“New Generation”
Distiller’s Dried Grains with Solubles
in Swine and Poultry Diets

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University of Minnesota

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

- DDGS is nutritionally DIFFERENT than other grain co-products
Comparison of Nutrient Composition (Dry Matter Basis) of “New Generation” DDGS to Corn Gluten Feed, Corn Gluten Meal, Corn Germ Meal, and Brewer’s Dried Grains

<table>
<thead>
<tr>
<th></th>
<th>“New” DDGS (UM)</th>
<th>Corn Gluten Feed (NRC)</th>
<th>Corn Gluten Meal (NRC)</th>
<th>Corn Germ Meal (Feedstuffs)</th>
<th>Brewer’s Dried Grains (NRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein, %</td>
<td>30.6</td>
<td>23.9</td>
<td>66.9</td>
<td>22.2</td>
<td>28.8</td>
</tr>
<tr>
<td>Fat, %</td>
<td>10.7</td>
<td>3.3</td>
<td>3.2</td>
<td>1.1</td>
<td>7.9</td>
</tr>
<tr>
<td>NDF, %</td>
<td>43.6</td>
<td>37.0</td>
<td>9.7</td>
<td>No data</td>
<td>52.9</td>
</tr>
<tr>
<td>DE, kcal/kg</td>
<td>4011</td>
<td>3322</td>
<td>4694</td>
<td>No data</td>
<td>2283</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3827</td>
<td>2894</td>
<td>4256</td>
<td>3222</td>
<td>2130</td>
</tr>
<tr>
<td>Lys, %</td>
<td>0.83</td>
<td>0.70</td>
<td>1.13</td>
<td>1.00</td>
<td>1.17</td>
</tr>
<tr>
<td>Met, %</td>
<td>0.55</td>
<td>0.39</td>
<td>1.59</td>
<td>0.67</td>
<td>0.49</td>
</tr>
<tr>
<td>Thr, %</td>
<td>1.13</td>
<td>0.82</td>
<td>2.31</td>
<td>1.22</td>
<td>1.03</td>
</tr>
<tr>
<td>Trp, %</td>
<td>0.24</td>
<td>0.08</td>
<td>0.34</td>
<td>0.22</td>
<td>0.28</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.06</td>
<td>0.24</td>
<td>0.06</td>
<td>0.33</td>
<td>0.35</td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.80</td>
<td>0.54</td>
<td>0.08</td>
<td>0.17</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Corn Dry-Milling Process Overview

1. Corn Cleaning
2. Hammermill
3. Mix Slurry
4. Liquefaction
5. Cooker
6. Yeast and Glucoamylase Enzyme
7. Fermentation
8. Centrifuge
9. Evaporator
10. Ethanol Alcohol
11. Distillers Dried Grains
12. Distillers Wet Grains
13. Cond. Distillers Solubles
14. Rotary Dryer
15. Whole Stillage
16. Thin Stillage
17. Coarse Solids
18. Feed Industry Co-products
Dry-Milling

Average Ethanol Yield Per Bushel (25.4 kg) of Corn

- Ethanol: 10.2 liters
- DDGS: 8.2 kg
- CO₂: 8.2 kg

Slide courtesy of Ms. Kelly Davis, CVEC, Benson, MN
Most Fuel Ethanol Production is in the Western U.S. “Corn Belt”

North American DDGS Production
North American DDGS Exports

Estimated North American DDGS Consumption in 2001 & 2002
“New Generation” vs. “Old Generation” DDGS

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

Use of Corn DDGS in Swine Diets
### Comparison of Energy Values of DDGS for Swine (88% DM Basis)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DE, kcal/kg</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3488</td>
<td>3528</td>
<td>3409</td>
<td>3449</td>
</tr>
<tr>
<td></td>
<td>Range 3418-3537</td>
<td>Range 2975-4086</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ME, kcal/kg</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3162</td>
<td>3367</td>
<td>3098</td>
<td>2672</td>
</tr>
<tr>
<td></td>
<td>Range 3087-3215</td>
<td>Range 2820-3916</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Corn (NRC, 1998): DE (kcal/lb) = 3484  
ME (kcal/lb) = 3382

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

<table>
<thead>
<tr>
<th></th>
<th>“New” DDGS</th>
<th>“Old” DDGS</th>
<th>DDGS NRC (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>0.99 (8.7)</td>
<td>0.88 (9.1)</td>
<td>0.98</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 for Swine (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>0.39</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>0.53</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>

