ETHANOL
The Good, the Bad, and the Ugly!

Reminders....
• Lab this week and next week: AGAD21
• Bring a calculator and your NRC tables to lab
• http://www.ansc.purdue.edu/swineclass/

Background
• Indiana, Midwest, Eastern Cornbelt
• Benefits
  – Added value to corn
  – Job creation
  – State revenues
• Who potentially benefits most
  – Corn growers
  – Beef producers?
  – Dairy producers?

Current and Proposed Ethanol Plants
• Dry grind vs. wet milling – 2.8 gal/bu
• 108 plants in operation = 5.16 billion gal.
  – 1.84 billion bushels of corn
  – 32.2 billion pounds of DDGS
• 82 plants under construction = 5.52 bil. gal
  – 1.97 billion bushels of corn
  – 34.5 billion lbs of DDGS
• Combined 10.67 billion gal. by end of 2007
  – 3.8 billion bushels of corn
  – 66.7 billion lbs of DDGS

What are the Uses of the by-products
• Landfills
• Crop fertilizer - pelletized
• Further refinement
  – Pyrolysis
  – Gasification
  – Component fractionation
  – Industrial
• Co-fire in power plants
• Livestock Feed
  – Domestic
  – International
How Much DDGS can the US Livestock Industry Use?

100% of the livestock category using DDGS at current recommended levels

<table>
<thead>
<tr>
<th>Category</th>
<th>DDGS (in billions lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slaughter Cattle</td>
<td>18.25</td>
</tr>
<tr>
<td>Beef Cows</td>
<td>20.34</td>
</tr>
<tr>
<td>Dairy Cows</td>
<td>16.75</td>
</tr>
<tr>
<td>Heifers and calves</td>
<td>18.20</td>
</tr>
<tr>
<td>Cattle Total</td>
<td>73.54</td>
</tr>
<tr>
<td>Swine</td>
<td>17.58</td>
</tr>
<tr>
<td>Broilers and Turkeys</td>
<td>6.02</td>
</tr>
<tr>
<td>Grand Total</td>
<td>97.14</td>
</tr>
</tbody>
</table>

** Estimated 66.7 billion lbs produced by the end of 2007 **

Indiana Proposed Ethanol Plants

- Dry grind – possible fractionation
- Estimated 1.4-1.9M tons DDGS
- Typical inclusion rates
  - Beef & Dairy 20%
  - Swine 10%
  - Poultry 5%
- USDA Ag Statistics, 2006
- Maximum IN utilization: 1.33M tons (70-90.5%)
- Realistic utilization in Indiana: 30-50%

SBM vs DDGS

- DDGS contains 57% of the protein of SBM – (27.3/47.5)
- DDGS contains 28% of the total lysine of SBM – (.84/3.02)
- DDGS contains 20% of the available lysine – (.52/2.57)
- This is why it replaces a greater percentage of Corn in the diet than SBM in monogastric diets

SBM vs DDGS

- Swine Example – 10% DDGS in WF
  - Pig consumes about 110 lb of SBM and 565 lb Corn from weaning to market
  - DDGS could replace about 2.42 lb SBM / Pig
  - DDGS could replace about 36.7 lb Corn / Pig
  - In Indiana = 4.2 million bushels of corn
  - In Indiana = 7,744 ton SBM

Handling, Storage & Transportation

- Wet system - frequent delivery of wet DGs
  - Flat storage
  - Cost of transporting water
  - 3 - 7 day shelf-life
  - Ensiling (corn stover, silage, soyhulls, straw)
- DDGS
  - Bridging in bins and rail cars (BN, UP)
  - Separation
  - Particle size ≤ 400 microns
  - Pellets (limited to 5 - 7% inclusion rate)

New Fractionation Processes will change DDGS and its nutritional value

- Degerming
  - Press the oil to human or Bio-diesel
  - Reduces oil and may reduce P
- Dehulling
  - Reduces fiber
- Separation post-fermentation
  - Fiber and/or oil removed
- Syrup levels used and fractioning or recycling
Comparison of Conventional DDGS and Fractionated Products

