Nutritional Value of U.S. DDGS in Swine, Poultry, and Aquaculture Diets

Dr. Jerry Shurson
Professor
Department of Animal Science
University of Minnesota
Comparison of Nutrient Composition of High Quality Corn DDGS to Corn Gluten Feed, Corn Gluten Meal, and Brewer’s Dried Grains (As Fed Basis)

<table>
<thead>
<tr>
<th></th>
<th>High Quality Corn DDGS</th>
<th>Corn Gluten Feed</th>
<th>Corn Gluten Meal</th>
<th>Brewer’s Dried Grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Protein, %</td>
<td>27.2</td>
<td>21.5</td>
<td>60.2</td>
<td>26.5</td>
</tr>
<tr>
<td>Crude Fat, %</td>
<td>9.5</td>
<td>3.0</td>
<td>2.9</td>
<td>7.3</td>
</tr>
<tr>
<td>NDF, %</td>
<td>38.8</td>
<td>33.3</td>
<td>8.7</td>
<td>48.7</td>
</tr>
<tr>
<td>DE, kcal/kg (swine)</td>
<td>3,639</td>
<td>2,990</td>
<td>4,225</td>
<td>2,100</td>
</tr>
<tr>
<td>ME, kcal/kg (swine)</td>
<td>3,378</td>
<td>2,605</td>
<td>3,830</td>
<td>1,960</td>
</tr>
<tr>
<td>Lys, %</td>
<td>0.74</td>
<td>0.63</td>
<td>1.02</td>
<td>1.08</td>
</tr>
<tr>
<td>Met, %</td>
<td>0.49</td>
<td>0.35</td>
<td>1.43</td>
<td>0.45</td>
</tr>
<tr>
<td>Thr, %</td>
<td>1.01</td>
<td>0.74</td>
<td>2.08</td>
<td>0.95</td>
</tr>
<tr>
<td>Trp, %</td>
<td>0.21</td>
<td>0.07</td>
<td>0.31</td>
<td>0.26</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.05</td>
<td>0.22</td>
<td>0.05</td>
<td>0.32</td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.71</td>
<td>0.49</td>
<td>0.07</td>
<td>0.19</td>
</tr>
</tbody>
</table>
DDGS Color and Digestibility Varies Among DDGS Sources

Lower Quality, Less Digestible DDGS

High Quality, Highly Digestible DDGS
# Variation in Digestible Amino Acids in 34 Sources of Corn DDGS (%)

<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Max</th>
<th>Min</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lys</td>
<td>0.77</td>
<td>0.33</td>
<td>18.4</td>
</tr>
<tr>
<td>Met</td>
<td>0.66</td>
<td>0.40</td>
<td>12.6</td>
</tr>
<tr>
<td>Thr</td>
<td>0.96</td>
<td>0.68</td>
<td>10.2</td>
</tr>
<tr>
<td>Trp</td>
<td>0.21</td>
<td>0.10</td>
<td>15.8</td>
</tr>
</tbody>
</table>

Urriola et al. (2007)
Relationship Between Lightness of Color (L*) and Digestible Lysine Content of Corn DDGS

\[ Dlys = 0.02(L^*) - 0.25 \]
\[ R^2 = 0.48 \]

\[ Dlys = 0.01(L^*) + 0.32 \]
\[ R^2 = 0.03 \]
Use of U.S. Corn DDGS in Swine Diets
Nutritional Characteristics of DDGS for Swine

- DDGS ME = corn ME
- Amino acid content and digestibility variable
  - Total lysine (0.61-1.06% DM basis)
  - Standardized true lysine digestibility (44-67%)
- High digestible P
  - Reduce diet inorganic P supplementation
  - May reduce manure P excretion
- Partially replaces some corn, soybean meal, and inorganic phosphate and reduces diet cost
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>
</tr>
</thead>
<tbody>
<tr>
<td>Total P, %</td>
<td>0.78</td>
<td>0.73</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Range 0.62-0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P Availability, %</td>
<td>90</td>
<td>77</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Range 88-92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.70</td>
<td>0.56</td>
<td>0.03</td>
</tr>
</tbody>
</table>
## Diet Composition When 18.8% DDGS and Phytase are Added to a Swine Grower 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>
Quick Calculation of Feed Cost Savings

Thumb rule:

Additions/1000 kg diet

+ 100 kg DDGS \( \times \) ______ $/kg = $_______
+ 1.5 kg limestone \( \times \) ______ $/kg = $_______
TOTAL ADDITIONS (A) ______

Subtractions/1000 kg diet

- 88.5 kg corn \( \times \) ______ $/kg = $_______
- 10 kg SBM (44%) \( \times \) ______ $/kg = $_______
- 3 kg dical. phos. \( \times \) ______ $/kg = $_______
TOTAL SUBTRACTIONS (S) ______