Comparison of Phosphorus Level and Relative Availability of DDGS for Swine (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>0.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P Availability, %</td>
<td>90</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>
### Comparison of Proximate Analysis of “New Generation” DDGS vs. NRC (1998) (100% Dry Matter Basis)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter, %</td>
<td>88.9 (1.7)</td>
<td>93.0</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>30.2 (6.4)</td>
<td>29.8</td>
</tr>
<tr>
<td>Fat, %</td>
<td>10.9 (7.8)</td>
<td>9.0</td>
</tr>
<tr>
<td>Crude fiber, %</td>
<td>8.8 (8.7)</td>
<td>4.8</td>
</tr>
<tr>
<td>Ash, %</td>
<td>5.8 (14.7)</td>
<td>No data</td>
</tr>
<tr>
<td>NFE, %</td>
<td>44.5 (6.1)</td>
<td>No data</td>
</tr>
<tr>
<td>ADF, %</td>
<td>16.2 (28.4)</td>
<td>17.5</td>
</tr>
<tr>
<td>NDF, %</td>
<td>42.1 (14.3)</td>
<td>37.2</td>
</tr>
</tbody>
</table>

Values in ( ) are CV’s among plants


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca, %</td>
<td>0.06 (57.2)</td>
<td>0.44</td>
<td>0.22</td>
</tr>
<tr>
<td>P, %</td>
<td>0.89 (11.7)</td>
<td>0.90</td>
<td>0.83</td>
</tr>
<tr>
<td>K, %</td>
<td>0.94 (14.0)</td>
<td>0.99</td>
<td>0.90</td>
</tr>
<tr>
<td>Mg, %</td>
<td>0.33 (12.1)</td>
<td>0.40</td>
<td>0.20</td>
</tr>
<tr>
<td>S, %</td>
<td>0.47 (37.1)</td>
<td>0.51</td>
<td>0.32</td>
</tr>
<tr>
<td>Na, %</td>
<td>0.24 (70.5)</td>
<td>0.28</td>
<td>0.27</td>
</tr>
<tr>
<td>Zn, ppm</td>
<td>98 (80)</td>
<td>80</td>
<td>86</td>
</tr>
<tr>
<td>Mn, ppm</td>
<td>16 (33)</td>
<td>50</td>
<td>26</td>
</tr>
<tr>
<td>Cu, ppm</td>
<td>6 (20)</td>
<td>14</td>
<td>61</td>
</tr>
<tr>
<td>Fe, ppm</td>
<td>120 (41)</td>
<td>219</td>
<td>276</td>
</tr>
</tbody>
</table>

Values in ( ) are CV’s among plants
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)

- Weight gain (kg)

(P > .22)
MSE 10.12
Effect of Feeding 0 or 50% DDGS Gestation Diets and 0 or 20% DDGS Lactation Diets on Pigs Weaned/Litter

Dietary treatment

 Different superscripts indicate significant difference (P < .10).

Effect of Dietary Treatment Combination on Sow Lactation ADFI

 Different superscripts indicate significant difference (P < .10).
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)

Means not sharing a common superscript letter are significantly different ($P < .05$)

Effect of DDGS Level on ADFI (Experiment 1)
Effect of DDGS Level on Gain/Feed (Experiment 1)

- **Phase 2**
  - 0% DDGS: SE = 0.11
  - 5% DDGS: SE = 0.06
  - 10% DDGS: SE = 0.06
  - 15% DDGS: SE = 0.06
  - 20% DDGS: SE = 0.06
  - 25% DDGS: SE = 0.06

Effect of DDGS Level on Growth Rate (Experiment 2)

- **Phase 2**
  - 0% DDGS: SE = 51.1
  - 5% DDGS: SE = 55.1
  - Linear effect of diet ($P = .09$)
- **Phase 3**
  - 10% DDGS: SE = 51.1
  - 15% DDGS: SE = 51.1
  - 20% DDGS: SE = 51.1
  - 25% DDGS: SE = 51.1
  - Linear effect of diet ($P < .01$)
**Effect of DDGS Level on Feed Intake (Experiment 2)**

- **Graph Details**:
  - Y-axis: ADFI (g/d)
  - X-axis: Experimental period (Phase 2, Phase 3)
  - Legend:
    - 0% DDGS
    - 5% DDGS
    - 10% DDGS
    - 15% DDGS
    - 20% DDGS
    - 25% DDGS

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

- **Means**:
  - Phase 2: Means not sharing a common superscript letter are significantly different ($P < .05$)

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

- **Graph Details**:
  - Y-axis: G/F
  - X-axis: Experimental period (Phase 2, Phase 3)

- **Statistical Results**:
  - Phase ($P = .06$)
  - SE = 0.03

- **Means**:
  - Phase 2: Means not sharing a common superscript letter are significantly different ($P < .05$)
Effect of DDGS Level on Final BW (Experiment 2)

