Feeding Pigs In a Biofuels World; Products and Strategies to Consider

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Nutrition and Production Consultant
First Choice Livestock, LLC

Agenda

- Current Situation
- Current Options
  - Value of Fat
  - Use of Crystalline Amino Acids
  - Use of Phytase
  - Use of DDGS
  - Use of Glycerin
  - Thanks to Dr. Brian Kerr, USDA-ARS

Future Options

- Corn Fractionation Technologies
  - Dakota Gold BFRAC™
    - Thanks to Dr. Matt Gibson, Poet Nutrition
  - Renessen Ecorn
    - Thanks to Matt Wolfe, Cargill Animal Nutrition
- Enzyme Technologies
  - Corn, Soy and DDGS Enzymes
    - Thanks to Dr. Dave Hall, ADM Alliance Nutrition

Today's Situation

The biofuels boom has increased the demand for corn and fat and decreased the supply of soybeans.
As energy costs have increased, the cost of all ingredients has increased.
Cost of feeding a pig wean to finish has increased over $35/head to nearly $80 in the last 3 years.

Value of Fat in Swine Diets

Trial consisting of moderate fat levels early w/ decreasing levels in late finishing vs high levels throughout growth phase

<table>
<thead>
<tr>
<th>Phase</th>
<th>St. Wt., lb</th>
<th>Fat lb 1</th>
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<tbody>
<tr>
<td>Ph 4</td>
<td>47</td>
<td>58</td>
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<td>Ph 5</td>
<td>90</td>
<td>53</td>
<td>132</td>
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<td>Ph 6</td>
<td>140</td>
<td>32</td>
<td>112</td>
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<td>Ph 7</td>
<td>180</td>
<td>6</td>
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<td>Ph 8</td>
<td>225</td>
<td>0</td>
<td>80</td>
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</table>

Pig weight and feed conversion measured as a response criteria

Pig Average Daily Gain

* P<.07
**Value of Fat**
- Depends on sale weight opportunity and space availability
- Feed cost of high fat ration is $5.93 more if pigs are fed to same day of age. Extra sale weight of 17 lbs is worth $7.65.
  - Net value of fat = $1.72/pig
- If barn availability is loose, and you can let low fat pigs grow to equal weight, 17 lbs = 9 days at no cost and added feed cost to get these pigs to same weight is $5.63.
  - Net value of fat = -$0.30/pig

**Crystalline Amino Acids**
- Crystalline lysine, methionine, and threonine are widely available and used in livestock diets
- Can replace significant soybean meal in diets
- Must formulate to the ideal amino acid pattern
- Growing a pig is like building a house, must have proper amount of each building material or can’t effectively use any of it

**Crystalline Amino Acids**
- Need proper ratio of 10, 8 and 6 ft 2x6’s or you can’t build the house
- Similarly, need proper ratio of lysine, methionine, threonine, tryptophan and isoleusine or you can’t build protein that makes muscle and organs
- Ideal ratio changes as pig grows due to changes in types of proteins deposited
Impact of Crystalline Amino Acid Use on Pig ADG

ADG and FG not affected by synthetic lysine usage up to 8.5 lb/ton in early grower and 4 lb/ton in late finisher.
Threonine, methionine, and tryptophan must be balanced relative to lysine.
Value of amino acid usage at today's cost is $0.85/pig.

Value of Phytase

Over 80% of the phosphorus in corn and 60% of the phosphorus in SBM is an indigestible phytate form.
Digestibility can be increased 50% to 70% with use of a phytase enzyme.
Phytase sources of various fungal and bacterial origins are now widely available.
Value of $1.70/pig vs no phytase.

Current DDGS Strategy

DDGS used from 25 lb to market in some flows.
Philosophy is that DDGS will only be used where feed cost savings is > $1.00/ton due to risk of mycotoxin contamination & ingredient variability.
Formulation method utilized NDF maximum based on size of pig. Loosely based on data from Turlington et al. showing that mid-wt pigs utilize fiber well up to 12% NDF, then next incremental amount decreased total digestability significantly.
DDGS Trial Details
- 10 reps of 30 pigs per pen
- Diets formulation to be iso-caloric, iso-lysineic, and to contain similar minimum ratios of threonine, methionine, and tryptophan to lysine
- Pig weight and feed conversion as a response criteria

DDGS Trial Design
- Four Dietary Treatments
  - No DDGS Control
  - 50% of Current Level
  - Current Max NDF Inclusion
  - 150% of Current Level
- All Diets Iso-energetic and Iso-Lysineic based on Current Loadings