(S – A) = Feed cost savings/ton by adding 10% DDGS to the diet
Current U.S. Dietary DDGS Inclusion Rates and Estimated Usage

- **Grower-finisher diets ~85-90%**
  - 10-40% of the diet

- **Sow diets ~5-10%**
  - Gestation – 10-40% of the diet
  - Lactation - 5-10% of the diet

- **Late nursery diets < 5%**
  - Added at 5-10% of the diet
Maximum Inclusion Rates of Golden High Quality U.S DDGS in Swine Diets

(Based Upon University Trials)

- Nursery pigs (> 7 kg)
  - Up to 30%
- Grow-finish pigs
  - Up to 30%
- Gestating sows
  - Up to 50%
- Lactating sows
  - Up to 30%

Assumptions: no mycotoxins
formulate on a digestible amino acid and available phosphorus basis
Feeding High Quality DDGS to Weaned Pigs
Summary of U.S. University Research Trials

- 7 experiments have been conducted
  - Pigs fed diets containing up to 30% DDGS have resulted in no differences in:
    - ADG
    - ADFI
    - Feed/Gain
      - (feed conversion was improved by adding DDGS in some studies)
Feeding High Quality DDGS to Grower-Finisher Pigs
Summary of Growth Performance Responses from U.S. University Research Trials

- 17 experiments have been conducted to evaluate adding 0–30% DDGS to corn-soybean meal grower-finisher diets

- **ADG**
  - Improved in 1 experiment
  - Not affected in 10 experiments
  - Reduced in 6 experiments

- **ADFI**
  - Improved in 1 experiment
  - Not affected in 10 experiments
  - Reduced in 6 experiments

- **Gain:Feed**
  - Improved in 4 experiments
  - Not affected in 10 experiments
  - Reduced in 3 experiments
**Effect of Formulating G-F Diets on a Digestible Amino Acid Basis, with Increasing Levels of DDGS, on Overall Growth Performance**

<table>
<thead>
<tr>
<th></th>
<th>0% DDGS</th>
<th>10% DDGS</th>
<th>20% DDGS</th>
<th>30% DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial wt., kg</td>
<td>22.5</td>
<td>22.8</td>
<td>22.5</td>
<td>22.5</td>
</tr>
<tr>
<td>Final wt., kg</td>
<td>114</td>
<td>115</td>
<td>114</td>
<td>113</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td>0.92</td>
<td>0.92</td>
<td>0.92</td>
<td>0.91</td>
</tr>
<tr>
<td>ADFI, kg/d&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.57</td>
<td>2.55</td>
<td>2.49</td>
<td>2.46</td>
</tr>
<tr>
<td>F/G&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.79</td>
<td>2.76</td>
<td>2.71</td>
<td>2.70</td>
</tr>
</tbody>
</table>

<sup>a</sup> Linear effect of DDGS level  
Data from 64 pens, 16 pens/treatment (Xu et al., 2007)
Effects of Feeding Increasing Levels of DDGS on Carcass Composition and Pork Quality
Adding Increasing Levels of DDGS to G-F Diets Slightly Reduces Carcass Yield

Xu et al. (2007)
Linear effect (P < 0.01)
Effects of Dietary DDGS Level on Last Rib Backfat

Xu et al. (2007)
30% DDGS tended to be lower than 0% DDGS (P = 0.09)
Effects of Dietary DDGS Level on % Carcass Lean

Xu et al. (2007)
30% DDGS tended to be higher than 0% DDGS (P = 0.11)
Effects of Dietary DDGS Level on Ultimate Muscle pH

![Bar chart showing the effects of different DDGS levels on ultimate muscle pH.](chart.png)

- **0% DDGS**
- **10% DDGS**
- **20% DDGS**
- **30% DDGS**

The chart illustrates the pH levels for muscles with different dietary DDGS levels.
Effects of Increasing Dietary DDGS Level on Loin Characteristics

- Loin firmness was linearly reduced
  - Due to reduced marbling
  - Within accepted U.S. quality standards

- Marbling was linearly reduced
  - Due to trend for reduced backfat
  - Within accepted U.S. quality standards

- Pigs fed the 30% DDGS diets had loins that were slightly less red
  - Within accepted U.S. quality standards

- No overall differences in subjective color score

- No differences in drip loss on day 0, 14, 21, or 28 post-harvest

- No differences in lipid oxidation in loins at 28 days of shelf storage
Effects of Increasing Dietary DDGS Level on Cook Loss and Off Flavor of Pork Loins

No significant differences among dietary treatments.
Effects of Increasing Dietary DDGS Level on Eating Characteristics of Pork Loins