Body weight, kg

Dietary treatment

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></th>
<th>0 %</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belly thickness, cm</td>
<td>3.15a</td>
<td>3.00a,b</td>
<td>2.84a,b</td>
<td>2.71b</td>
</tr>
<tr>
<td>Belly firmness score, degrees</td>
<td>27.3a</td>
<td>24.4a,b</td>
<td>25.1a,b</td>
<td>21.3b</td>
</tr>
<tr>
<td>Adjusted belly firmness score, degrees</td>
<td>25.9a</td>
<td>23.8a,b</td>
<td>25.4a,b</td>
<td>22.4b</td>
</tr>
<tr>
<td>Iodine number</td>
<td>66.8a</td>
<td>68.6b</td>
<td>70.6c</td>
<td>72.0c</td>
</tr>
</tbody>
</table>

Means within a row lacking common superscripts differ (P < .05).

### Does Feeding DDGS Improve Gut Health?
What is Ileitis?

- Porcine Proliferative Enteropathy
- Caused by *Lawsonia intracellularis*
  - Present in 96% of U.S. swine herds (Bane et al., 1997)
    - 28% 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
Effect of Dietary Treatment on Lesion Length (21 d Post-Challenge) Experiment 2

- **Section of gastro-intestinal tract**
  - Jejunum*
  - Ileum*
  - Cecum
  - Colon*

- **Lesion length, cm**
  - NC
  - PC
  - D10
  - PC+AR
  - D10+AR

- **SE = 3.3 0.9 0.1 0.3**

- **D10 (P = .02)**

- **Effect of disease challenge (P < .01).**

---

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

- **Section of gastro-intestinal tract**
  - Jejunum*
  - Ileum*
  - Cecum
  - Colon*

- **Lesion score (0-4)**
  - NC
  - PC
  - D10
  - PC+AR
  - D10+AR

- **SE = 0.16 0.17 0.08 0.11**

- **AR (P = .03)**

- **D10 (P = .02)**

- **D10 (P = .09)**

- **D10 (P = .10)**

- **D10 (P = .09)**

- **Effect of disease challenge (P < .01).**
Effect of Dietary Treatment on Lesion Prevalence (21 d Post-Challenge) Experiment 2

* Effect of disease challenge ($P < .01$).

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

* Effect of disease challenge ($P < .01$).
Effect of Treatment on *L. intracellularis* Infection (IHC Analysis) Experiment 2

### Summary of Results, Experiment 2

- Inoculation level was close 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 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 Composition When 18.8% DDGS and Phytase are Added to the Diet

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Corn-SBM-1.5 kg Lysine</th>
<th>18.8% DDGS + Phytase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, kg</td>
<td>798.3</td>
<td>636.3</td>
</tr>
<tr>
<td>Soybean meal 44%, kg</td>
<td>176.9</td>
<td>159.4</td>
</tr>
<tr>
<td>DDGS, kg</td>
<td>0.0</td>
<td>188</td>
</tr>
<tr>
<td>Dicalcium phosphate, kg</td>
<td>11.6</td>
<td>0.0</td>
</tr>
<tr>
<td>Limestone, kg</td>
<td>7.2</td>
<td>9.8</td>
</tr>
<tr>
<td>Salt, kg</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>L-lysine HCl, kg</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>VTM premix, kg</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Phytase, 500 FTU/kg</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>TOTAL, kg</td>
<td>1000.0</td>
<td>1000.0</td>
</tr>
</tbody>
</table>
Use of Corn DDGS in Poultry Diets

Unidentified Growth or Hatchability Factors

- Growth response (Couch et al., 1957)
  - 5% DDGS in turkey diets
  - 17-32% improvement in gain

- Feed preference (Alenier & Combs, 1981)
  - 10% DDGS in chicken layer diets

- Reproduction improvement (Manley, 1978)
  - 3% DDGS in turkey breeder hen diets
  - Improvement in egg numbers and hatch (late lay)
### Comparison of Energy Values of DDGS for Poultry (88% DM Basis)

<table>
<thead>
<tr>
<th></th>
<th>“New Generation” DDGS</th>
<th>NRC (1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AME, kcal/kg</td>
<td>2260</td>
<td>2480</td>
</tr>
<tr>
<td></td>
<td>Range 2090-2418</td>
<td></td>
</tr>
<tr>
<td>TME, kcal/kg</td>
<td>2850</td>
<td>3097</td>
</tr>
<tr>
<td></td>
<td>Range 2650 - 3082</td>
<td></td>
</tr>
</tbody>
</table>


