Hydrolytic Enzymes Production from Distillers Dried Grains with Solubles (DDGS)

Attia Iram[1], Ali Demirci[1] , and Deniz Cekmecelioglu[2]

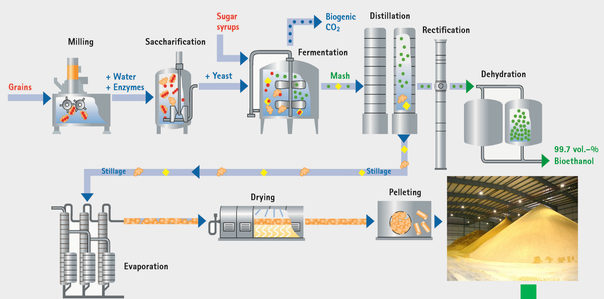
[1]Department of Agricultural and Biological Engineering, The Pennsylvania State University, University Park, PA, 16802, USA

[2] Department of Food Engineering, Middle East Technical University, 06800 Ankara, Turkey

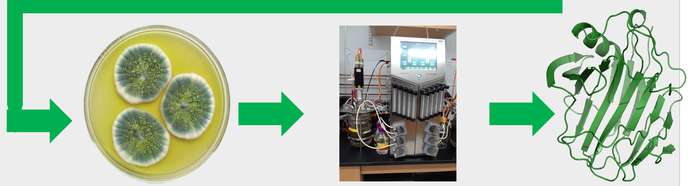
Department of Agriculture and Biological Engineering

Distillers' Dried Grains with Solubles (DDGS) is a by-product of bioethanol production from grains. It is currently being used the animal feed, but more value can be added to this product which can also ultimately help in the production of more bioethanol from sources which are not food-based. DDGS is rich in different types of fibers, amino acids, and lipids and can be used as the feedstock for cellulase and xylanase production. In our study, we attempted to use DDGS as the feedstock by evaluating various pre-treatment strategies, microbial strains, and media ingredients. The pre-treatment strategies included dilute-acid hydrolysis, ammonia hydrolysis, and semi-continuous steam hydrolysis and dilute-acid hydrolysis was found as the best treatment. For the second phase, 11 microbial strains were evaluated and four of them selected for further optimization. In the phase 3, nitrogen sources such as yeast extract, peptone, and ammonium sulfate were analyzed for their effect on enzyme production.

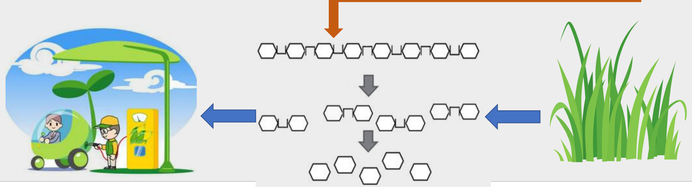
Bioethanol and DDGS



DDGS as the Microbial Feedstock:



Applications of Cellulases and Xylanases:



Phase 1

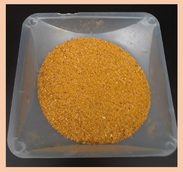
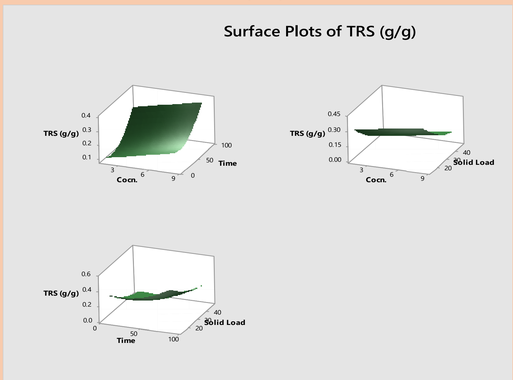


Table 1. The composition of Distillers' dried grains with solubles (DDGS).

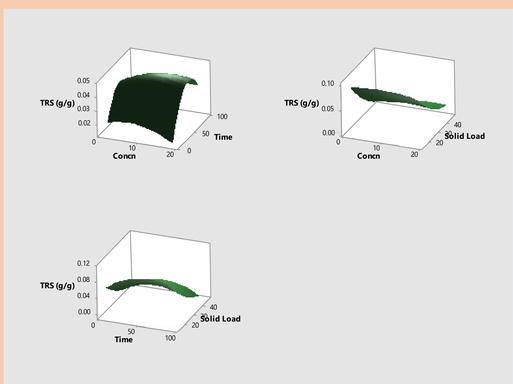
Component	Percent Composition	Method of detection
Dry matter	88.10	NFTA 2.2.2.5
Protein (crude)	27.30	AOAC 990.03
Fat (crude)	8.01	AOAC 945.16
NDF	28.40	AOAC 2001.11
ADF	11.20	Ankom Tech. Method
Fiber (Crude)	7.82	AOCS BA 6A-05
Hemicellulose*	17.2	Calculation
Ash	4.36	AOAC 942.05

NDF: Neutral detergent fiber, ADF: Acid detergent fiber,

Semi-continuous steam hydrolysis



Surface plots for dilute sulfuric acid pre-treatment.

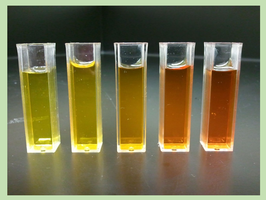


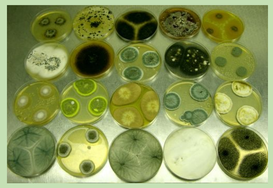
Surface plots for ammonia pre-treatment.

