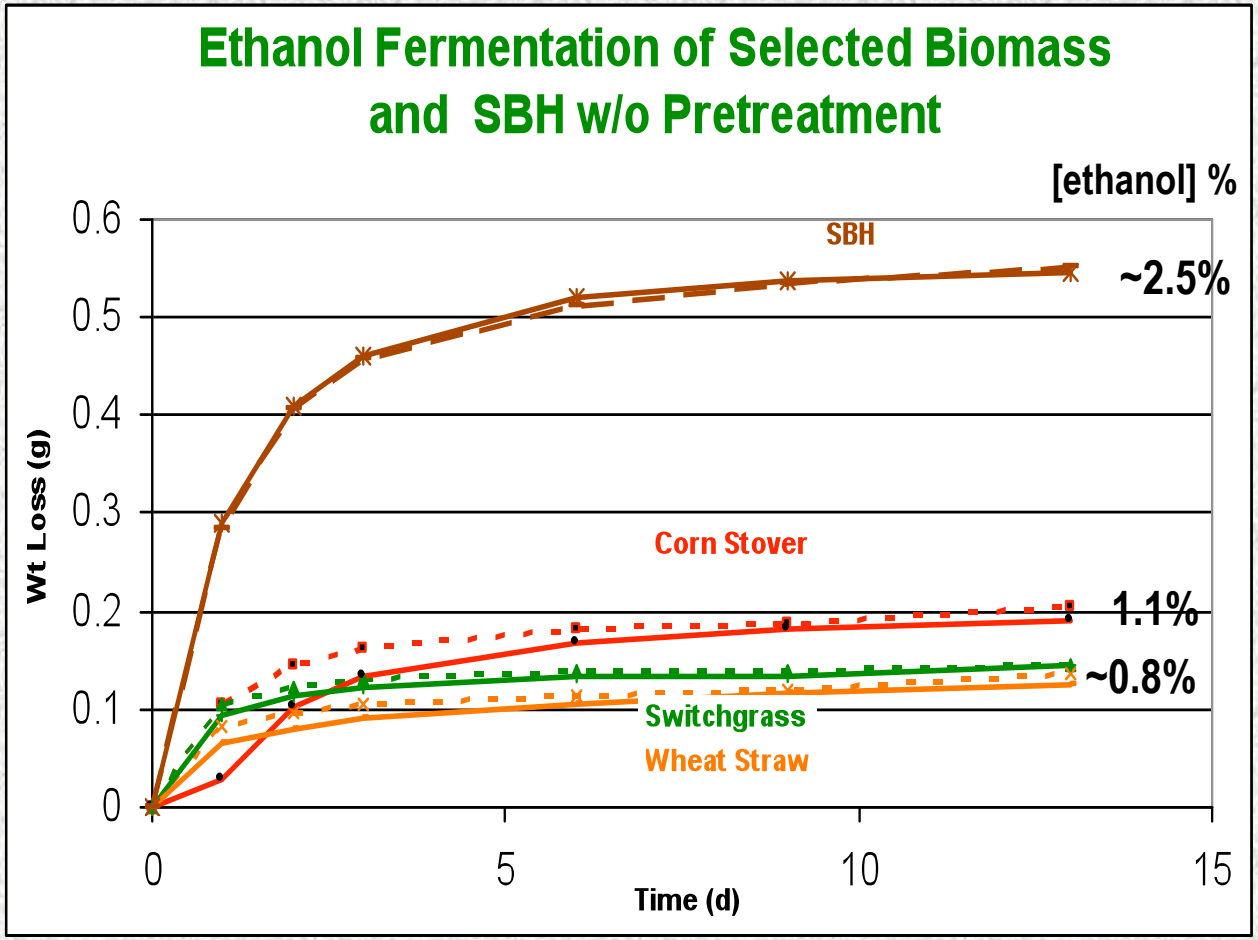
Ethanol production from biomass: technology and commercialization status Mielenz

Current Opinion in Microbiology 2001, 4:324–329

Source of the Invention

- Inventors Mielenz and Bardsley at Dartmouth College in labs of biomass experts Wyman, and Lynd
  - Wyman Dilute Acid Pretreatment Expert
  - Lynd Fermentation Expert
- United Soybean Board interested in alternate uses for 5-7 million tons of soybean hulls
- Inventors undertook initial fermentation tests included conventional *pretreatment*, added enzymes and yeast fermentation
- First set of tests showed control tests w/o costly and hazardous *pretreatment* work surprisingly well too.

Question: Do the Conditions *Really* Not Require Pretreatment?