Ingredient Nutrient Loadings

<table>
<thead>
<tr>
<th></th>
<th>DDGS</th>
<th>Com</th>
<th>SBM</th>
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<tbody>
<tr>
<td>ME/ % of Com</td>
<td>1488</td>
<td>1550</td>
<td>1395</td>
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<tr>
<td>NDF</td>
<td>38.37</td>
<td>9.60</td>
<td>8.90</td>
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<tr>
<td>Lysine</td>
<td>7.3</td>
<td>2.5</td>
<td>3.04</td>
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<tr>
<td>Avail Lys</td>
<td>387</td>
<td>166</td>
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<tr>
<td>Avail TSAA/Ratio</td>
<td>573/1.48</td>
<td>261/1.57</td>
<td>1.13/43</td>
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<tr>
<td>Avail Thr/Ratio</td>
<td>346/1.41</td>
<td>196/1.18</td>
<td>1.43/55</td>
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<tr>
<td>Avail Trp/Ratio</td>
<td>132/34</td>
<td>936/22</td>
<td>53.20</td>
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<tr>
<td>Avail P</td>
<td>704</td>
<td>94</td>
<td>28</td>
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Trial DDGS Levels

Trial NDF Levels

Pig Average Daily Feed Intake

'a Linear P<.10  
b Linear P<.01
Trial Conclusions

- DDGS levels up to 150 lbs in early grower and 475 lbs in late finishing had no effect on growth rate and improved feed efficiency.
- It appears that the new generation DDGS had an energy value greater than 96% the value of corn.
- Higher levels may be possible since plateau was not reached in this study.
- At these levels would use approximately 100 lb per pig.
- This would result in 5,000,000 tons of product used with 100% market share.

Summary of Proximate Values

<table>
<thead>
<tr>
<th></th>
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<th>Mean</th>
<th>Stdev</th>
<th>CV</th>
<th>Range</th>
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<td>Moisture</td>
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<td>10.1</td>
<td>1.7</td>
<td>16.9</td>
<td>6.9 - 14.7</td>
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<td>150</td>
<td>26.1</td>
<td>2.3</td>
<td>8.9</td>
<td>20.2 - 31.0</td>
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<tr>
<td>Fat</td>
<td>150</td>
<td>9.9</td>
<td>2.8</td>
<td>28.3</td>
<td>3.0 - 13.8</td>
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<tr>
<td>Fiber</td>
<td>150</td>
<td>6.3</td>
<td>1.6</td>
<td>24.5</td>
<td>4.7 - 23.1</td>
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<tr>
<td>LYS</td>
<td>158</td>
<td>0.71</td>
<td>0.17</td>
<td>24.5</td>
<td>0.10 - 1.07</td>
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</table>

Summary of Digestible Amino Acid Values (Swine)

<table>
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<tr>
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<th>Mean</th>
<th>Stdev</th>
<th>CV</th>
<th>Range</th>
</tr>
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<tbody>
<tr>
<td>ARG</td>
<td>14</td>
<td>79 (72)*</td>
<td>4.6</td>
<td>5.9</td>
<td>78 – 92</td>
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<tr>
<td>CYS</td>
<td>14</td>
<td>73 (57)</td>
<td>5.5</td>
<td>7.5</td>
<td>65 - 85</td>
</tr>
<tr>
<td>ILE</td>
<td>14</td>
<td>73 (66)</td>
<td>5.4</td>
<td>7.4</td>
<td>72 – 88</td>
</tr>
<tr>
<td>LEU</td>
<td>14</td>
<td>82 (76)</td>
<td>4.7</td>
<td>5.8</td>
<td>82 – 99</td>
</tr>
<tr>
<td>LYS</td>
<td>14</td>
<td>60 (47)</td>
<td>8.7</td>
<td>14.5</td>
<td>35 – 84</td>
</tr>
<tr>
<td>MET</td>
<td>14</td>
<td>81 (72)</td>
<td>4.6</td>
<td>5.7</td>
<td>79 – 90</td>
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<tr>
<td>THR</td>
<td>14</td>
<td>70 (55)</td>
<td>7.1</td>
<td>10.0</td>
<td>66 – 83</td>
</tr>
<tr>
<td>TRP</td>
<td>14</td>
<td>73 (50)</td>
<td>10.8</td>
<td>14.9</td>
<td>73 – 95</td>
</tr>
<tr>
<td>VAL</td>
<td>14</td>
<td>72 (63)</td>
<td>5.4</td>
<td>7.5</td>
<td>75 - 89</td>
</tr>
</tbody>
</table>