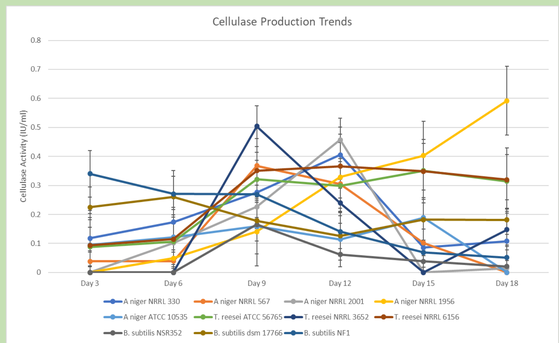
Table 2. Total Reducing Sugar (TRS) yield (g TRS/g DDGS, d.b.) for semi-continuous steam explosion experiments.

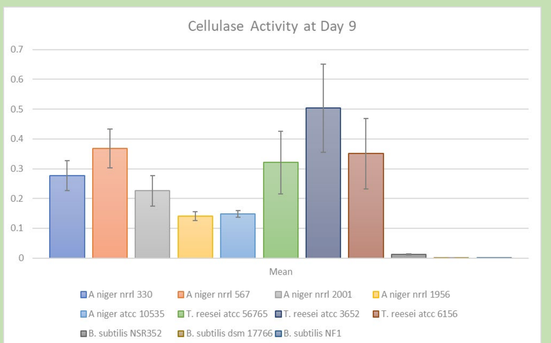
Temperature (°C)	Residence Time (Min)								
	5			10			15		
	TRS (g/g)	Furfural (mg/g)	HMF (mg/g)	TRS (g/g)	Furfural (mg/g)	HMF (mg/g)	TRS (g/g)	Furfural (mg/g)	HMF (mg/g)
120	0.016	0	0	0.019	0	0	0.026	0	0
140	0.026	0	0	0.022	0	0	0.027	0	0
160	0.027	0	0.25	0.035	0	0.22	0.029	0.064	0.49
180	0.048	0	0.18	0.030	0	0.52	0.055	0	0.64
200	0.049	0.67	1.30	0.051	0.31	1.85	0.040	0	1.60

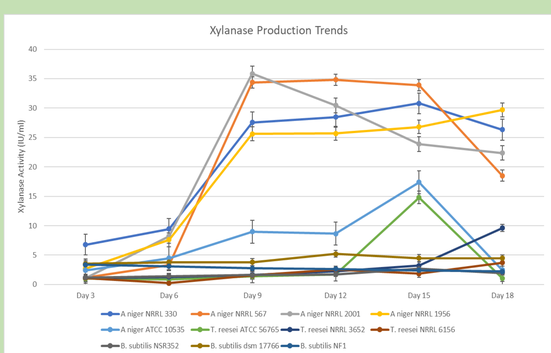
Phase 2



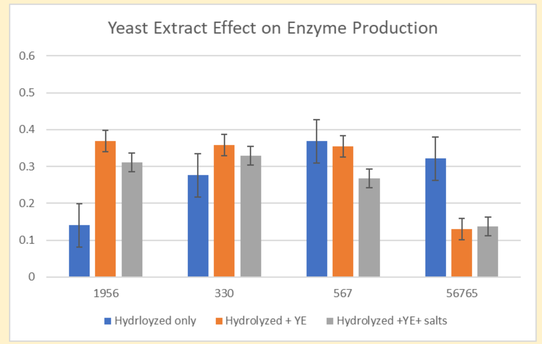


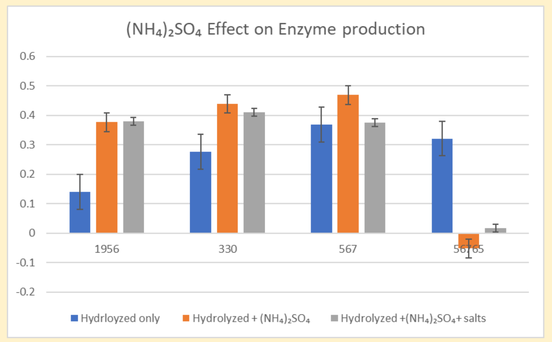


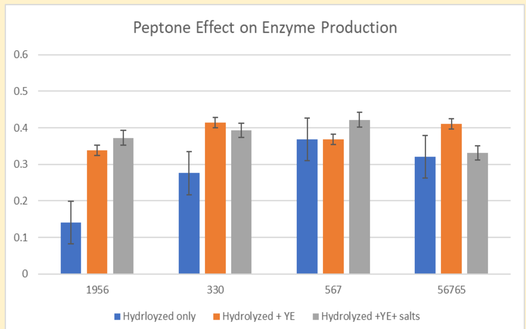




Phase 3







Conclusions:

- Acid hydrolysis is better than ammonia pretreatment and steam extrusion for DDGS to release more sugars for microbial fermentation.
- Fungal strains are better than bacterial strains to produce cellulase and xylanase using DDGS as the sole feedstock.
- Peptone and ammonium sulfate are better than yeast extract for cellulase and xylanase production without the addition of other salts.
- Further optimization is needed for the growth parameters in bioreactors.

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