### Amino Acid Content of Corn DDGS (5 Sources)

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Range</th>
<th>Average</th>
<th>NRC, 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methionine, %</td>
<td>0.44 – 0.56</td>
<td>0.49</td>
<td>0.60</td>
</tr>
<tr>
<td>Cystine, %</td>
<td>0.45 – 0.60</td>
<td>0.52</td>
<td>0.40</td>
</tr>
<tr>
<td>Lysine, %</td>
<td>0.64 – 0.83</td>
<td>0.74</td>
<td>0.75</td>
</tr>
<tr>
<td>Arginine, %</td>
<td>1.02 – 1.23</td>
<td>1.08</td>
<td>0.98</td>
</tr>
<tr>
<td>Tryptophan, %</td>
<td>0.19 – 0.23</td>
<td>0.22</td>
<td>0.19</td>
</tr>
<tr>
<td>Threonine, %</td>
<td>0.94 – 1.05</td>
<td>0.98</td>
<td>0.92</td>
</tr>
</tbody>
</table>

### True Digestible Amino Acid Levels of Corn DDGS for Poultry (5 Sources)

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>True Dig. Amino Acid, %</th>
<th>Average</th>
<th>Digestibility Coefficient, %</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methionine</td>
<td>0.35 – 0.53</td>
<td>0.43</td>
<td>86 - 90</td>
<td>88</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.28 – 0.57</td>
<td>0.40</td>
<td>66 - 85</td>
<td>76</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.37 – 0.74</td>
<td>0.53</td>
<td>59 - 83</td>
<td>71</td>
</tr>
<tr>
<td>Arginine</td>
<td>0.73 – 1.18</td>
<td>0.93</td>
<td>80 - 90</td>
<td>86</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.14 – 0.21</td>
<td>0.18</td>
<td>76 - 87</td>
<td>82</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.61 – 0.92</td>
<td>0.74</td>
<td>67 - 81</td>
<td>75</td>
</tr>
</tbody>
</table>


### Correlation Between DDGS Color and Amino Acid Digestibility ($r^2$)

<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 for Poultry (88% dry matter basis)

<table>
<thead>
<tr>
<th></th>
<th>“New Generation” DDGS</th>
<th>NRC (1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total P, %</td>
<td>0.74</td>
<td>0.72</td>
</tr>
<tr>
<td>P Availability, %</td>
<td>61</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Range 54 - 68</td>
<td></td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.45</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Source: 2003 Lumpkins, Dale, and Batal, University of Georgia. Abstract.

Xanthophyll Content of Control and DDGS Diets During a 12-Wk Layer Trial in Jalisco Mexico

![Graph showing xanthophyll content over weeks]

- 10% DDGS
- Control
Average Percentage of Production by Week for Layers Fed Control and DDGS Diets – Jalisco Mexico

Differences in Yolk Color (Roche Units) in Eggs Produced by Layers Fed Control and DDGS Diets – Jalisco Mexico
Results from Recent Broiler DDGS Trials

- Broiler chicks (0 to 18 days) fed diets containing:
  - 0% DDGS - 3000 kcal ME/kg
  - 15% DDGS – 3000 kcal ME/kg
  - 0% DDGS – 3200 kcal ME/kg
  - 15% DDGS – 3200 kcal ME/kg
- ADG and G/F higher for 3200 kcal ME diets
- No difference in performance between 0% or 15% DDGS within dietary energy level


Results from Recent Broiler DDGS Trials

- Broiler chicks (0 to 42 days) fed isocaloric and isonitrogenous diets containing:
  - 0% DDGS
  - 6% DDGS
  - 12% DDGS
  - 18% DDGS
- No difference in ADG and G/F when 0, 6, or 12% DDGS diets were fed
- ADG was reduced for chicks fed 18% DDGS
- No difference in carcass yields

Results from Recent Layer DDGS Trials

- Laying hens (21 to 43 weeks of age) fed diets containing:
  - 0% DDGS – 2800 kcal ME/kg
  - 15% DDGS – 2800 kcal ME/kg
  - 0% DDGS – 2870 kcal ME/kg
  - 15% DDGS – 2870 kcal ME/kg
- No differences in egg production except when low energy, 15% DDGS diet was fed (reduction)
- No differences in egg weight, specific gravity, Haugh units, yolk color, or shell breaking strength


Recommended Inclusion Rates of DDGS for Poultry

- Broilers
  - 10% inclusion rates (Starter/Finisher)
    - Without energy adjustments
  - > 10%
    - With adjustments for lys, met, thr, trp, and energy
- Chicken Egg Layers
  - 10% inclusion rate
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