

IMPROVING THE VALUE AND UTILIZATION OF DISTILLERS GRAINS



Goal: The primary goal of this initiative is to add value to distillers grains, which will improve the viability of the ethanol industry in South Dakota as well as the Nation, and thus the overall rural economy.

Background: The production of corn-based ethanol in the US is dramatically increasing; so is the quantity of coproducts generated from this processing sector. These streams are primarily utilized as livestock feed, which provides ethanol processors with a substantial revenue source and significantly increases the profitability of the production process. With the construction of many new plants in recent years, it is imperative to find new outlets for these coproducts, in order to maintain the economic viability of this industry.

Economic Impacts: In 2004, 80 fuel ethanol plants produced approximately 3.5 billion gallons of ethanol and 7.3 million metric tons of distillers grains in the US. In 2005, 17 additional fuel ethanol plants either started production or expanded. This resulted in a national production of approximately 4.4 billion gallons of ethanol and over 8.5 million metric tons of distillers grains, which equates to a 17% increase. In 2006, it is estimated that the industry grew another 17 to 20%. The quantity of distillers grains produced over time has paralleled the growth of ethanol production, and currently presents many opportunities and challenges for both the ethanol industry as well as livestock producers, the primary purchasers of these coproducts.

Initiative Objectives: To address the opportunities and needs presented by the growing quantity of distillers grains, a partnership has been formed between MBI International, South Dakota State University (SDSU), and the United States Department of Agriculture – Agricultural Research Service (USDA – ARS). This partnership is actively engaged in research to benefit the ag-based renewable fuels industry, livestock producers, and natural resources. New technologies are being developed to add efficiencies to ethanol production and livestock feeding. These technologies must be objectively evaluated and refined, and potential impacts on natural resources must be understood. Specific research objectives for each of these parties include:

SDSU – Assess Utility and Value of Modified Dried Distillers Grains

- Assess the value of distillers dried grains and modified distillers dried grains in livestock diets, specifically beef cattle, dairy cattle, and swine rations
- Study the use of distillers grains in novel aquaculture diets, human foods, and other value-added products

MBI International – Improved Uses and Values for Distillers Grains and C₄ Grass Feedstocks

- Develop ammonia fiber explosion (AFEX) pretreatment process for corn stover, corn fiber, and DDGS feedstocks
- Establish a pretreatment laboratory and pilot plant for conducting these feedstock processing trials
- Develop high protein beef rations from these treated feedstocks, utilizing quick germ removal process and other biorefining process innovations

USDA-ARS – Fiber Extrusion to Improve Use and Production of Ethanol Byproducts

- Identify, characterize, and quantify specific physical and chemical properties of distillers grains that can be utilized or altered to improve storability and flowability behavior of these coproducts during storage and transport
- Develop and evaluate improved processes, such as extrusion and pellet milling, for converting distillers grains into value-added feed materials
- Develop and evaluate processes for converting distillers grains into value-added products, such as industrial products, human foods, or functional intermediates

Initiative Accomplishments: Since the project's inception in 2002, substantial progress has been achieved by each of the parties. Highlights to date include:

SDSU – Improved Uses and Values for Dried Distillers Grains and C₄ Grass Feedstocks

1. Evaluated the suitability of DDGS as a protein source for beef feeder calves.
2. Evaluated the suitability of bran and condensed distillers solubles (CDS) in beef feedlot diets.
3. Incorporated distillers dried grains with solubles (DDGS) in calf starter diets (up to 23%), and dairy cattle diets with differing forage levels (up to 15%).
4. Evaluated dried and wet distillers grains with solubles in the diets of lactating dairy cattle (up to 20%).
5. Measured changes of organic carbon in soil due to tillage effects, residue management, and crop rotation treatments, and determined that residue can be removed without jeopardizing future crop production.

