Use of Distiller's Dried Grains with Solubles in Swine Feeds

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What is DDGS?
- Co-product of the dry-milling ethanol industry
  - Corn (maize) DDGS - Midwestern US
  - Wheat DDGS - Canada
  - Sorghum (milo) DDGS - Great Plains US
  - Barley DDGS
  - Rye DDGS

Production of DDGS
- Yeasts and enzymes are used to ferment the starch fraction of corn
- Ethanol and carbon dioxide are produced
- Distiller's grains and distiller's solubles are the residues remaining after fermentation
- These fractions are blended and dried to produce distiller's dried grains with solubles (DDGS)

Dry-Milling Average Ethanol Yield Per Bushel (25.4 kg) of Corn
- Ethanol 2.7 gallons (10.2 liters)
- DDGS 18 lbs (8.2 kg)
- CO₂ 18 lbs (8.2 kg)

Slide courtesy of Ms. Kelly Davis, CVEC, Benson, MN
“New Generation” vs. “Old Generation” DDGS

- **High Quality, Highly Digestible DDGS**
- **Lower Quality, Less Digestible DDGS**

**Comparison of Energy Values for DDGS (88% Dry Matter Basis)**

<table>
<thead>
<tr>
<th></th>
<th>“New” DDGS</th>
<th>“Old” DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE, kcal/lb</td>
<td>1582</td>
<td>1600</td>
</tr>
<tr>
<td>Range</td>
<td>1550-1604</td>
<td>1349-1853</td>
</tr>
<tr>
<td>ME, kcal/lb</td>
<td>1434</td>
<td>1527</td>
</tr>
<tr>
<td>Range</td>
<td>1400-1458</td>
<td>1279-1776</td>
</tr>
</tbody>
</table>

Corn (NRC, 1998): DE (kcal/lb) = 1580 ME (kcal/lb) = 1534

**Comparison of Amino Acid Composition of DDGS (88% dry matter basis)**

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>“New” DDGS</th>
<th>“Old” DDGS</th>
<th>DDGS (NRC, 1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine, %</td>
<td>0.75 (17.3)</td>
<td>0.47 (26.5)</td>
<td>0.59</td>
</tr>
<tr>
<td>Methionine, %</td>
<td>0.63 (13.6)</td>
<td>0.44 (4.5)</td>
<td>0.48</td>
</tr>
<tr>
<td>Threonine, %</td>
<td>0.99 (6.4)</td>
<td>0.86 (7.3)</td>
<td>0.89</td>
</tr>
<tr>
<td>Tryptophan, %</td>
<td>0.22 (6.7)</td>
<td>0.17 (19.8)</td>
<td>0.24</td>
</tr>
<tr>
<td>Valine, %</td>
<td>1.32 (7.2)</td>
<td>1.22 (2.3)</td>
<td>1.23</td>
</tr>
<tr>
<td>Arginine, %</td>
<td>1.06 (9.1)</td>
<td>0.81 (18.7)</td>
<td>1.07</td>
</tr>
<tr>
<td>Histidine, %</td>
<td>0.67 (7.8)</td>
<td>0.54 (15.2)</td>
<td>0.65</td>
</tr>
<tr>
<td>Leucine, %</td>
<td>3.12 (6.4)</td>
<td>2.61 (12.4)</td>
<td>2.43</td>
</tr>
<tr>
<td>Isoleucine, %</td>
<td>0.95 (8.7)</td>
<td>0.88 (5.1)</td>
<td>0.88</td>
</tr>
<tr>
<td>Phenylalanine, %</td>
<td>1.29 (6.6)</td>
<td>1.12 (8.1)</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Values in ( ) are CV’s among plants

