(21) Utilizing the National Corn-to-Ethanol Pilot Plant to Develop a Predictive Model for Distillers Dried Grain for the Fuel Ethanol and Animal Feed Industries
The objective of this two-year effort is to develop and validate a neutral network predicitive plant model for the composition of Distillers Dried Grain with Solubles (DDGS), a coproduct resulting from the dry grind fuel ethanol process.

Total project cost: $807,221
Funding request: $633,149
Project Lead: Southern Illinois University Edwardsville: National Corn-to Ethanol Research Center
Project Participants: Washington University, St. Louis, Missouri-Department of Chemical Engineering; Emerson Process Management; Illinois Department of Commerce and Economic Opportunity.

Start Date: May 23, 2005
End Date: May 23, 2007

Presentations/Publications

None.

Patents
None.

Progress in Past Quarter and Current Status

Trial using Dupps pilot dryer

The center was loaned a pilot-scale drum dryer for use in testing the properties of DDGS under a variety of conditions. The Dupps dryer has the unique capability to dry DDGS using hot air or superheated steam. A comparison of the two modes is useful for determining variability in DDGS quality due to temperature, residence time, and contact with oxygen.

A trial was recently performed comparing DDGS dried using air and steam as the heat transfer medium. The inlet air / steam temperature and residence time were fixed (700° F, Fan speed at 40 Hz) to determine the effect of oxygen content. The results were compared using standard tests for crude protein, fiber, and fat. In addition, tests were performed by Novus International using their IDEA™ assay to determine the overall digestibility of the protein dried under the different conditions. Digestible protein is the percentage of protein in a feed that can be used by the animal.

Table 1 shows the measured digestibility of various amino acids using both the feed to the dryer and the product. The loss in a single pass of the dryer was approximately 1% of the digestible protein. Statistically, no difference can be determined between the effects of drying with steam or air. As a check, a sample of DDGS dried at higher temperatures showed a significant degradation of protein.

Table 1: Correlated values for essential amino acids using the Novus IDEA assay for digestible protein

Sample	DDGS IDEA Assay Predicted Amino Acid Digestibility									Protein	IDEA Value
	Lys	Met	Cys	Thr	Arg	Val	Ile	Leu	Trp		
Air Feed	68.6	87.0	76.1	74.5	85.5	81.3	82.8	88.9	83.0	31.8%	0.959
Air Product	67.3	86.6	75.0	73.7	84.8	80.8	82.3	88.5	82.0	27.9%	0.919
Steam Feed	70.7	87.5	77.7	75.6	86.4	82.0	83.4	89.4	84.4	28.3%	1.019
Steam Product	69.3	87.1	76.6	74.8	85.8	81.5	83.0	89.0	83.4	35.5%	0.978
Overdried Product	55.2	83.6	65.5	67.0	79.4	76.7	78.3	85.1	73.2	35.0%	0.565

The next set of trials with the Dupps pilot dryer will determine the effects of temperature and residence time on the quality of air dried feed. Significant variables which affect DDGS quality will be used as a guide for future pilot plant trials.

5.2 Neural net development

An expert on neural net models was consulted to determine how to best create a neural net model of DDGS quality. The consultation centered on methodology and validation of the proposed model.

The recommendation was to create sub models of the DDGS production process which can be combined to predict the overall quality of DDGS. Fuel ethanol production is characterized by a continuous corn cooking process feeding a batch fermentation which in turn feeds a continuous ethanol and DDGS production process. Emerson's advice is to create neural net models of each phase of production and then feed the output of these models into a neural net predicting the nutritional value of DDGS. An example of the concept is shown in ***Figure 1***.

