DISTILLERS GRAINS TECHNOLOGY COUNCIL

“Increasing the awareness of the value of Distillers Grains”
INVESTIGATION OF DRIED DISTILLERS GRAINS WITH SOLUBLES (DDGS) SUSCEPTIBILITY TO RED FLOUR BEETLE (RFB) INFESTATION

Mahsa Fardisi
Dr. Linda Mason
Dr. Klein Ileleji
Introduction

- DDGS is used in animal diets
- Demand in U.S.A and export market
- Lots of studies on DDGS production process and its effect on animals
- None on DDGS susceptibility to insect infestation
- Vietnam Ministry of Agriculture's Plant Production Department (PPD) had found insects in a container shipment of U.S. DDGS
Objectives

- Determine DDGS susceptibility as raw ingredient to red flour beetle infestation
- Determine the simulated commercial diets containing DDGS to red flour beetle infestation

Red Flour Beetle (RFB) (*Tribolium castaneum* Herbst)
Insect Development

Larval development
Temp.: 32.5°C
r.h.: 30 and 50%
Control Diet: Flour/Yeast (F/Y)(9:1) & ground corn
Controlled environmental chambers
Diet

Larval Development (d)

DDGS

F/Y  G-CORN  G-DDGS  DDGS

DDGS

30%  50%

Larval development on commercial diet at 50% r.h.

<table>
<thead>
<tr>
<th>Diet</th>
<th>5% DDGS</th>
<th>10% DDGS</th>
<th>20% DDGS</th>
<th>30% DDGS</th>
<th>40% DDGS</th>
<th>Frog Diet 5% DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>50%</td>
<td>16.33</td>
<td>15.77</td>
<td>15.87</td>
<td>15.91</td>
<td>15.98</td>
<td>29.69</td>
</tr>
</tbody>
</table>
### Conclusion

- RFB development significantly increased on DDGS diets
- Adding any amount of F/Y to raw DDGS results in an increase in vulnerability of the diet to RFB infestation

### Recommendations

- Storing DDGS at lower humidity (30% r.h.)
- Bigger particle size (at low humidity) = longer developmental time
- DDGS in pellet form might provide an advantage against *Tribolium* or secondary feeders
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“Increasing the awareness of the value of Distillers Grains”
Effects of Adding Cellulosic Ethanol wet distillers grains on steer performance and carcass characteristics

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Iowa State University, Ames, Iowa
Introduction

• Expanding trend to extract corn oil during ethanol production
• No research conducted with distillers grains (DG) from a secondary fermentation process
  ➢ Conversion of corn kernel fiber into cellulosic ethanol
  ➢ Utilizing cellulosic enzymes, yeast, and heat
  ➢ Product called Adding Cellulosic Ethanol (ACE) wet distillers grain (A-WDG)
Objective

• The objective of this study was to evaluate the impact of wet distillers grains (WDG) from a secondary fermentation process (A-WDG) compared to traditional WDG (T-WDG) on performance and carcass characteristics of finishing steers.
Materials and methods

• Both A-WDG and T-WDG were produced within two consecutive days, delivered to our research farm, and stored in bags for feeding.

• One hundred sixty-eight crossbred Angus steers (928 ± 10.0 lbs) were assigned to one of four treatments fed for 94 days:
  - Corn-based control [with 13% T-WDG on a dry matter (DM) basis; CON]
  - 30% T-WDG (30% T-WDG)
  - 30% A-WDG (30% A-WDG)
  - 30% A-WDG plus solubles (30% A-WDGS)

• Weights were collected on two consecutive days at the start of the trial, 28 day interims, the start of the Optaflexx feeding period, and two consecutive days again at the end of the trial.

• Steers were harvested at a commercial abattoir, and carcass data were collected from each individual animal after a 24 hour chill.
Results and discussion

• Feed conversion was not different between 30% A-WDG and 30% A-WDGS-fed steers, but 30% A-WDGS-fed steers had lesser dry matter intake and ADG, suggesting that higher sulfur content of the solubles may have limited performance of cattle fed 30% A-WDGS.

• Yield and quality grade distribution were not different between treatment comparisons.

• Steers finished on the 30% T-WDG diet had improved ADG, feed conversion, heavier final body weights and hot carcass weights, as well as larger ribeye areas compared to steers fed corn-based control diet.