* Values in parenthesis () refer to NRC digestible values for swine.
**Variability Conclusions**
- Large variation with-in and between plants in proximate analysis and amino acid digestibility
- Variation makes it difficult to formulate predictably
- Reasons for variation?
  - Variability of incoming ingredients (corn)
  - Variability of solubles added
  - Variability in drying process
- Novus Idea Test may provide tool for guaranteeing digestibility

**Mycotoxin Concerns**
- Mycotoxins concentrated 3 fold by fermentation with no de-activation
- Mycotoxins cause large productivity losses, especially in sows
- This threat limits use in grow-finish pigs and minimizes use in sows

**Pork Fat Quality Concerns**
- For the pig, “you are what you eat”
- High levels of unsaturated fatty acids cause soft pork
- Problem magnified in modern high-lean pigs
- Significant problem with bacon slice-ability
- Limits use in many integrated swine operations

**The Biodiesel Reaction**
\[
\begin{align*}
\text{CH}_3\text{COOR}^* & \quad \text{+ ROH} \\
\text{CH}_3\text{COOR}^* & \quad \text{NaOH} \\
\text{CH}_3\text{COOR} & \quad \text{NaOH}
\end{align*}
\]

**Estimated US Biodiesel Sales**

Mark Bertram, 2008 Iowa Pork Regional Conferences
Glycerin in Swine Diets

- Mourot et al., 1994 (Livest. Prod. Sci. 38:237-244)
  - Crude glycerol (Cl-free) 0 or 5% of the diet to 36 to 102 kg pigs. (10 pigs/treatment)
  - No effect on growth performance (slight drop in gain and feed efficiency), carcass characteristics, or plasma glycerol.
  - Drip loss was reduced by 0.51% units while cooking loss was reduced by 3.8% units due to glycerol supplementation. (No change in SM pH.)
  - Glycerol did not affect total lipid content of BF, SM, or liver tissue.
  - Glycerol increased the proportion of oleic acid (18:1) in the BF at the expense of linoleic (18:2) and linolenic (18:3) acids, and consequently decreased the unsaturation index of fat.

- Glycerol in Swine Diets

  - Pigs from 26.9 to 99.3 kg were fed diets containing 0 or 10% glycerol.
  - No change in pig performance due to dietary glycerol.
  - Small numerical changes in: ↓% muscle, ↑BF, ↑pH, ↑flesh color, and ↑marbling.
  - There was no change in total unsaturated FA in pigs fed glycerol.
  - Reduced incorporation of polyenic acids relative to other unsaturated FA (oleic increased, albeit not significant).

- Glycerol in Swine Diets

- Bartlet and Schneider / UFOP-Schriften Heft 17, 2002, pp. 15-36
  - Pigs weighing 34 kg were fed 0, 5, 10, and 15% pure glycerol.
  - Wheat, barley, SBM, corn starch based diet.
  - Prececal digestibility of glycerol was marginally affected.
  - 99.3, 98.5, and 97.6% for 5, 10, and 15% glycerol, respectively.
  - A decrease in the ME of glycerol as the level increased.
  - 4177, 3436, and 2524 kcal/kg for 5, 10, and 15% pure glycerol, respectively.

Energy Determination in Swine

- Pigs adapted to metabolism cages, dietary treatments, and feeding regimens for 10 d prior to initiation of collection.
- Total fecal and aliquot urinary collection for 6 d.
- Pigs fed on a graded scale relative to crude glycerin consumption.
- Energy determination of feces and urine by bomb calorimetry.
- 86.95% glycerin, 9.63% water, 0.028% methanol, 3.13% NaCl, 0.29% total FA

Apparent ME of crude glycerol fed to starter pigs

\[
y = -21208x^2 + 20131x - 3383.1 \\
R^2 = 0.8669
\]

- 0-10%: 3463 kcal/kg
- 10%: 3239
- 20%: 2579

Initial body weight 11.0 ± 0.5 kg

Mark Bertram, 2008 Iowa Pork Regional Conferences
**Crude Glycerin ME summary – Swine**