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Fractionation Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>2.8 gal</td>
<td>2.8 gal</td>
</tr>
<tr>
<td>DDGS</td>
<td>17 lb</td>
<td>7 lb</td>
</tr>
<tr>
<td>Germ</td>
<td>---</td>
<td>4 lb</td>
</tr>
<tr>
<td>Fiber/hull</td>
<td>---</td>
<td>4 lb</td>
</tr>
<tr>
<td>Corn Oil</td>
<td>(2 lb)</td>
<td>2 lb</td>
</tr>
</tbody>
</table>

Dakota Gold Product Profiles (As Fed)

<table>
<thead>
<tr>
<th></th>
<th>DDGS</th>
<th>DDGS-HP</th>
<th>Corn Germ</th>
<th>Dakota Bran&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>26.6</td>
<td>43.0</td>
<td>15.6</td>
<td>13.7</td>
</tr>
<tr>
<td>Lys</td>
<td>0.89</td>
<td>1.19</td>
<td>0.82</td>
<td>?</td>
</tr>
<tr>
<td>M+C</td>
<td>1.25</td>
<td>1.81</td>
<td>0.74</td>
<td>?</td>
</tr>
<tr>
<td>Thre</td>
<td>1.01</td>
<td>1.83</td>
<td>0.57</td>
<td>?</td>
</tr>
<tr>
<td>Tryp</td>
<td>0.28</td>
<td>0.36</td>
<td>0.20</td>
<td>?</td>
</tr>
<tr>
<td>Fat</td>
<td>8.7</td>
<td>3.0</td>
<td>17.8</td>
<td>8.1</td>
</tr>
<tr>
<td>Fiber</td>
<td>6.1</td>
<td>6.9</td>
<td>5.1</td>
<td>5.0?</td>
</tr>
<tr>
<td>ME&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1647</td>
<td>1695</td>
<td>1844</td>
<td>?</td>
</tr>
<tr>
<td>Phos</td>
<td>0.79</td>
<td>0.37</td>
<td>1.40</td>
<td>0.61</td>
</tr>
</tbody>
</table>

<sup>a</sup> Corn ME = 1505  
<sup>b</sup> only 52% DM

Effect of Processing Method on DDGS Quality

How is DDGS Quality Defined?

• Color?  
  – Subjective measure
• Nutrient availability to livestock?
• End-use, different measures?
• Who should do this, the industry?
• ????????

Variations in Distillers Dried Grains w/solubles from 4 New Generation Plants

<table>
<thead>
<tr>
<th></th>
<th>Swine Digestibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>58.1 – 78.6%</td>
</tr>
<tr>
<td>Lysine</td>
<td>51.3 – 75.7%</td>
</tr>
<tr>
<td>Threonine</td>
<td>67.8 – 83.7%</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>41.4 – 71.6%</td>
</tr>
<tr>
<td>Methionine</td>
<td>76.4 – 87.8%</td>
</tr>
</tbody>
</table>
| Phosphorus       | .77 - .80% Tot.P vs Corn at .26% Tot.P (15% Dig.)
                    | 35-85% Digestible (Stein, 2006)
• Stein et al., 2004

Rapid Lab Tests

• One-Step pepsin digest – $R^2 = 0.52$
• Two-Step pepsin-pancreatin digest – $R^2 = 0.79$
• Color – $R^2 = 0.53$-0.67
• KOH Solubility – $R^2 = 0.47$
• Furosine – $R^2 = 0.71$
• Reactive lysine – $R^2 = 0.66$
• IDEA Value (Novus) vs. True Lys Dig. (Poultry) – $R^2 = 0.88$

Stein, Pahm, and Pederse, 2005
Use of DDGS in Beef and Dairy

Animal Performance, Co-Product Quality & Nutrient Management
- Historical use has been WDG by feedlots (proj. 25-30% of by-product)
- Excess N, P & S
  - Amino acid imbalance
  - Environmental implications
- Limited data across species
  - ADG, G/F, repro., longevity
  - Fiber digestibility, milk quality, immune function.
  - Carcass composition, marbling, FA profile

