The Ethanol Industry, Dried Distiller’s Grains with Solubles (DDGS), and Their Impact on Pork Production

Dr. Jerry Shurson
Department of Animal Science
University of Minnesota
U.S. Ethanol Plants
AS OF: June 2006

- In operation: 102 plants, 4.75 bgy
- Construction: 32 plants, 2.03 bgy
- Proposed: 127 plants, 8.21 bgy
Projected Ethanol Production (Billion gallons) and Corn Required (Billion bu.) from 2007-2011 (FAPRI, 2006)
Projected % of U.S. Corn Crop Used to Produce Ethanol and the Amount of By-Product Feeds Produced (million tons) 2007-2011 (FAPRI, 2006)
North American DDGS Production

Source: Sean Broderick, Commodity Specialists Company
# Theoretical Potential of Distiller’s By-Product Use in the U.S. Livestock and Poultry Industries (Cooper, 2006)

<table>
<thead>
<tr>
<th>Species (% of Total)</th>
<th>Maximum Dietary Inclusion Rate, %</th>
<th>50% Market Penetration</th>
<th>75% Market Penetration</th>
<th>100 % Market Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy (10.3)</td>
<td>20</td>
<td>1,887</td>
<td>2,831</td>
<td>3,774</td>
</tr>
<tr>
<td>Beef (50.2)</td>
<td>40</td>
<td>9,176</td>
<td>13,764</td>
<td>18,352</td>
</tr>
<tr>
<td>Pork (23.7)</td>
<td>20</td>
<td>4,348</td>
<td>6,521</td>
<td>8,695</td>
</tr>
<tr>
<td>Poultry (15.7)</td>
<td>10</td>
<td>2,877</td>
<td>4,315</td>
<td>5,754</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>18,288</td>
<td>27,431</td>
<td>36,575</td>
</tr>
</tbody>
</table>
Relative Value of DDGS Differs Depending on Species

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.

<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>

Source: Tilstra, Land O’ Lakes
Quick Calculation of Feed Cost Savings

Thumb rule:

Additions/1000 kg diet

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

Subtractions/1000 kg diet

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

(S – A) = Feed cost savings/ton by adding 10% DDGS to the diet
USDA historical wholesale prices for DDGS ($/short ton) compared to monthly average closing prices of near-month corn and soybean meal futures from the CBT.

Soybean Meal, Corn, and DDGS Historical Prices
Implications for Corn Prices

- Increased demand for corn is expected to:
  - Increase corn prices
  - Increase corn acres

- Long run price impact will depend on
  - Price of oil and energy value of ethanol
  - Timing and cost efficiency of converting biomass to ethanol
  - Inclusion rates of by-product feeds in livestock diets

- Short term price impact could be significant
  - Weather induced shortages
  - Mismatch of acres and ethanol plants
Barriers Limiting DDGS Use in Swine Diets

- Variability in nutrient content and digestibility
- Small particle size and flowability problems for some DDGS sources
- Perceived risk of mycotoxins (sows)
- Ability to pellet DDGS diets
  - High quality pellet
  - Maintain throughput of mill
DDGS Varies in Nutrient Content and Digestibility, Color, and Particle Size Among U.S. Sources
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>
Barriers Limiting DDGS Use in Swine Diets

- Understanding and managing implications of feeding DDGS diets on pork fat quality
- Inconsistent feed intake responses with increasing levels of DDGS in the diet
- *In vitro* procedures to estimate amino acid digestibility among DDGS sources
  - Fast
  - Accurate
  - Inexpensive
- Net energy values of DDGS sources need to be determined
Use of DDGS in Swine Diets
Estimated DDGS Usage in U.S. Swine Feeds 2001-2006 (Metric Tonnes)
Current Commercial Dietary DDGS Inclusion Rates and Estimated Usage

