The Use of Distiller’s Grains By-products in Livestock and Poultry Diets

Dr. Jerry Shurson
Department of Animal Science
University of Minnesota
The Keys To Increased DDGS Use Are:

- Understanding the value and limitations of DDGS in livestock and poultry feeds
- Overcoming the challenges
DDGS Nutrition

- DDGS is a “package of nutrients”
  - Mid-protein ingredient
    - Like corn, has poor protein quality (amino acid balance) for swine and poultry
  - High fat
  - High available P
    - valuable for monogastrics
    - can result in overfeeding P for ruminants
The Use of DDGS in Dairy Rations
Benefits and Limitations for Lactating Dairy Cows

**Benefits**
- More protein and energy than corn
- Feed at up to 20% of ration dry matter
- Highly digestible fiber source
  - Fewer digestive upsets
  - Can be a partial forage replacement
- “Golden” DDGS gives best performance
- Highly palatable

**Limitations**
- Low protein (lysine) quality
  - add other supplements high in lysine
- Manure P excretion increases at high feeding levels
- No effect on milk fat if adequate forage in the ration
The Use of DDGS in Beef Feedlot Rations
Benefits and Limitations for Finishing Feedlot Cattle

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- More protein and energy than corn</td>
<td>- Need to supplement calcium to achieve proper Ca:P ratio</td>
</tr>
<tr>
<td>- Feed up to 40% of ration dry matter to replace corn</td>
<td>- Avoid urinary calculi</td>
</tr>
<tr>
<td>- Feed excess protein and P</td>
<td>- Manure N and P excretion increases at high feeding levels</td>
</tr>
<tr>
<td>- Highly digestible fiber source</td>
<td>- Monitor sulfur level of water and diet (&lt; 0.4% ration DM)</td>
</tr>
<tr>
<td>- Fewer digestive upsets</td>
<td>- Avoid polioencephalomalacia</td>
</tr>
<tr>
<td>- “Golden” DDGS gives best performance</td>
<td></td>
</tr>
<tr>
<td>- No effect on carcass yield, quality, or eating characteristics of beef</td>
<td></td>
</tr>
</tbody>
</table>
Feeding Value of DDGS for Swine
Benefits and Limitations of Feeding DDGS Diets to Swine

**Benefits**
- Energy value = corn
- High available P
  - Reduce diet P supplementation
  - May reduce manure P excretion
- Partially replaces some corn, soybean meal, and dicalcium phosphate and reduces diet cost
- Commonly fed at 10% of diet
  - Higher levels can be used if amino acids are supplemented
- Only “golden” DDGS should be used
  - High amino acid digestibility
- Appears to reduce gut health problems due to ileitis
- May increase litter size weaned when fed at high levels to sows
- Increases pig weight gain when fed to sows during lactation

**Limitations**
- Low protein (lysine) quality
  - add other supplements high in lysine and tryptophan
- Variability in nutrient content and digestibility among sources
- Manure N excretion increases
- Belly firmness and pork fat quality may be reduced at high dietary inclusion rates
- Fine particle size can contribute to flowability problems in bins and feeders
- Difficult to pellet and maintain throughput of pellet mills
- Mycotoxin free grain should be used to produce ethanol and DDGS
- Short-term feed intake may be reduced when feeding high DDGS diets to sows
Effects of Formulating G-F Diets Containing Increasing Levels of DDGS on a Digestible Amino Acid Basis on Growth Performance and Pork Quality
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., lbs</td>
<td>49.7</td>
<td>50.3</td>
<td>49.7</td>
<td>49.7</td>
</tr>
<tr>
<td>Final wt., lbs</td>
<td>252</td>
<td>253</td>
<td>251</td>
<td>250</td>
</tr>
<tr>
<td>ADG, lbs/d</td>
<td>2.03</td>
<td>2.03</td>
<td>2.03</td>
<td>2.01</td>
</tr>
<tr>
<td>ADFI, lbs/d(^a)</td>
<td>5.66</td>
<td>5.62</td>
<td>5.49</td>
<td>5.42</td>
</tr>
<tr>
<td>F/G(^a)</td>
<td>2.79</td>
<td>2.76</td>
<td>2.71</td>
<td>2.70</td>
</tr>
</tbody>
</table>

\(^a\) Linear effect of DDGS level
Data from 64 pens, 16 pens/treatment (Xu et al., 2007)
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 Increasing Dietary DDGS Level on Fat Stability of Pork Loins (TBARS, mg malonaldehyde/kg)

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

Xu et al. (2007)
Summary of Effects of Feeding DDGS on Pork Quality

- Diets containing 10% DDGS will provide the same ADG as pigs fed typical corn-SBM diets
  - Diets formulated on a total lysine basis
  - Diets formulated on a digestible amino acid basis

- If >10% DDGS is added to G-F diets, diets should be formulated on a digestible amino acid basis to achieve good performance.