- E1 (11.0 – 15.9 kg, 24 ♂) (0-3164 basal ME & 5, 10%): 3,463 kcal/kg
- E3 (8.6 – 11.2 kg, 24 ♂) (0-3211 basal ME & 10%): 3,177 kcal/kg
- E4 (11.3 – 13.3 kg, 24 ♂) (0-3247 basal ME & 10%): 3,544 kcal/kg
- E2 (109.2 – 125.4 kg, 24 ♀) (0-3175 basal ME, 5, 10, & 20%): 3,088 kcal/kg
- E5 (99.9 – 102.7 kg, 24 ♀) (0-3254 basal ME & 10%): 3,352 kcal/kg

\[ y = 3206.5x + 73.443 \]
\[ R^2 = 0.9991 \]

**Evaluation of Crude Glycerin in GF Pigs**

- Pigs (96) allotted to pens based on body weight and gender.
- Corn-SBM diets supplemented with 0, 5, and 10% crude glycerol.
- Pigs allowed free access to feed and water.
- 84.51% glycerol, 12.24% water, 0.318% methanol, 2.93% NaCl, 0% total FA.
- Pig performance, carcass composition, and meat quality assessment.

**Glycerol in Swine Diet**

- **Concerns**
  - Shipping cost: Liquid ingredient 10-12% H2O
  - Need heated liquid tank for mill application
  - Other compounds in product may limit use
- **Conclusions**
  - Glycerol provides a highly available energy source for pigs and poultry
  - Energy 1450 – 1500 kcal/lb or roughly equivalent to corn
  - Supplementation up to 10% has little to no impact on performance, carcass composition, or meat quality

**Bio-refinery Concept**

- Generally, “Up-Front” Corn Processing (Pre-Fermentation)
Broin Process Flow:
Ingredient Origin*

Whole Corn
FF Germ (Corn Germ Dehydrated)
Bran Endosperm
Dakota Gold® HP™ (Improved DDG)
CCDS
Dakota Germ™ (Corn Germ Dehydrated)

Bio-Refining Products
Nutrient Profiles*

<table>
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<tr>
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<th>DG-HP</th>
<th>CGD</th>
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<td>CP</td>
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<td>EE</td>
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<td>20.2</td>
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<tr>
<td>LYS</td>
<td>1.43</td>
<td>0.84</td>
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<td>MET</td>
<td>1.21</td>
<td>0.31</td>
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<tr>
<td>THR</td>
<td>1.64</td>
<td>0.60</td>
</tr>
<tr>
<td>Phos</td>
<td>0.54</td>
<td>1.66</td>
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* Selected Nutrients
Complete Profile available

Energy Nutrition¹
ME-S Values, kcal/kg²

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>NRC</th>
<th>DGRA</th>
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<tbody>
<tr>
<td>Corn</td>
<td>3,842</td>
<td>3,864</td>
</tr>
<tr>
<td>DDG/S</td>
<td>3,032</td>
<td>3,940</td>
</tr>
<tr>
<td>Dakota Gold HP</td>
<td>-</td>
<td>4,049</td>
</tr>
<tr>
<td>Corn Germ Dehy</td>
<td>-</td>
<td>4,540</td>
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¹ U MO
² DMB

Other Processes
In Start-up Phase

Solaris™ Products*
- ProBran™
- NutraFiber™
- Germ
- Energia™
- Glutenol™
- Glutenol XP™

* from HydroMilling™ process
www.QTITech.com
www.CornVP.com

HydroMilling™
Phase I

Ethanol
CO₂
Fermentation
Centrifuge
Corn
Germ
Energia™

HydroMilling™
Phase II

Ethanol
CO₂
Fermentation
Centrifuge
Corn
Germ
NutraFiber™
Solubles
Glutenol XP™
ProBran™
Glutenol™
Energia™

Mark Bertram, 2008 Iowa Pork Regional Conferences
HydroMilling™
Ingredient Nutrients*

<table>
<thead>
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<th>CP</th>
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<th>Fiber</th>
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<td>97</td>
<td>17.5</td>
<td>45.0</td>
<td>6.0</td>
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<td>NutraFiber™</td>
<td>90</td>
<td>6.8</td>
<td>1.5</td>
<td>17.1</td>
</tr>
<tr>
<td>ProBran™</td>
<td>90</td>
<td>9.5</td>
<td>2.0</td>
<td>16.0</td>
</tr>
<tr>
<td>Glutenol™</td>
<td>90</td>
<td>45.0</td>
<td>3.3</td>
<td>3.8</td>
</tr>
<tr>
<td>Energia™</td>
<td>90</td>
<td>30.0</td>
<td>2.5</td>
<td>8.2</td>
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* from Pilot Plant Tests