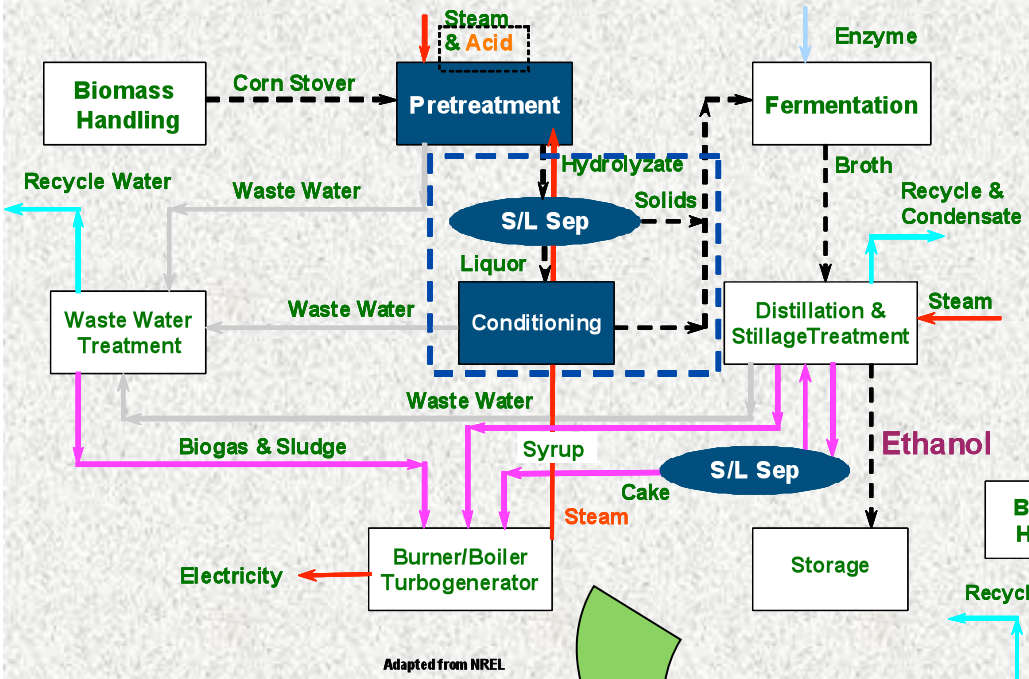


With NO pretreatment SBH respond to ethanol fermentation differently than three other biomass source regardless of enzyme dosage

Potential Process Simplification:

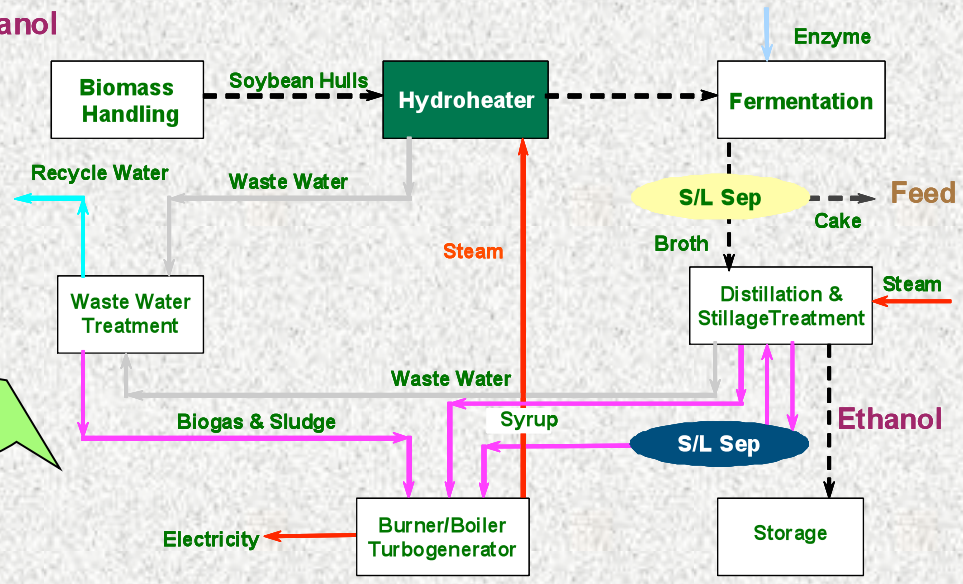
- Potential for about 20% cost reduction with no pretreatment
- Other biomass lack protein co-product sales

Biomass Ethanol: A Simplified Process Schematic



Adapted from NREL

Soybean Hull Ethanol: A Simplified Process Schematic



Adapted from NREL

Technology Advantages:

- Process concentrates 10% protein material to >25% protein by weight with target at 48%
  - Soybean products valued by protein content (%)
- Potential for up to 450 million gallons of ethanol in the US with minor capital investment
  - Process installed at the soybean processing plant?
- Potential for 2 million tons of high protein feed
  - Possibly market price at $300/T @48% protein
- Low fiber opens up poultry and pig feed market

Similar market potential in Brazil plus Argentina: Soybean production surpassing US production and both produce ethanol and soybeans

Considerations for Commercial Potential:

Higher levels of ethanol are possible with higher levels of hulls

The fermentation residues have the same protein composition as the hulls

Potential Revenues from Process

	Feed (T)	Ethanol (gal.)	Revenue ($)
NOW	6.5 million @ 5¢/ lb	none	$650 million
With this process	2 million @ 15¢/ lb	450 million @ $1.60	$600 million + $720 million or $1.1 billion

Next Steps to Commercialization: Determine business potential and more targets for technical improvements

Technical improvements:

- Determine process upper limit of SBH-derived ethanol& protein
- Test additional enzyme mixtures to extract more free sugars
- Find and test additional GRAS yeast for better ethanol yields
- Improve rate of fermentation for faster fermentor turn-around
- Produce enough residue for feeding studies for multiple species (bovine, porcine and poultry)

Commercialization steps

- Produce engineering design (P&ID) to permit process costing
  - Stand alone
  - Integrated in bean processing facility

Acknowledgements

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Questions?

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