- Feed intake may decline with increasing levels of DDGS in the diet
  - Unclear why different studies show different feed intake responses
  - Diets containing >10% DDGS may result in improved feed efficiency
Summary of Effects of Feeding DDGS on Pork Quality

- Carcass yield is slightly linearly reduced with increasing dietary DDGS levels
  - No difference in % lean
  - No difference in backfat
  - May be due to increased viscera weight from increased dietary fiber?

- 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.

- Muscle quality and eating characteristics are generally unaffected by feeding diets containing increasing levels of DDGS
Use of DDGS in Poultry Diets
**Benefits and Limitations for Poultry**

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Good energy and amino acid source when limited to &lt; 15% of the diet</td>
<td>- Energy value ~ 84% of corn</td>
</tr>
<tr>
<td>- Source of highly available P</td>
<td>- Low protein quality</td>
</tr>
<tr>
<td>- Reduce manure P</td>
<td>- add other supplements high in lys, arg, trp</td>
</tr>
<tr>
<td>- May improve egg yolk and skin color (xanthophyll)</td>
<td>- Sources high in sodium may increase litter moisture if adjustments to dietary salt levels are not made</td>
</tr>
<tr>
<td>- Source of “unidentified growth factors”?</td>
<td></td>
</tr>
<tr>
<td>- “Golden” DDGS gives best performance</td>
<td></td>
</tr>
<tr>
<td>- Highly palatable</td>
<td></td>
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</tbody>
</table>
Relative Value of DDGS Differs Depending on Species

<table>
<thead>
<tr>
<th>Feed</th>
<th>Dollars/ ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy Lactation</td>
<td>$114.24</td>
</tr>
<tr>
<td>Poultry Finisher</td>
<td>$100.09</td>
</tr>
<tr>
<td>Layer Diet</td>
<td>$104.66</td>
</tr>
<tr>
<td>Swine G-F Diet</td>
<td>$96.34</td>
</tr>
<tr>
<td>Beef Feedlot</td>
<td>$108.00</td>
</tr>
</tbody>
</table>

Assumptions:
- Corn $2.00 / bu
- SBM $175.00 / ton
- Urea $360.00 / ton
- Non-ruminant diets corn/SBM
- Ruminant diets typical diets with competing by-products.

Source: Tilstra, Land O’ Lakes
Nutritionists make the decisions on feed ingredient use

- Decisions are based on:
  - Price relative to competing ingredients
    - Corn
    - Soybean meal
    - Dicalcium phosphate
  - Consistency of supply
  - Ability to source and manage quality
  - Physical characteristics
    - Particle size and flowability
    - Bulk density
    - Ability to pellet
  - Risk of mycotoxins
  - Product consistency/variability
What Are the Issues/Challenges?

1. By-product variability
   a. nutrient content
   b. nutrient digestibility
   c. physical characteristics

2. Feeding value of new corn distiller’s by-products

3. Lack of a quality grading system
   a. difficult sourcing to obtain desired quality and price

4. Lack of standardized testing procedures

5. Need for quality management and certification

6. Need a high degree of
   a. research
   b. education
   c. technical support

7. Presence of quality contaminants?
1. By-Product Variability

- Nutrient content
- Nutrient digestibility
  - Color (amino acid digestibility)
- Physical characteristics
  - Particle size
  - Bulk density
### Averages, Coefficients of Variation, and Ranges of Selected Nutrients Among 32 U.S. DDGS Sources (100% Dry Matter Basis)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Average</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter, %</td>
<td>89.3</td>
<td>87.3 – 92.4</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>30.9 (4.7)</td>
<td>28.7 – 32.9</td>
</tr>
<tr>
<td>Crude fat, %</td>
<td>10.7 (16.4)</td>
<td>8.8 – 12.4</td>
</tr>
<tr>
<td>Crude fiber, %</td>
<td>7.2 (18.0)</td>
<td>5.4 – 10.4</td>
</tr>
<tr>
<td>Ash, %</td>
<td>6.0 (26.6)</td>
<td>3.0 – 9.8</td>
</tr>
<tr>
<td>Swine ME, kcal/kg</td>
<td>3810 (3.5)</td>
<td>3504 – 4048</td>
</tr>
<tr>
<td>Lysine, %</td>
<td>0.90 (11.4)</td>
<td>0.61 – 1.06</td>
</tr>
<tr>
<td>Phosphorus, %</td>
<td>0.75 (19.4)</td>
<td>0.42 – 0.99</td>
</tr>
</tbody>
</table>
DDGS Varies Nutrient Content and Digestibility, Color, and Particle Size Among U.S. Sources
Fig. 1. Regression of digestible lys (%) and color (L*, b*)

Source: Dr. Sally Noll (2003)
Prediction of Digestible Lysine from Front Face Fluorescence in DDGS