- Grower-finisher diets ~85-90%
  - 10-15% dietary inclusion rates

- Sow diets ~5-10%
  - Gestation - up to 30% dietary inclusion
  - 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 of Minnesota Performance Trials)

- Nursery pigs (> 7 kg)
  - Up to 25%
- 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
Standardized Ileal Lysine Digestibility Coefficients Among 10 “Golden” Corn DDGS Sources (Stein et al, 2005)
Fig. 1. Regression of digestible lys (%) and color (L*, b*)

Source: Dr. Sally Noll (2003)
# Benefits and Limitations for Swine

## Benefits
- Energy value = corn
- High available P
  - Reduce diet P supplementation
  - Reduce manure P excretion
- Commonly fed at 10% of diet
  - Higher levels can be used if amino acids are supplemented
- Appears to reduce gut health problems due to ileitis
- May increase litter size weaned and pig weaning weights when fed at high levels to sows

## Limitations
- Low protein (lysine) quality
  - add other supplements high in lys and trp
- Manure N excretion increases
- Belly firmness and pork fat quality may be reduced when > 20% in the diet
- Mycotoxin free grain should be used to produce ethanol and DDGS
- Short-term feed intake may be reduced when transitioning from a corn-SBM diet to high DDGS diets for sows
Effect 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., kg</td>
<td>21.9</td>
<td>22.3</td>
<td>22.0</td>
<td>22.0</td>
</tr>
<tr>
<td>Final wt., kg</td>
<td>115.0</td>
<td>115.6</td>
<td>114.8</td>
<td>114.2</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, unpublished)
Adding Increasing Levels of DDGS to G-F Diets Slightly Reduces Carcass Yield

Xu et al. (2007) unpublished
Linear effect (P < 0.01)
Xu et al. (2007) unpublished
30% DDGS tended to be lower than 0% DDGS (P = 0.09)
Effects of Dietary DDGS Level on % Carcass Lean

Xu et al. (2006) unpublished
30% DDGS tended to be higher than 0% DDGS (P = 0.11)
Effects of Increasing Dietary DDGS Level on Loin Characteristics

- No effect on ultimate pH
- Loin firmness was linearly reduced but still acceptable
  - Due to reduced marbling
- Marbling was linearly reduced
  - Within NPPC acceptable range (2-4%)
  - Due to trend for reduced backfat
- Pigs fed the 30% DDGS diets had loins that were slightly less red
- 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 Fat Stability of Pork Loins (TBARS, mg malonaldehyde/kg)

No significant differences among dietary treatments. Values < 0.5 mg malonaldehyde/kg indicate minimal lipid oxidation.
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. (2006) unpublished
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*

- Backfat was slightly darker (lower L*) for pigs fed the 20% and 30% DDGS diets

- No differences in backfat color
  - Japanese color score
  - Minolta a*, b*
Take Home Messages

- Continued rapid growth of the North American ethanol industry will:
  - Increase demand for corn (and other grains)
  - Increase corn price
  - Reduce corn availability
  - Require livestock and poultry producers to find less expensive alternative feed ingredients
  - Require increased use of DDGS in all livestock and poultry sectors

- Barriers for increased DDGS use must be overcome
  - Variability
  - Flowability problems
  - Implementation of quality assurance programs in DDGS production
  - Pelleting issues
  - Understanding and managing impacts of growth performance and pork quality
Take Home Messages

- Adding 10% DDGS to swine diets:
  - Does not affect growth performance
  - Does not affect reproductive performance
  - Does not affect carcass or pork quality
  - May reduce manure P excretion
  - May reduce diet cost
  - May reduce gut health problems in growing pigs

- Adding > 10% DDGS to swine diets:
  - Requires more careful attention to diet formulation
  - May affect feed intake under certain conditions
  - Reduces carcass yield
  - Reduces belly firmness
  - Does not affect pork eating characteristics or shelf-life
  - Will increase manure nitrogen excretion
  - May increase litter size and pig weaning weights
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