Potential Use of DDGS in Beef
- Beef industry will prefer to use the dry product
- Research is clear concerning the utilization of DDGS in feedlot diets
  - Max. of 40% DM intake
  - Greater than 25% may decrease marbling
- Product may be used in cow, creep, and heifer development diets
  - May help with low quality fiber source digestion
- DG inclusion will alter Ca:P ratio
  - Feedlot diets - urinary calculi (water belly)
  - MUST add calcium to diets (Ca:P at least 1.1:1)
  - P excretion will increase (nutrient management issue)
  - SULFUR!!!

Dairy Cattle Feeding
- Young Calves – up to 50% of the grain mix
- Older calves – could be greater than 50%
- Max. of 20% DMI in Lactation Rations
- Check particle size of final ration to ensure adequate effective fiber
- Balance for RUP and RDP
- Determine Fat, P, and Mycotoxin levels of purchased distillers products

Ruminate Potential Problems
- Storage
- Transportation
- Upper limits for cow and creep diets
- Reproductive efficiencies
- Variation of co-products
- P and S content
- N and P Excretion
- Fat level
- Effective fiber
- Long term issues
Ensiling Storage DDGS

• Many small producers
  – Can't utilize semi-load lots of wet co-product
  – Need a longer term storage method
• 100% wet co-product
  – Will bust ag bag seams
    • Need a “diluter” for density and nitrogen (CP)
  – pH is low – should store in airtight structure
• Potential “diluters”
  – Corn silage, corn stalks, straw, soyhulls, hay

Use of DDGS in Swine and Poultry

Feeding DDGS to Poultry

Dry product only

Broilers – 5-7.5% typical, 10% max.

Layers – 10% could be used, 15% in non-peak production

Turkeys – 5-15% inclusions

Pig GF Performance fed DDGS

<table>
<thead>
<tr>
<th>DDGS, %</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG/lb/d</td>
<td>1.90a</td>
<td>1.89a</td>
<td>1.80b</td>
<td>1.78b</td>
</tr>
<tr>
<td>G:F</td>
<td>0.377a</td>
<td>0.377a</td>
<td>0.365ab</td>
<td>0.360b</td>
</tr>
<tr>
<td>Carcass wt.</td>
<td>189.0a</td>
<td>191.1a</td>
<td>177.5b</td>
<td>177.2b</td>
</tr>
<tr>
<td>Dressing %</td>
<td>73.37a</td>
<td>73.03a</td>
<td>71.50b</td>
<td>71.74b</td>
</tr>
<tr>
<td>Loin, mm</td>
<td>56.5</td>
<td>54</td>
<td>54.2</td>
<td>51.8</td>
</tr>
<tr>
<td>Belly Thickness</td>
<td>3.15a</td>
<td>3.00ab</td>
<td>2.84ab</td>
<td>2.71a</td>
</tr>
<tr>
<td>Adj. Belly firm.</td>
<td>25.9a</td>
<td>23.8ab</td>
<td>25.4a</td>
<td>22.4b</td>
</tr>
<tr>
<td>Belly IV value</td>
<td>66.8a</td>
<td>68.6b</td>
<td>70.6b</td>
<td>72.0c</td>
</tr>
</tbody>
</table>

* 4-1.5% Soy Oil Control, balanced on total AA – Whitney et al., 2001, Univ. MN and SDS

Recent Research

• Cook et al., 2005 (Grow-finish)
  – No effect on ADG up to 30% DDGS
  – Feed Eff. Decreased above 10% DDGS
  – 30% DDGS decreased FI
  – Mortality linearly decreased from 6% to less than 2%
  – Carcass yield linearly decreased

• Gourley et al., 2005 (Grow-finish)
  – No effect on ADG and ADFI up to 29% DDGS
  – G:F Decreased above 7.3% DDGS
  – Carcass yield linearly decreased
  – Iodine value increased from 66 to 73 as DDGS increased to 22 and 29%