Predicted Dig-Lys, %

Digestible Lys, %

$R^2 = 99.9$

Adj $R^2 = 99.3$

RMSE = 0.009

PC = 30
Variation in Particle Size Among DDGS Samples Representing 25 U.S. Ethanol Plants
1/05
Variation in Bulk Density (Lbs/Cubic Ft.) Among DDGS Samples Representing 25 U.S. Ethanol Plants

1/05
2. Understanding new corn distiller’s by-products
Comparison of Nutrient Content of Dakota Gold DDGS with High Protein Dakota Gold and Corn Protein Concentrate (100% DM Basis)
Comparison of Amino Acid Content of Dakota Gold DDGS with High Protein Dakota Gold and Corn Protein Concentrate (100% DM Basis)
Comparison of Mineral Content of Dakota Gold DDGS with High Protein Dakota Gold and Corn Protein Concentrate (100% DM Basis)
Opportunity Costs of Corn By-Products in Swine and Poultry Diets

<table>
<thead>
<tr>
<th></th>
<th>DDGS Spec. 1</th>
<th>DDGS Spec. 2</th>
<th>HP DDGS</th>
<th>CPC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Swine</strong></td>
<td>$80.00</td>
<td>$78.00</td>
<td>$51.00</td>
<td>$61.60</td>
</tr>
<tr>
<td><strong>Poultry</strong></td>
<td>$80.00</td>
<td>$75.20</td>
<td>$53.00</td>
<td>$43.00</td>
</tr>
</tbody>
</table>
Product Flowability

- Particle size is sometimes too fine
- Difficult and costly to pellet
- Minimal cooling or “curing” time before loading
  - Extensive damage to trucks and rail cars
3. Lack of a Quality Grading System

- Difficult for buyers to differentiate quality and price

- Can be as much as $20-$30/ton price differential due to quality in the market

- “What you want isn’t always what you get”
Some of the Nutrient Variability is Due to the Use of Different Approved Laboratory Testing Procedures
4. Lack of Standardized Testing Procedures

- Different labs may use different procedures
  - variable results

- No referee laboratories have been established
### Variability of Moisture Content from One DDGS Source Using Approved AOAC Lab Procedures

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure 1</td>
<td>12.69</td>
</tr>
<tr>
<td>Procedure 2</td>
<td>10.48</td>
</tr>
<tr>
<td>Procedure 3</td>
<td>10.09</td>
</tr>
<tr>
<td>Procedure 4</td>
<td>10.64</td>
</tr>
<tr>
<td>Procedure 5</td>
<td>13.30</td>
</tr>
<tr>
<td>Procedure 6</td>
<td>12.60</td>
</tr>
</tbody>
</table>
5. Need for Quality Management and Certification

- Paradigm shift in parts of the ethanol industry toward improved DDGS quality and consistency
  - Implementation of DDGS Quality Assurance Programs
    - Many commercial feed mills are ISO 9000:2001 and HAACP Certified
    - EU – International Feed Ingredient Standard
      - GMP Certification
  - Transparency of information about the by-products produced
  - Aggressive sampling and nutrient analysis
Lysine Monitoring - Big River Resources
1/11/05 – 3/6/06 (100% DM Basis)
6. Need a High Degree of Research, Education, and Technical Support

- Additional research is needed to improve DDGS acceptance in the feed industry

- High degree of education and technical support is required in the market place
7. Quality Contaminants??

- Antimicrobials in ethanol production
  - Used to control bacterial (lactobacillus) contamination
  - Can increase ethanol yield by as much as 25%
  - Which ones are used?
    - Virginiamycin (0.25 to 2.0 ppm)
    - Penicillin (1 g/1000 liters)
  - Unique compared to forms used in animal feeds
7. Quality Contaminants??

- Antimicrobials in ethanol production
  - Virginiamycin
    - Does not affect yeast productivity
    - Does not remain in ethanol after distillation
    - Is destroyed at temperatures > 93° C
    - Dryer temperatures range from 93 to 232° C
    - Is destroyed and there are no detectable residues in DDGS
7. Quality Contaminants??

- Antimicrobials in ethanol production
  - Penicillin
    - Most stable at pH 6.0 to 6.4
    - Half life of 14 days when in solution at 24° C
    - Easily inactivated by primary alcohols and some sugars
    - At pH of 4.5 or 9.0, rate of inactivation increases 10-fold
    - At pH 3.2 or 10.5, rate of inactivation increases 100-fold
    - Completely degraded at pH 3 and a temperature of 37° C for 30 minutes
    - No residues in DDGS
7. Quality Contaminants??

- Mycotoxins
  - If contaminated corn is used, concentrations of mycotoxins are concentrated 3x in DDGS
  - ELISA tests for mycotoxins may give false positive results

- Sulfur levels
  - Range from 0.31 to 1.93%
  - Variation partially due to use of sulfuric acid to clean fermenters
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