**Comparison of Apparent Ileal Digestible Amino Acid Composition of DDGS (88% dry matter basis)**

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>“New” DDGS</th>
<th>“Old” DDGS</th>
<th>DDGS (NRC, 1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine, %</td>
<td>0.29</td>
<td>0.00</td>
<td>0.27</td>
</tr>
<tr>
<td>Methionine, %</td>
<td>0.28</td>
<td>0.21</td>
<td>0.34</td>
</tr>
<tr>
<td>Threonine, %</td>
<td>0.55</td>
<td>0.32</td>
<td>0.49</td>
</tr>
<tr>
<td>Tryptophan, %</td>
<td>0.13</td>
<td>0.13</td>
<td>0.12</td>
</tr>
<tr>
<td>Valine, %</td>
<td>0.81</td>
<td>0.45</td>
<td>0.77</td>
</tr>
<tr>
<td>Arginine, %</td>
<td>0.79</td>
<td>0.83</td>
<td>0.77</td>
</tr>
<tr>
<td>Histidine, %</td>
<td>0.45</td>
<td>0.26</td>
<td>0.40</td>
</tr>
<tr>
<td>Leucine, %</td>
<td>2.26</td>
<td>1.62</td>
<td>1.85</td>
</tr>
<tr>
<td>Isoleucine, %</td>
<td>0.63</td>
<td>0.37</td>
<td>0.64</td>
</tr>
<tr>
<td>Phenylalanine, %</td>
<td>0.78</td>
<td>0.60</td>
<td>0.96</td>
</tr>
</tbody>
</table>

**Correlation Between DDGS Color and Amino Acid Digestibility (r²)**

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lys</td>
<td>.67</td>
<td>NS</td>
<td>.77</td>
</tr>
<tr>
<td>Cys</td>
<td>.67</td>
<td>NS</td>
<td>.74</td>
</tr>
<tr>
<td>Thr</td>
<td>.51</td>
<td>NS</td>
<td>.58</td>
</tr>
</tbody>
</table>
Comparison of Phosphorus Level and Relative Availability of DDGS (88% dry matter basis)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total P, %</td>
<td>0.78</td>
<td>0.79</td>
<td>0.73</td>
<td>0.25</td>
</tr>
<tr>
<td>Range</td>
<td>0.62-0.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P Availability, %</td>
<td>80</td>
<td>No data</td>
<td>77</td>
<td>14</td>
</tr>
<tr>
<td>Range</td>
<td>88-92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.70</td>
<td>No data</td>
<td>0.56</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Why is there so much interest in feeding DDGS to swine?

- "New Generation" DDGS is high in digestible nutrients
- Economical partial replacement for:
  - corn
  - soybean meal
  - dicalcium phosphate
- Increasing production and supply
- Unique properties
  - reduce P excretion in manure
  - increase litter size weaned/sow
  - gut health benefits?

Maximum Inclusion Rates of “New Generation” DDGS in Swine Diets

(Based Upon University of Minnesota Performance Trials)

- Nursery pigs (> 7 kg)
  - Up to 25 %
- Grow-finish pigs
  - Up to 20% (higher levels may reduce pork fat quality)
- Gestating sows
  - Up to 50%
- Lactating sows
  - Up to 20%

Assumptions: no mycotoxins
formulate on a digestible amino acid and available phosphorus basis

Feeding “New Generation DDGS to Sows”

Effect of Feeding a 50% DDGS Diet on Sow Weight Gain During Gestation (Reproductive Cycle 1)

Effect of Feeding 0 or 50% DDGS Gestation Diets and 0 or 20% DDGS Lactation Diets on Pigs Weaned/Litter

- Different superscripts indicate significant difference (P < .10)
Effect of Dietary Treatment Combination on Sow Lactation ADFI

Feeding “New Generation” DDGS to Weaned Pigs

Materials and Methods – Nursery Experiments

- **Experiment 1**
  - Pigs weaned at 19.0 ± 0.3 d of age
  - Weighed 7.10 ± 0.07 kg
- **Experiment 2**
  - Pigs weaned at 16.9 ± 0.4 d of age
  - Weighed 5.26 ± 0.07 kg
  - Pigs were fed a commercial pelleted diet (d 0 to 3 postweaning)
- **Phase II (d 4–17) and Phase III (d 18 – 35)** diets were formulated on a digestible amino acid basis.
  - Diets contained 0, 5, 10, 15, 20, or 25% DDGS

Effect of DDGS Level on Growth Rate (Experiment 1)