MBI International – Improved Uses and Values for Distillers Grains and C₄ Grass Feedstocks

1. Treated corn stover and DDGS with NaOH. Determined that digestibility of corn stover could be increased by 28.7% with the addition of 4% NaOH and 4% molasses. Also determined that digestibility of rations containing 50% DDGS and 50% treated corn stover with molasses was improved by 19.8%, TDN was increased by 19.8%.
2. Established a bench scale facility for ammonia treatment of lignocellulosic biomass and completed a series of experiments to determine the optimum parameters for corn stover, switchgrass, and corn fiber.
3. Developed computer simulation models for a 50 million gallon per year ethanol plant using corn stover or switchgrass feedstocks.
4. Completed ethanol fermentation studies with AFEX treated corn fiber feedstock and determined that ethanol can be produced at 77 grams per liter at 87% efficiency (glucan conversion to ethanol).
5. Completed design engineering work on a modular AFEX Pilot Plant, which can operate at 3,000 pounds of corn fiber per hour on a continuous basis. Ammonia will be contained and reused.

USDA-ARS – Fiber Extrusion to Improve Use and Production of Ethanol Byproducts

1. Quantified essential physical and chemical properties of typical distillers dried grains with solubles (DDGS) streams from dry grind ethanol plants located in South Dakota.
2. Determined storability and flowability behavior of typical DDGS.
3. Extrusion processed DDGS to develop potential aquaculture feeds and pet foods, which are high-value feeds.
4. Developed human food (corn flour) ingredients and biodegradable plastic composites using DDGS.
5. Developed cooperative relationships with MBI International focusing on new technologies to enhance the value of the byproducts of ethanol production, and SDSU to conduct experiments to examine the digestibility and feeding value of currently available ethanol byproduct streams.

Representative Publications from Initiative Efforts

1. Anderson, J. L., D. J. Schingoethe, K. F. Kalscheur, and A. R. Hippen. 2006. Evaluation of dried and wet distillers grains included at two concentrations in the diets of lactating dairy cows. *J. Dairy Sci.* 89:3133-3142.
2. Hoffman, A., Guettler, M., Tiedje, T., Rajagopalan, S., McCalla, D., Stowers, M. AFEX Pretreatment of Corn Fiber-Ethanol Fermentation and Animal Feed Analysis of Residue. 27th Presented at Symposium on Biotechnology for Fuels and Chemicals, Denver, May 1-4, 2005.
3. Huls, T. J., A. J. Bartosh, J. A. Daniel, R. D. Zelinsky, J. Held, and A. E. Wertz-Lutz. 2006. Efficacy of feeding dried distiller's grains with solubles as a replacement for soybean meal and a portion of the corn in a finishing wether diet. *Sheep and Goat Res. J.* 21:30-34.
4. Kleinschmit, D. H., D. J. Schingoethe, A. R. Hippen, and K. F. Kalscheur. 2006. Comparison of using a reflux apparatus or ANKOM Fiber Analyzer with sequential or direct analysis to evaluate the fiber content in various feeds. *J. Dairy Sci.* 89(Suppl 1):361-362 (abstr).
5. Rajagopalan, S., Ponnampalam, E., McCalla, D. Enhancing Profitability of Dry Mill Ethanol Plants - Process Modeling and Economics of Degermed Defibered Corn to Ethanol. *Applied Biochemistry & Biotechnology*, Vol 120, Iss 1, Jan 2005.
6. Rosentrater, K. A., Otieno, A. W. 2006. Considerations for Manufacturing Bio-Based Products. *Journal of Polymers and the Environment* 14(4).
7. Rosentrater, K.A. 2006. Some Physical Properties of Distillers Dried Grains with Solubles (DDGS). *Applied Engineering in Agriculture* 22(4): 589-595.
8. Rosentrater, K.A., Krishnan, P.G. 2006. Incorporating Distillers Grains in Food Products. *Cereal Foods World*. Vol 51, No. 2, Pp. 52-60.