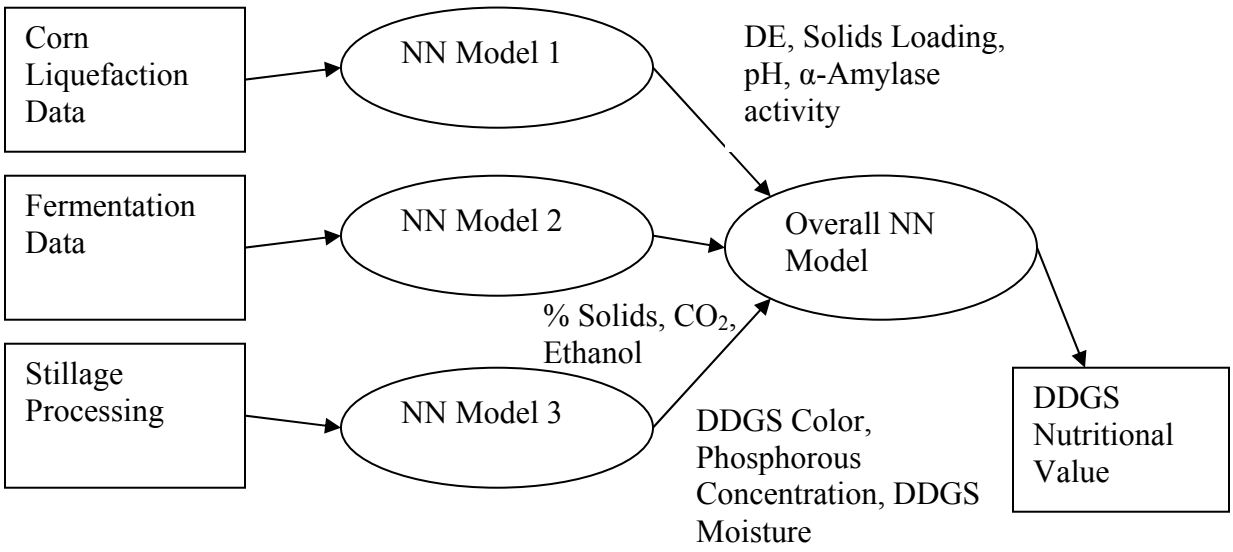

Figure 1: Proposed scheme for developing a neural net (NN) model for DDGS production quality.

A multi-model scheme provides a great deal of operating flexibility, allowing much smaller plant trials that link to form an overall model.

Several examples in the pulp and paper industry were discussed and it is possible that experts from pulp and paper will be consulted. Like corn, wood fiber is a non-homogeneous and changing feedstock. The pulp and paper industry has used neural nets extensively to calculate properties that are difficult to measure and control.

In addition, several instruments were proposed to better characterize the process. One of the more innovative measurements would be to use a microphone to determine changes in the characteristic vibration of critical equipment, such as the hammer mill used for corn grinding.

In addition to a consultation, Dr. Taylor and Mr. Bob Heider attended a week-long class in neural net creation held at Emerson Process Management in Austin, TX. The class provided training in advanced methods of process prediction and control. Several examples were used in the class that are directly applicable to the DDGS production process.

5.3 Equipment installation

An HPLC-MS/MS from Applied Biosystems has been installed in the analytical lab and is operational. Laboratory staff are being trained in its use. Validation of the instrument with known samples is the next step in its commissioning. Once protocols have been created, tested, and validated the HPLC-MS/MS will be used to perform the Stein digestibility assay for swine using trial samples.

Plans for Next Quarter

The next quarter will be the start of several plant trials aimed at generating the data necessary for creating a neural net model. An expert in statistical design of experiments will be at the NCERC in April and will be consulted on this work. A trial will be designed to create a liquefaction neural net model, a key first step in predicting DDGS nutritional composition. The trial will vary several plant parameters over a period of days. Flask fermentation will be used to study the effects of liquefaction and prepare for a second trial studying fermentation variables. The Dupps dryer will be used to determine the effects of operating temperature and residence time on the digestibility of DDG and DDGS during the trial.

Protocols for testing swine protein digestibility using the Stein assay will be developed and validated. The Novus IDEA™ assay will be used to detect poultry digestibility. Several samples of DDG and DDGS will be sent for a full essential amino acid analysis. Protocols for determining crude protein, fat, and fiber have already been developed in house.