• Steers fed 30% A-WDG or T-WDG had similar ADG, final body weights, hot carcass weights, ribeye areas, and marbling scores. Steers fed 30% A-WDG had greater dry matter intakes, decreased feed conversion, and decreased backfat thickness compared to steers fed 30% T-WDG.
Overall conclusion

- Consistent with previous research, results from this study reiterate that WDG are superior to corn in feeding value and energy content.

- In order to produce additional ethanol from corn fiber, incorporation of a secondary fermentation process results in a co-product (A-WDG) that maintains significant feeding value for feedlot cattle.
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“Increasing the awareness of the value of Distillers Grains”
Three Dimensional Heat Transfer Model For Cooling of M-DDGS Pile

Kaliramesh Siliveru\textsuperscript{1}, Mark Casada\textsuperscript{2}, Kingsly Ambrose\textsuperscript{3}

\textsuperscript{1}Graduate Research Assistant
\textsuperscript{2}Lead Scientist, USDA-ARS
\textsuperscript{3}Assistant Professor
Almost 50% of existing dry grind corn ethanol industries extract oil from DDGS.

Caking of DDGS in rail cars; segregation during discharge

**Economic loss:** Cost to break the ‘cakes’ and unload cars

Avoiding loading hot DDGS can delay onset of caking (Kingsly and Ileleji, 2011)

Important to characterize the flowability of low-oil DDGS (Modified DDGS)
Objectives

- Develop heat transfer model for cooling of M-DDGS pile
- Validate the developed model experimentally in a lab scale
Materials and Methods

Governing equation:

\[(\rho_{bulk} c_{bulk}) \frac{\partial T}{\partial t} + (\rho_a c_a) u_j \frac{\partial T}{\partial x_j} = \frac{\partial}{\partial x_j} \left( k_{bulk} \frac{\partial T}{\partial x_j} \right) + \rho_{bulk} h_{fg} \frac{\partial M}{\partial t} + Q_h\]

Solved by: **Finite volume method** in ANSYS FLUENT

Experiments were conducted for summer and winter seasons

Simulation

Validation
Results

Predicted and actual temperature profile when cooled to 297.92 K

Predicted and actual temperature profile when cooled to 279.15 K

Standard error of prediction (K) for the developed model

<table>
<thead>
<tr>
<th>Location</th>
<th>cooled to 297.92 K</th>
<th>cooled to 279.15 K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom side A</td>
<td>0.60</td>
<td>2.17</td>
</tr>
<tr>
<td>Bottom mid</td>
<td>0.79</td>
<td>5.98</td>
</tr>
<tr>
<td>Bottom side B</td>
<td>0.55</td>
<td>3.10</td>
</tr>
<tr>
<td>Center side A</td>
<td>1.57</td>
<td>5.67</td>
</tr>
<tr>
<td>Center mid</td>
<td>2.69</td>
<td>8.28</td>
</tr>
<tr>
<td>Center side B</td>
<td>1.65</td>
<td>3.90</td>
</tr>
<tr>
<td>Top</td>
<td>1.36</td>
<td>2.70</td>
</tr>
</tbody>
</table>
A 3-dimensional heat transfer model based on finite volume method was developed to predict cooling pattern of M-DDGS pile.

The developed model predicted temperatures with acceptable accuracy.

Future work: The model will be validated with the field data which will be collected in an industry in summer and winter seasons.
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“Increasing the awareness of the value of Distillers Grains”
Validation of ME Prediction Equations and the Impact of Feeding Diets Containing Distillers Dried Grains with Solubles (DDGS) with Variable Oil Content on Growth Performance of Growing-Finishing Pigs

F. Wu¹,*, L.J. Johnston², P.E. Urriola¹, A.M. Hilbrands² and G.C. Shurson¹

¹ Department of Animal Science, University of Minnesota, St. Paul, ²West Central Research and Outreach Center, University of Minnesota, Morris.
Impact of Reduced-Oil (RO) DDGS in Swine Diets

- The majority of U.S. ethanol plants are extracting oil prior to producing RO-DDGS
  - Currently, DDGS oil content ranges from 4 to 14%
- Does less oil = less metabolizable energy (ME)?
- Kerr et al. (2013) showed a poor relationship between crude fat and ME content in reduced-oil DDGS
  - How do we manage variability in oil and ME content among DDGS sources?
Prediction Equations Can Be Used to Help to Manage ME Variability Among DDGS Sources

