Enzymatic Dewatering of Distiller Dried Grains

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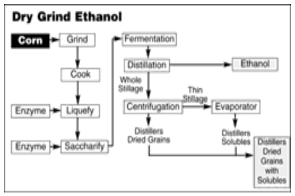
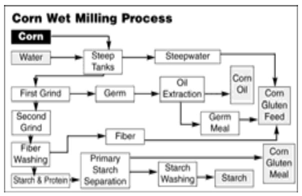
Abstract

The removal of water from coproducts in the fuel ethanol process requires a significant energy input. In this study, the addition of cell wall degrading enzymes was investigated to determine if the enzymes could reduce the amount of bound water within the wet grains. This would have the effect of allowing more water to be removed during centrifugation, reducing the time and energy needed during the drying process . The experiment utilized sixteen fermentors, fifteen for the selected enzymes and one for the control (no enzyme). It was observed that six of the fifteen enzymes tested, produced a solid pellet that was up to 18% drier than the control. This result could translate into savings of up to $1,080,000 per year for a forty million gallon per year dry grind ethanol plant.

Background

- Current world oil consumption is 80 million barrels/day which will continue to grow rapidly
- By 2050 the world population could be 9-10 billion and current reserves of both oil and natural gas will be exhausted
- Bioethanol is a renewable source of energy, and is considered a clean biofuel
- Bioethanol is produced from corn via dry grind or wet milling corn-to-ethanol processes:



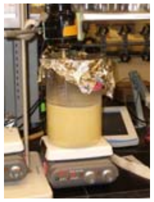


- Ethanol can be produced from corn, a starch-based feedstock, according to the following reaction:

$$C_6H_{12}O_6 \xrightarrow{\text{yeast, }30^\circ C} 2\,C_2H_5OH + 2\,CO_2$$

- Current cost of ethanol is $1.84/gallon
- A large portion of the cost comes from drying the DDGs, since gas dryers require a significant amount of energy
- DDGs leave the centrifuge at about 70% moisture and is dried to 10% moisture
- In this experiment we modify the fermentation process by adding enzymes to degrade water binding cellwall components
- Success could mean savings of up to $7.22 / hr / % moisture content of the wet grains going into dryer
- Enzymes used were: cellulases, xylanases and complexes that are known for their ability to break down and degrade cellwalls
- Ultimate goal is to produce ethanol cheap enough to be able to compete with fossil-based fuels such as gasoline and natural gas, thus decreasing US dependency on foreign oil

Experimental Setup/Methodology

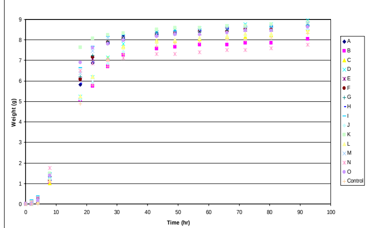


Corn Grind → Liquefaction → Saccharification → Fermentation and Enzymatic Hydrolysis

→ Centrifugation → Filtration → Evaporation → Analysis

Results/Analysis

Figure 1: Weight Loss Normalized over time



- Figure 1 shows weight loss over time of all 16 flasks
- Weight loss corresponds to CO_2 produced during fermentation
- From this data one can estimate the amount of ethanol produced
- Some flasks had higher or lower wt loss than the control

- Table (Figure 2) shows liquid and pellet weight for each treated flask and control
- Liquid weight was taken after centrifugation and vacuum filtration
- Solid pellet was weighted, dried and weighted again to calculate moisture removed after centrifugation compared to control
- As it can be seen, 6 of the enzymes (in bold) were able to produce a smaller pellet (less moist) than the control
- Similarly, those same 6 enzymes produced a bigger liquid fraction but conserving the mass balance

Enzyme	Liquid Wt (g)	Solid Dry Wt (g)
A	**30.35**	**1.81**
B	27.59	2.22
C	28.78	2.13
D	27.40	2.22
E	**30.01**	**1.97**
F	29.90	2.04
G	**30.99**	**1.86**
H	**30.79**	**1.86**
I	**29.54**	**1.90**
J	28.91	2.20
K	29.41	1.94
L	29.16	2.10
M	**30.72**	**1.92**
N	28.60	1.98
O	29.43	1.96
Control	**27.36**	**2.16**

Figure 2: Liquid and pellet weight for all enzymes and control

Results/Analysis

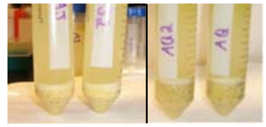


Figure 3: Comparison of pellet size after centrifugation for enzyme A (left) and control (right)

Enzyme	Enzyme (mL)	EtOH
A	1 ml	13.02
E	1 ml	13.09
G	1 ml	12.93
H	1ml	13.02
I	1ml	12.91
M	1ml	12.84
Control	--	12.81

Figure 4: Ethanol production for top enzymes and control

- Figure 4 shows ethanol production for top 6 treatments and control
- As can be seen, the control produced the smallest amount of ethanol compared to the others
- The 6 enzymes listed above were chosen to rerun the experiment using different enzyme loads of 0.1, 0.5 and 1 ml

Discussion/Conclusion

- It was visually possible to see that some flasks had a higher liquid volume than the control
- The pellet part (wet grains) was smaller for some enzyme treatments when compared to the control
- There was a increase in ethanol yield by the end of fermentation compared to the control
- 3 unknown compounds were detected on the chromatogram; tests will be performed to identify them and their significance
- Enzymes degrade the cellwalls and release bound water
- Once the mash is centrifuged the water is separated making the grains drier requiring less energy to dry
- It is believed that the extra compounds found on the chromatogram are sugars that have been broken down by the enzymes, and that those sugars could potentially be fermented to produce higher ethanol yields
- Saving of $60,000 per year for each % moisture reduction of the wet grains for a 40 million gallon per year plant
- Based on lab results this would result in an 18% moisture reduction of the wet grains and potentially save $1,080,000 per year for a 40 million gallon per year plant
- Processing costs would decrease and production capacity would increase if a higher yield of ethanol was obtained

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