Recent Research

• Decreased Carcass yield will Decrease DDGS value in swine
  – For each 10% inclusion in the diet carcass yield went down 0.6%
  – That is 1.6 lb of lost carcass wt. at 10% inclusion
  – $1.05/pig lost income at 10% inclusion
  – At 10% inclusion 1 ton of DDGS could be fed to 33 pigs for all of grow-finish = $34.65/ton lower value of DDGS to swine!
Poultry and Swine Feed Manufacturing
Issues with DDGS

- Flow rates
- Bridging- bad with high inclusion rates
- Particle size
- Separation/settling issues
- Pelletability – “molasses balls” Gummed dies, fines
- Sodium content – Poultry
- Mycotoxins – become concentrated

Swine Feeding Issues

- Reproductive performance (sows and boars)?
  - Any effects on sow longevity?
  - Effects on fatty acid composition of milk?

- Feeding level during high energy demands of lactation and Paylean feeding?

Swine Feeding Issues

- Ingredient shifts
  - Oil in DDGS displacing animal fat and AV blends?
  - Less need for inorganic P and/or less phytate P available for phytase activity?

- Fiber content and energy availability from fiber
- Heat increment of fiber- summer time feeding

Swine and Poultry Nutrient Excretion
Issues with DDGS

- N excretion increases 15-200+%
  - Ammonia emissions?
- P can be managed by decreases MCP/DCP
- Increased DM excretion/Increased solids? Increased Sludge?
- Crust formation? Flies? Ammonia?

DDGS and Pork Quality

- Processing/Handling issues
  - Fat firmness (IV values increase to 75-80)
  - Shelf-life
  - Export marketing- decrease in marbling score
  - Increased problems with processed products

- Potential health issues
  - n-6:n-3
    - n-6 increases drastically (doubles)
  - Fatty acid composition – high linoleic (18:2)
Potential Body Fat Changes

- Assume sows are 65 IV points, sold two weeks after farrowing.
  - Fed 20% DDGS, now 71.4
  - Fed 30% DDGS, now 74.6
  - Fed 40% DDGS, now 77.8
  - Fed 50% DDGS, now 81.0

- Long Term use of DDGS may create a change in CWG FA profiles – reflective of the DDGS fed to slaughter animals!

Brat Quality
Proper Production and Utilization

- Increase value of co-products
  - Mitigate negative environmental effects
  - Separate phosphorus, fat, protein, fiber

- Potentially make livestock industry
  - More competitive
  - More attractive

Recommended Use of DDGS in Swine Diets

- Swine industry will only use the dry product

<table>
<thead>
<tr>
<th></th>
<th>0% DDGS</th>
<th>5% DDGS</th>
<th>10% DDGS</th>
<th>20% DDGS</th>
<th>40% DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestation</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactation</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td></td>
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</tr>
<tr>
<td>Nursery</td>
<td>XX</td>
<td>XX</td>
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<td></td>
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</tr>
<tr>
<td>Grower</td>
<td>XX</td>
<td>XX</td>
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<td></td>
</tr>
<tr>
<td>Finishing</td>
<td>XX</td>
<td>XX</td>
<td>XX</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

My Recommendations
- Nursery – 0, 5, 10, 15-25%
- Grow-finish – 20-30, 15, 0%
- Lactation – 0-10%
- Gestation – 20-30%

Overall Issues with DDGS

- Product Variation
- Handling, Storage, Transportation
- Effect on Animal Performance
- Effect on Product Quality
- Effect on Nutrient Management
- Antibiotic contamination
- Producer Education
- Food vs. Fuel National Policy

Project Objectives

1. Processing, Handling, Storage and Digestibility of DDGS
2. Animal Performance and Product Quality
3. Environmental Impact of DDGS Ration Inclusion

⇒ Phase I: next 9-12 months
⇒ Phase II: 9 months & beyond

Final Thoughts

- Infrastructure does not exist in Indiana
  - Handling, storing, distribution
- Cost of livestock production could increase
  - By-products shipped out of state
  - Rising corn price
  - Diverting soybean acres to corn
- Opportunities for alternative processing / fractionation