- Many ME prediction equations have been developed

- Urriola et al. (2014) conducted a cross-validation study
  - The “best” ME equation was published by Anderson et al. (2012)

\[
\begin{align*}
\text{DE} &= -2,161 + (1.39 \times \text{Gross Energy}) - (20.7 \times \text{NDF}) - (49.3 \times \text{Ether Extract}) \\
\text{ME} &= -261 + (1.05 \times \text{DE}) - (7.89 \times \text{Crude Protein}) + (2.47 \times \text{NDF}) - (4.99 \times \text{Ether Extract})
\end{align*}
\]

- Final validation of accuracy of this equation was needed using a pig growth performance study
Objectives

1. Validation of the accuracy of the Anderson (2012) ME prediction equations

2. Determine the impact of DDGS sources with similar ME but variable oil content on growth performance, carcass composition, and pork fat quality
Experimental Design

- Randomized complete block design: 432 pigs, 9 pigs/pen, 12 replications/trt
- Phase 2 diet composition (as-fed basis)

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, %</td>
<td>72.3</td>
<td>50.9</td>
<td>51.0</td>
<td>50.9</td>
</tr>
<tr>
<td>Soybean meal, %</td>
<td>25.3</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>DDGS, %</td>
<td>-</td>
<td>40.0</td>
<td>40.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Ether extract of DDGS, %</td>
<td>-</td>
<td>5.9</td>
<td>9.9</td>
<td>14.2</td>
</tr>
<tr>
<td>Predicted ME of DDGS, kcal/kg</td>
<td>-</td>
<td>(2,998 \times 40% = 1,199)</td>
<td>(3,067 \times 40% = 1,227)</td>
<td>(2,999 \times 40% = 1,199)</td>
</tr>
<tr>
<td>Dietary ME, kcal/kg</td>
<td>3,325</td>
<td>3,186</td>
<td>3,212</td>
<td>3,186</td>
</tr>
</tbody>
</table>

- All diets were balanced for similar SID amino acids & STTD phosphorus
- Growth performance, carcass composition, and pork fatty acid profile were determined
Overall Average Daily Feed Intake and Gain

**ADFİ, kg/d**

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.72</td>
<td>2.65</td>
<td>2.61</td>
<td>2.60</td>
</tr>
</tbody>
</table>

**ADG, kg/d**

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.97</td>
<td>0.92</td>
<td>0.92</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Diet ($P = 0.01$), Phase ($P < 0.01$)
Diet x Phase ($P = 0.62$), SEM = 0.029

**ADFİ, kg/d**

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.97</td>
<td>0.92</td>
<td>0.92</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Diet ($P < 0.01$), Phase ($P < 0.01$)
Diet x Phase ($P = 0.07$), SEM = 0.009

*Least squares means with different superscripts differ ($P \leq 0.05$)*
Overall Gain:Feed

Diet (P = 0.02)
Phase (P < 0.01)
Diet × Phase (P = 0.05)
SEM = 0.003

Dietary Treatment

<table>
<thead>
<tr>
<th>Dietary Treatment</th>
<th>G:F</th>
</tr>
</thead>
<tbody>
<tr>
<td>CON</td>
<td>0.368</td>
</tr>
<tr>
<td>LOW</td>
<td>0.356</td>
</tr>
<tr>
<td>MED</td>
<td>0.365</td>
</tr>
<tr>
<td>HIGH</td>
<td>0.367</td>
</tr>
</tbody>
</table>

a,b Least squares means with different superscripts differ (P ≤ 0.05)
## Carcass Composition

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>LOW</th>
<th>MED</th>
<th>HIGH</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot carcass weight, kg</td>
<td>91.0\textsuperscript{a}</td>
<td>86.6\textsuperscript{b}</td>
<td>86.6\textsuperscript{b}</td>
<td>86.8\textsuperscript{b}</td>
<td>0.89</td>
</tr>
<tr>
<td>Carcass yield, %</td>
<td>74.1\textsuperscript{a}</td>
<td>73.0\textsuperscript{b}</td>
<td>72.8\textsuperscript{b}</td>
<td>72.7\textsuperscript{b}</td>
<td>0.18</td>
</tr>
<tr>
<td>Backfat depth, mm</td>
<td>21.1\textsuperscript{a}</td>
<td>19.6\textsuperscript{b}</td>
<td>19.0\textsuperscript{b}</td>
<td>19.7\textsuperscript{b}</td>
<td>0.45</td>
</tr>
<tr>
<td>Loin muscle area, cm\textsuperscript{2}</td>
<td>42.6\textsuperscript{a}</td>
<td>39.1\textsuperscript{b}</td>
<td>38.9\textsuperscript{b}</td>
<td>39.1\textsuperscript{b}</td>
<td>0.54</td>
</tr>
<tr>
<td>Fat-free lean, %</td>
<td>50.1</td>
<td>49.9</td>
<td>50.1</td>
<td>49.9</td>
<td>0.28</td>
</tr>
</tbody>
</table>