No significant differences among dietary treatments.
Adding Increasing Levels of DDGS to G-F Diets Linearly Reduces Belly Firmness

Effects of Dietary DDGS Level on Belly Firmness

Xu et al. (2007)
Effects of Increasing Dietary DDGS Level on Belly and Backfat Characteristics

- No effect on belly thickness
- No differences in belly fat color
  - Japanese color score
  - Minolta L*, a*, b*
- No differences in backfat color
  - Japanese color score
  - Minolta a*, b*
Effects of Increasing Dietary DDGS Level on Belly and Backfat Characteristics

- Backfat thickness is unaffected, and may be slightly reduced, with increasing dietary levels of DDGS.
- Bellies will be less firm as higher dietary levels of DDGS are fed.
- Belly thickness may or may not be affected by increasing dietary DDGS levels.
- No concern about reduced shelf life and fat oxidation in loins under typical retail storage conditions for at least 28 days.
Does Feeding DDGS Improve Gut Health of Growing Pigs?
Effect of Dietary Treatment on Lesion Length (21 d Post-Challenge)

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

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

* Effect of disease challenge ($P < .01$).
Feeding DDGS to Sows
Producer Perceptions and Observations

- **Perception**
  - DDGS is a risky ingredient because of mycotoxin concerns
    - Has limited DDGS use compared to potential

- **Observations**
  - Increased lactation feed intake
  - Sows are more content
  - Fewer constipation problems
University of Minnesota – Wilson et al. (2003)

- Used 93 sows
  - randomly assigned to 1 of 4 dietary treatment combinations
  - sows remained on dietary treatments through 2 reproductive cycles

- Each dietary treatment combination consisted of both a gestation and lactation diet

  - Corn-SBM Gestation and Corn-SBM Lactation
  - Corn-SBM Gestation and 20% DDGS Lactation
  - 50% DDGS Gestation and Corn-SBM Lactation
  - 50% DDGS Gestation and 20% DDGS Lactation
Effect of Feeding a 50% DDGS Diet on Sow Weight Gain During Gestation

![Bar chart showing weight gain comparison between Control and DDGS dietary treatments.]

- a, b, x, y Different superscripts indicate significant difference (P < .10).
Effect of Feeding 0 or 50% DDGS Gestation Diets and 0 or 20% DDGS Lactation Diets on Pigs Weaned/Litter

Number of Pigs

Dietary treatment

Control/Control  Control/DDGS  DDGS/Control  DDGS/DDGS

a, b, x, y Different superscripts indicate significant difference (P < .10).
Effect of Dietary Treatment Combination on Sow Lactation ADFI

<table>
<thead>
<tr>
<th>Dietary Treatment</th>
<th>Feed Intake, kg/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control/Control</td>
<td>a, xy</td>
</tr>
<tr>
<td>Control/DDGS</td>
<td>b, x</td>
</tr>
<tr>
<td>DDGS/Control</td>
<td>a, y</td>
</tr>
<tr>
<td>DDGS/DDGS</td>
<td>a, xy</td>
</tr>
</tbody>
</table>

Different superscripts indicate significant difference (P < .10).
To determine the effects of increasing levels of DDGS in lactation diets on:

- Sow and litter performance
- Energy and nitrogen balance in sows
- Milk fat and protein concentrations
## Analyzed Nutrient Composition of Experimental Diets

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>10% DDGS</th>
<th>20% DDGS</th>
<th>30% DDGS</th>
<th>30% DDGS HP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein, %</td>
<td>17.81</td>
<td>18.00</td>
<td>17.33</td>
<td>16.99</td>
<td>20.27</td>
</tr>
<tr>
<td>ADF, %</td>
<td>8.94</td>
<td>4.37</td>
<td>5.29</td>
<td>6.98</td>
<td>8.48</td>
</tr>
<tr>
<td>Total calcium, %</td>
<td>0.88</td>
<td>0.88</td>
<td>0.84</td>
<td>0.82</td>
<td>0.76</td>
</tr>
<tr>
<td>Total phosphorus, %</td>
<td>0.81</td>
<td>0.78</td>
<td>0.75</td>
<td>0.74</td>
<td>0.73</td>
</tr>
<tr>
<td>Gross energy, Mcal/kg</td>
<td>3.95</td>
<td>4.03</td>
<td>4.10</td>
<td>4.18</td>
<td>4.02</td>
</tr>
<tr>
<td>Metabolizable energy, Mcal/kg</td>
<td>3.34</td>
<td>3.37</td>
<td>3.51</td>
<td>3.57</td>
<td>3.42</td>
</tr>
</tbody>
</table>

Song et al. (2007)
Genetics and Housing

- Used 307 mixed parity sows
  - Group housed = 147 sows
  - Individual crates = 160 sows