Effect of DDGS Level on ADFI (Experiment 1)

Effect of DDGS Level on Gain/Feed (Experiment 1)
Effect of DDGS Level on Growth Rate (Experiment 2)

- Linear effect of diet ($P = .09$)
- Phase ($P < .01$)

Effect of DDGS Level on Feed Intake (Experiment 2)

- Linear effect of diet ($P = .05$)
- Phase ($P < .01$)
- Phase x Diet ($P = .02$)

Effect of DDGS Level on Gain/Feed (Experiment 2)

- Phase ($P = .06$)

Effect of DDGS Level on Final BW (Experiment 2)

- SE = 1.3

Feeding “New Generation” DDGS to Grow-Finish Pigs

Fat Quality Characteristics of Market Pigs Fed Corn-Soy Diets Containing 0 to 30% DDGS

<table>
<thead>
<tr>
<th>% DDGS</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belly thickness, cm</td>
<td>3.19&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.84&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.71&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Belly firmness score, degrees</td>
<td>27.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>21.3&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Adjusted belly firmness score, degrees</td>
<td>25.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>23.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25.4&lt;sup&gt;c&lt;/sup&gt;</td>
<td>22.4&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Iodine number</td>
<td>66.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>68.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>70.6&lt;sup&gt;c&lt;/sup&gt;</td>
<td>72.0&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means within a row lacking common superscript differ ($P < .05$).
Formulation Methods for Diets Containing DDGS

- Total vs digestible amino acid basis
  - Maximum DDGS inclusion rate = 10%
  - Much higher DDGS inclusion rates (>10%)
- Total vs available phosphorus basis
  - Formulating diet on an available P basis increases economic benefit and reduces P content of manure

Cost Savings Depends on Diet Formulation Method Used

- Maximum DDGS inclusion rate = 10% if formulating on a total amino acid basis
- Much higher DDGS inclusion rates (>10%) if diets are formulated using digestible amino acids

Comparison of Formulating DDGS Diets on a Total Lysine and P Basis vs. Digestible Lysine and Available P Basis

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Typical Corn-SBM-Lysine Diet</th>
<th>10% DDGS Total Lysine</th>
<th>10% DDGS Digestible Lysine Available P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, lb</td>
<td>1080</td>
<td>1200</td>
<td>1200</td>
</tr>
<tr>
<td>Soybean meal 44%, lb</td>
<td>486</td>
<td>588</td>
<td>588</td>
</tr>
<tr>
<td>DDGS, lb</td>
<td>6</td>
<td>68</td>
<td>28</td>
</tr>
<tr>
<td>Dicalcium phosphate, lb</td>
<td>26</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>L-lysine, lb</td>
<td>18</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Salt, lb</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>L-lysine HCl, lb</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>VTM premix, lb</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>TOTAL, lb</td>
<td>2000</td>
<td>2009</td>
<td>2009</td>
</tr>
</tbody>
</table>

Total Cost, $ 136.26 134.52 136.11
Difference, $ -1.5

Quick Calculation of Feed Cost Savings

Thumb rule:

Additions/2000 lbs diet

- 200 lbs DDGS x ______ $/lb = ______
- 3 lbs limestone x ______ $/lb = ______
TOTAL ADDITIONS (A) ______ $______

Subtractions/2000 lbs diet

- 177 lbs corn x ______ $/lb = ______
- 20 lbs SBM (44%) x ______ $/lb = ______
- 6 lbs dical. phos. x ______ $/lb = ______
TOTAL SUBTRACTIONS (S) ______ $______

(S – A) = Feed cost savings/ton by adding 10% DDGS to the diet

DDGS and Phytase are a Key Part of Manure Phosphorus Management

- Adding 20% DDGS to a corn-soy diet and formulating on an available P basis
  - can reduce manure P by > 12%
- Adding phytase to a corn-soy diet
  - increases P bioavailability from 15% to > 45%
- Lowering dietary P, adding 20% DDGS & phytase
  - can reduce manure P excretion by 40 to 50%