“Oil from Syrup”

Use of Oil
- Bio-diesel (probably...?)
  - Crude
  - Post-Fermentation
Nutrition Issues
- Lower Fat DDG/S
  - 11% → 5%
  - Energy will be lower

EXTRAX™
processing system

The food, feed, and biofuels industries all benefit from the Extrax™ process

Carcass results (backfat, % lean, yield) are comparable between Ecorn™ and controls
Fat iodine values are lowered in Ecorn™ fed pigs

Trial Results
- Conducted 13 commercial trials involving 23,000+ head
- Ecorn™ replaces 100% of the corn in a swine grower finisher ration and achieves similar performance (ADG, ADFI, F:G)
- Carcass results (backfat, % lean, yield) are comparable between Ecorn™ and controls
- Fat iodine values are lowered in Ecorn™ fed pigs

Formulation

- Ecorn™ replaces all of the corn in a grow-finish ration, 25% of the SBM, and 25% of added phosphorus

Example Diets

<table>
<thead>
<tr>
<th></th>
<th>100% Ecorn™</th>
<th>Control</th>
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<tr>
<td>Corn</td>
<td>1490.0</td>
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<tr>
<td>Ecorn™</td>
<td>352.4</td>
<td>434.6</td>
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<tr>
<td>SBM</td>
<td>104.6</td>
<td>84.0</td>
</tr>
<tr>
<td>Fat</td>
<td>9.4</td>
<td>12.0</td>
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Licensing

- Renessen will offer a limited number of licenses for the Extrax™ technology
- Multiple ways to participate
  - Ecorn™ off take agreements
  - Ownership share in Extrax™ facility
  - Purchase of Ecorn™
  - Ethanol plant ownership of Extrax™ enabled facility
The need of exogenous enzyme

- NSP (non-starch, non-digestible polysaccharides)
  - Retards endogenous enzyme access to feed nutrients.
  - Inhibits absorption of digested nutrients.
  - Leads to imprecise matching of nutrient specifications to diet specifications (AME variability).
  - Retards uniformity of animal performance.
  - And...
    - High osmolarity (osmotic pressure)
    - Low convensional mobility
    - Low hydrolysis
    - Fast intestinal feed passage

Effect of Endonase (in vitro ileal digesta)

<table>
<thead>
<tr>
<th></th>
<th>Corn soy</th>
<th>DDGS</th>
<th>Wheat midds</th>
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<td>62.8</td>
<td>57.9</td>
<td>55.9</td>
</tr>
<tr>
<td>Endonase P&lt;.05</td>
<td>64.5</td>
<td>58.8</td>
<td>60.8</td>
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ADM Trials S03601 & S03602

Effect of Endo-Power β

<table>
<thead>
<tr>
<th></th>
<th>Com-Soy</th>
<th>CS+0.01% Endo-Power β</th>
<th>CS+0.02% Endo-Power β</th>
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<tbody>
<tr>
<td>Initial weight, lb</td>
<td>13.8</td>
<td>13.9</td>
<td>13.8</td>
</tr>
<tr>
<td>Final weight, lb</td>
<td>41.8</td>
<td>42.0</td>
<td>42.1</td>
</tr>
<tr>
<td>ADG, lb</td>
<td>0.80</td>
<td>0.80</td>
<td>0.81</td>
</tr>
<tr>
<td>Feed/Gain*</td>
<td>1.74</td>
<td>1.63</td>
<td>1.67</td>
</tr>
</tbody>
</table>

Kim et al., JAS (2003) *P<.05 University of Illinois

Effect of Endo-Power β on DDGS

Spencer et.al, 2006

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>PSE</th>
<th>P-value</th>
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<tbody>
<tr>
<td>Corn-soy</td>
<td>+30% DDGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>+30% DDGS + E</td>
<td></td>
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</tr>
<tr>
<td>ADG, kg</td>
<td>1.18b</td>
<td>1.19b</td>
<td>1.23a</td>
</tr>
<tr>
<td>ADFI, kg</td>
<td>1.77a</td>
<td>1.65c</td>
<td>1.73ab</td>
</tr>
<tr>
<td>FCR</td>
<td>1.50a</td>
<td>1.39c</td>
<td>1.40c</td>
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</table>

300 pigs (3 treatments x 10 pens x 10 pigs)

Thank You

- Questions?