- English Belle, GAP genetics, Winnipeg, MB, Canada
- Average initial weight of about 222 ± 15 kg

Group housing

Individual housing
Effect of Increasing Dietary DDGS Level on Sow ADFI in Lactation

No significant difference (P = 0.10)
Effect of Increasing Dietary DDGS Level on Sow Body Weight Change

a, b Means with different superscripts are significantly different (P < 0.05)
Effect of Increasing Dietary DDGS Level on Litter Size at Weaning

No significant difference (P = 0.31)
Effect of Increasing Dietary DDGS Level on Litter Weight Gain

No significant difference (P = 0.67)
Effect of Increasing Dietary DDGS Level on Average Daily Piglet Weight Gain

10, 20, and 30% DDGS vs. 30% DDGS HP (P < 0.1)
10, 20, and 30% DDGS vs. Control (P < 0.1)
Effect of Increasing Dietary DDGS Level on Wean to Estrus Interval

No significant difference (P = 0.35)
Effect of Increasing Dietary DDGS Level on Pre-Weaning Mortality

No significant difference (P = 0.71)
Effect of Increasing Dietary DDGS Level on Coefficient of Variation of Individual Pig Weight within Litters

No significant difference on Day 0 (P = 0.85) and Day 19 (P = 0.53)
Effect of Increasing Dietary DDGS Level on Metabolizable Energy

No significant difference (P = 0.37)
Effect of Increasing Dietary DDGS Level on Nitrogen Digestibility

No significant difference (P = 0.29)
Effect of Increasing Dietary DDGS Level on Nitrogen Content of Sow Milk

Nitrogen in milk - D0 and D19

No significant difference at Day 0 (P = 0.73) and Day 19 (P=0.41)
Effect of Increasing Dietary DDGS Level on Fat Concentration in Sow Milk

No significant difference on Day 0 (P = 0.99) and Day 19 (P = 0.59)
Conclusion

- Inclusion of up to 30% DDGS in sow lactation diets did not affect:
  - Sow and litter performance
  - Digestible and metabolizable energy
  - Nitrogen retention and digestibility
  - Milk nitrogen and fat concentration
Use of Corn DDGS in Poultry Diets
Benefits and Limitations for Poultry

Benefits

- Good energy and amino acid source when limited to < 15% of the diet
- Source of highly available P
  - Reduce manure P
- May improve egg yolk and skin color (xanthophyll)
- Source of “unidentified growth factors”?
- “Golden” DDGS gives best performance
- Highly palatable

Limitations

- Energy value ~ 84% of corn
- Low protein quality
  - add other supplements high in lys, arg, trp
- Sources high in sodium may increase litter moisture if adjustments to dietary salt levels are not made
Recommended Inclusion Rates of DDGS for Poultry

- Broilers
  - 10% inclusion rates
    - Without energy adjustments
  - > 10%
    - With adjustments for lys, met, thr, trp, and energy

- Chicken Egg Layers
  - 10% inclusion rate
  - > 10%
    - With adjustments for lys, met, thr, trp, and energy
Use of Corn DDGS in Aquaculture Diets
Current Recommendations for Maximum Dietary Inclusion Rates of DDGS for Various Species of Fish

<table>
<thead>
<tr>
<th>Species</th>
<th>% DDGS</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catfish</td>
<td>Up to 30%</td>
<td></td>
</tr>
<tr>
<td>Trout</td>
<td>Up to 15%</td>
<td>Without synthetic lys and met supplementation</td>
</tr>
<tr>
<td>Trout</td>
<td>Up to 22.5%</td>
<td>With synthetic lys and met supplementation</td>
</tr>
<tr>
<td>Salmon</td>
<td>Up to 10%</td>
<td></td>
</tr>
<tr>
<td>Freshwater Prawns</td>
<td>Up to 40%</td>
<td>Can replace some or all of the fish meal in the diet</td>
</tr>
<tr>
<td>Shrimp</td>
<td>Up to 10%</td>
<td>No studies are available but based upon research results with freshwater prawns, a minimum of 10% DDGS in shrimp should be acceptable.</td>
</tr>
<tr>
<td>Tilapia</td>
<td>Up to 35%</td>
<td>Without synthetic lys and supplementation in high protein diets (40% CP)</td>
</tr>
<tr>
<td>Tilapia</td>
<td>Up to 82%</td>
<td>With synthetic lys and trp supplementation in low protein diets (28% CP)</td>
</tr>
</tbody>
</table>
University of Minnesota
DDGS Web Site
www.ddgs.umn.edu

We have developed a DDGS web site featuring:

* nutrient profiles and photos of DDGS samples
* research summaries
  - swine, poultry, dairy, & beef
  - DDGS quality
* presentations given
* links to other DDGS related web sites
* international audiences