Diet Compositions and Cost Comparison from Adding 18.8% DDGS and Phytase

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Corn-SBM-3 lb Lysine</th>
<th>18.8% DDGS + Phytase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, lb</td>
<td>1086.6</td>
<td>1272.6</td>
</tr>
<tr>
<td>Soybean meal 44%, lb</td>
<td>375.6</td>
<td>376.6</td>
</tr>
<tr>
<td>DDGS, lb</td>
<td>0</td>
<td>276.0</td>
</tr>
<tr>
<td>Dicalcium phosphate, lb</td>
<td>23.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Limestone, lb</td>
<td>14.4</td>
<td>19.6</td>
</tr>
<tr>
<td>Salt, lb</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>L-lysine HCl, lb</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>VTM premix, lb</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Phytase, 1760 FTU/lb</td>
<td>0.0</td>
<td>1.7</td>
</tr>
<tr>
<td>TOTAL, lb</td>
<td>2020.0</td>
<td>2000.0</td>
</tr>
</tbody>
</table>

Total Cost, $ 120.29 120.46
Difference, $ - 0.17
**Does Feeding DDGS Improve Gut Health?**

**DDGS and Gut Health**
- Field reports:
  - Beneficial effect of adding 5 to 10% DDGS in grow-finish diets
- DDGS contains low levels of soluble (0.7%) and high levels of insoluble (42.2%) fiber (Shurson et al., 2000)
  - Low soluble fiber diets may reduce the proliferation of pathogenic organisms in the GI tract (Hampson, 1999).
- DDGS contains components of yeast cells
  - May have nutraceutical properties

**What is Ileitis?**
- Porcine Proliferative Enteropathy
  - Caused by *Lawsonia intracellularis*
    - Present in 96% of U.S. swine herds (Bane et al., 1997)
    - 25% of pigs affected (NAHMS, 2000)
    - Can be shed in infected pigs for up to 10 weeks
    - Animals are infected by oral contact with feces from animals shedding the bacteria
  - 7-10 days after infection:
    - Lesions of the intestinal wall begin to form
    - Lesions maximized around 21 days post-infection

**Clinical Forms of Ileitis**
- Porcine Intestinal Adenomatosis (PIA)
  - Chronic form
    - Seen in growing pigs (6 - 20 weeks of age)
    - Decreased feed intake, lethargic
- Porcine Hemorrhagic Enteropathy (PHE)
  - Acute form, affects heavier pigs
    - Greatest frequency appears to be from 65 – 110 kg pigs
  - Massive intestinal hemorrhaging, bloody diarrhea, increase in mortality

**Healthy**  **Ileitis**

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**Image:**
- Healthy pigs
- Ileitis-affected pigs with lesions on the intestinal wall.
Effect of Dietary Treatment on Lesion Length (21 d Post-Challenge) Experiment 2

Effect of Dietary Treatment on Lesion Severity (21 d Post-Challenge) Experiment 2

Effect of Dietary Treatment on Lesion Prevalence (21 d Post-Challenge) Experiment 2

Effect of Dietary Treatment on Fecal Shedding (PCR Analysis) Experiment 2

Effect of Treatment on *L. intracellularis* Infection (IHC Analysis) Experiment 2

Summary of Results, Experiment 2

- Inoculation level was closer to goal
- DDGS inclusion (10%) or antimicrobial regimen had a positive effect on the pig’s ability to resist an ileitis challenge
- No beneficial additive effects of combining DDGS and BMD®/Aureomycin® regimen
DDGS For Odor Control?

Effect of Feeding a 20% DDGS Diet on Odor Detection Threshold

Week MSE ± .1152 P > .10

Effect of Feeding a 20% DDGS Diet on Ammonia Emissions

Week MSE ± .0876 P > .10

Effect of Feeding a 20% DDGS Diet on Hydrogen Sulfide Emissions

Week MSE ± .0426 P > .10

U of M DDGS Web Site
www.ddgs.umn.edu

We have developed a DDGS web site featuring:
* research summaries
  - swine, poultry, dairy, & beef
  - DDGS quality
* presentations given
* links to other DDGS related web sites
* international audiences