\textsuperscript{a,b} Least squares means with different superscripts differ (\(P \leq 0.05\))
Belly Fat Iodine Value

Dietary Treatment

CON  LOW  MED  HIGH

60.2  70.7  72.0  76.4

Diet (P < 0.01)
SEM = 0.67

a,b Least squares means with different superscripts differ (P ≤ 0.05)
Conclusions

The “best” ME equation adequately predicts ME for HIGH and MED, but appears to slightly overestimate ME in LOW.

Reduced oil content of DDGS does not affect pig’s growth performance, but improves pork fat quality.
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“Increasing the awareness of the value of Distillers Grains”
Evaluation of In Vitro Dry Matter Digestibility (IVDMD) of High Fiber Feed Ingredients for Monogastrics

Z. Huang*, I. J. Salfer, P. E. Urriola, M. D. Stern, and G. C. Shurson
Department of Animal Science
University of Minnesota
The Need for “Nutritional Tools”

- Use of high fiber by-products in swine diets is increasing
  - Relatively less expensive than corn and soybean meal
  - Readily available
  - Variable in energy and nutrient content

- “Nutritional tools” are needed to estimate energy and nutrient digestibility and feeding value without the cost and time of conducting animal nutrient balance trials
  - Fast, accurate, and inexpensive
Objectives

- Determine *in vitro* dry matter digestibility (IVDMD) among sources of high fiber ingredients in nursery (5 to 7 wks of age) and finishing pigs (17 to 20 wks of age) that vary in:
  - Fiber concentration
  - Fiber characteristics
    - Proportion of various carbohydrates
    - Fermentability of carbohydrates
Materials and Methods

- Sample collection

<table>
<thead>
<tr>
<th>Item</th>
<th>Wheat Straw</th>
<th>Soybean Hulls</th>
<th>DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDF, %</td>
<td>75.7</td>
<td>66.1</td>
<td>33.8</td>
</tr>
<tr>
<td>ATTD of NSP, %</td>
<td>16.3</td>
<td>79.1</td>
<td>48.2</td>
</tr>
</tbody>
</table>

- N = 16 for all the 3 ingredients
- TDF = total dietary fiber
- ATTD = apparent total tract digestibility
- NSP = non-starch polysaccharide

- Three step procedure to determine dry matter digestibility

1. Enzymatic hydrolysis - gastric
2. Enzymatic hydrolysis – small intestine
Filtration and drying
3. Large intestine fermentation
Filtration and drying

- Calculations and statistical analysis
  - Randomized block design
  - Treatments
    - 3 ingredients (wheat straw, soybean hulls, DDGS)
    - 16 sources within each ingredient
    - 2 pig ages (nursery pigs 5-7 wks of age and finishing pigs 17-20 wks of age)
  - Calculate gastric and small intestine hydrolysis ($\text{IVDMD}_h$) and large intestine fermentation ($\text{IVDMD}_f$)
Results

Gastric and small intestine IVDMD

- DDGS > SBH > WS
  - WS (P < 0.01)
  - SBH (P < 0.01)
  - DDGS (P < 0.01)

Large intestine IVDMD

- SBH > DDGS > WS
  - WS (P < 0.01)
  - SBH (P = 0.05)
  - DDGS (P < 0.01)
Summary

- **Gastric and small intestine hydrolysis (IVDMD<sub>h</sub>)**
  - DDGS > SBH > WS
  - Significant variation among sources within each ingredient

- **Large intestine fermentation (IVDMD<sub>f</sub>)**
  - SBH > DDGS > WS in both finishing pigs and nursery pigs

- Next step is to validate and compare *in vivo* dry matter and fiber digestibility values among high, medium, and low sources of WS, SBH, and DDGS with *in vitro* digestibility values
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