What We’ve Learned About Feeding Reduced-Oil DDGS to Pigs

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Ultimate Question

• Does oil extraction from DDGS affect energy and feeding value in swine diets?
Key Questions – Reduced-Oil DDGS

• How much does oil extraction affect DDGS nutrient content and energy value?

• What is the ME and NE content, and can oil content be used to estimate energy value?

• Does reduced-oil DDGS affect growth performance, carcass characteristics, and pork fat quality?

• Should the price be discounted?
“Just Tell Me How Much ME is Reduced for Each 1% Reduction in Oil Content in DDGS!”
Nutrient Composition Changes – What Does the “New” Swine NRC (2012) Tell Us?
### Nutrient Content of Low, Medium, and High-Oil DDGS

<table>
<thead>
<tr>
<th>%, As-fed Basis</th>
<th>Low-oil (&lt;4%) DDGS</th>
<th>Medium-oil (&gt; 6 and &lt; 9%) DDGS</th>
<th>Traditional (&gt;10%) DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>89.3</td>
<td>89.4</td>
<td>89.3</td>
</tr>
<tr>
<td><strong>Crude protein</strong></td>
<td><strong>27.9</strong></td>
<td><strong>27.4</strong></td>
<td><strong>27.3</strong></td>
</tr>
<tr>
<td>Ether extract (oil)</td>
<td>3.6</td>
<td>8.9</td>
<td>10.4</td>
</tr>
<tr>
<td>Ash</td>
<td>4.6</td>
<td>4.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Starch</td>
<td>10.0</td>
<td>9.6</td>
<td>6.7</td>
</tr>
<tr>
<td><strong>NDF</strong></td>
<td><strong>33.8</strong></td>
<td><strong>30.5</strong></td>
<td><strong>32.5</strong></td>
</tr>
<tr>
<td>ADF</td>
<td>16.9</td>
<td>12.0</td>
<td>11.8</td>
</tr>
</tbody>
</table>

NRC (2012)
## Amino Acid Content of Low, Medium, and High-Oil DDGS

<table>
<thead>
<tr>
<th>%, As-fed Basis</th>
<th>Low-oil (&lt;4%) DDGS</th>
<th>Medium-oil (&gt; 6 and &lt; 9%) DDGS</th>
<th>Traditional (&gt;10%) DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.68</td>
<td>0.90</td>
<td>0.77</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.50</td>
<td>0.57</td>
<td>0.55</td>
</tr>
<tr>
<td>Cysteine</td>
<td>0.51</td>
<td>0.44</td>
<td>0.51</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.97</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.18</td>
<td>0.20</td>
<td>0.21</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>1.02</td>
<td>1.06</td>
<td>1.02</td>
</tr>
<tr>
<td>Valine</td>
<td>1.34</td>
<td>1.39</td>
<td>1.35</td>
</tr>
</tbody>
</table>

*NRC (2012)*
GE, DE, ME, and NE Content of Low, Medium, and High-Oil DDGS

<table>
<thead>
<tr>
<th>Kcal/kg, as-fed basis</th>
<th>Low-oil (&lt;4%) DDGS</th>
<th>Medium-oil (&gt; 6 and &lt; 9%) DDGS</th>
<th>Traditional (&gt;10%) DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross energy</td>
<td>5,098</td>
<td>4,710</td>
<td>4,849</td>
</tr>
<tr>
<td>Digestible energy</td>
<td>3,291</td>
<td>3,582</td>
<td>3,620</td>
</tr>
<tr>
<td>Metabolizable energy</td>
<td>3,102</td>
<td>3,396</td>
<td>3,434</td>
</tr>
<tr>
<td>Net energy</td>
<td>2,009</td>
<td>2,343</td>
<td>2,384</td>
</tr>
</tbody>
</table>

NRC (2012)
Nutrient Composition Changes – What Does U of M/USDA-ARS Research Tell Us?
Gross Energy **But Not** NDF, TDF, CP, or Ash is Correlated with Crude Fat (EE) Content in Reduced-Oil DDGS

Kerr and Shurson (2013)
There is a Poor Relationship Between Crude Fat (EE) Content of DDGS and DE and ME Content

Experiment 1

- DE, kcal/kg DM = 3414 + (20.72 x %EE)
- ME, kcal/kg DM = 3103 + (30.28 x %EE)

Experiment 2

- DE, kcal/kg DM = 3461 + (31.832 x %EE)
- ME, kcal/kg DM = 3130 + (46.23 x %EE)
Comparison of Crude Fat Content of DDGS Sources Relative to ME Content

Kerr and Shurson (2013)
We Can’t Use Crude Fat to Estimate ME Content in DDGS

<table>
<thead>
<tr>
<th>DDGS Source</th>
<th>DDGS Source 11</th>
<th>DDGS Source 9</th>
<th>DDGS Source 8</th>
<th>DDGS Source 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME, kcal/kg</td>
<td>3,553</td>
<td>3,550</td>
<td>3,603</td>
<td>3,277</td>
</tr>
<tr>
<td>Crude fat, %</td>
<td>11.8</td>
<td>9.7</td>
<td>13.2</td>
<td>11.1</td>
</tr>
<tr>
<td>Starch, %</td>
<td>1.1</td>
<td>2.8</td>
<td>1.3</td>
<td>0.9</td>
</tr>
<tr>
<td>NDF, %</td>
<td>38.9</td>
<td>28.8</td>
<td>34.0</td>
<td>39.7</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>32.1</td>
<td>29.8</td>
<td>30.6</td>
<td>31.6</td>
</tr>
<tr>
<td>Ash, %</td>
<td>4.9</td>
<td>5.0</td>
<td>5.3</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Comparing DDGS Source 11 vs. 9:

2.1 percentage unit decrease in fat reduced ME by 3 kcal/kg

Comparing DDGS Source 8 vs. 5:

2.1 percentage unit decrease in fat reduced ME by 326 kcal/kg

Kerr and Shurson (2013)
**Crude Fat Content CANNOT Be Used to Predict NE Content in Reduced-Oil DDGS**

<table>
<thead>
<tr>
<th>DDGS Source</th>
<th>NE, kcal/kg</th>
<th>Crude fat, %</th>
<th>NDF, %</th>
<th>Crude protein, %</th>
<th>Ash, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2,381</td>
<td>11.4</td>
<td>31.1</td>
<td>32.2</td>
<td>5.5</td>
</tr>
<tr>
<td>5</td>
<td>2,326</td>
<td>7.0</td>
<td>27.8</td>
<td>29.8</td>
<td>5.5</td>
</tr>
<tr>
<td>1</td>
<td>2,262</td>
<td>13.3</td>
<td>38.3</td>
<td>29.7</td>
<td>4.8</td>
</tr>
<tr>
<td>2</td>
<td>2,249</td>
<td>10.4</td>
<td>38.5</td>
<td>32.0</td>
<td>4.7</td>
</tr>
<tr>
<td>3</td>
<td>2,219</td>
<td>9.1</td>
<td>39.6</td>
<td>31.6</td>
<td>5.4</td>
</tr>
<tr>
<td>4</td>
<td>2,129</td>
<td>8.0</td>
<td>31.0</td>
<td>30.6</td>
<td>5.6</td>
</tr>
</tbody>
</table>

*Kerr and Shurson (2013)*
Why Is There A Poor Relationship Between Crude Fat Content and DE, ME, and NE Content?

• Chemical composition of DDGS is highly variable among sources.
  – Corn oil extraction does not uniformly increase other chemical components among sources

• Fiber (e.g. NDF or TDF) represents a much greater proportion (30 to 40%) of DDGS than oil (5 to 13%).

• Total tract digestibility of fiber can range from 23 to 55%.
  – Can contribute a significant proportion of energy to pigs

• Remaining oil in reduced-oil DDGS is less digestible (52%) than extracted oil (94%).
What Can We Do To Estimate Energy Content of Reduced-Oil DDGS for Swine?
Prediction Equations Are Not Always Accurate for Estimating ME in Corn Co-products for Swine

\[ \text{ME kcal/kg DM} = (0.949 \ \text{kcal GE/kg DM}) - (32.238 \ % \text{TDF}) - (40.175 \ % \text{ash}) \]

Anderson et al. (2012)  \quad r^2 = 0.95  \quad \text{SE} = 306

\[ \text{ME kcal/kg DM} = -4,212 + (1.911 \ \text{GE, kcal/kg}) - (108.35 \ % \text{ADF}) - (266.38 \ % \text{ash}) \]

Pedersen et al. (2007)  \quad r^2 = 0.94  \quad \text{SE} = \text{not provided}
Pedersen (2007) Equations Significantly Underestimate ME in Reduced-Oil DDGS Sources

Kerr and Shurson (2013)

In vivo ME
Anderson Equation 2

$r = 0.74$
P $< 0.01$
Anderson (2012) Equations Reasonably Predict ME Content of Reduced-Oil DDGS

Kerr and Shurson (2013)
Noblet (1993) NE Equation Overestimates NE Content of Reduced-Oil DDGS Sources

<table>
<thead>
<tr>
<th>DIET</th>
<th>DE</th>
<th>EE</th>
<th>ST</th>
<th>CP</th>
<th>ADF</th>
<th>Predicted</th>
<th>Determined</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal</td>
<td>0.7</td>
<td>1.61</td>
<td>0.48</td>
<td>-0.91</td>
<td>-0.87</td>
<td>2617</td>
<td>2478</td>
<td>+139</td>
</tr>
<tr>
<td>1</td>
<td>3750</td>
<td>3.14</td>
<td>10.84</td>
<td>17.04</td>
<td>3.35</td>
<td>2686</td>
<td>2416</td>
<td>+270</td>
</tr>
<tr>
<td>2</td>
<td>3774</td>
<td>5.32</td>
<td>8.29</td>
<td>21.53</td>
<td>5.99</td>
<td>2630</td>
<td>2482</td>
<td>+148</td>
</tr>
<tr>
<td>3</td>
<td>3836</td>
<td>5.53</td>
<td>8.03</td>
<td>22.86</td>
<td>6.65</td>
<td>2671</td>
<td>2369</td>
<td>+302</td>
</tr>
<tr>
<td>4</td>
<td>3784</td>
<td>5.09</td>
<td>8.48</td>
<td>22.46</td>
<td>5.57</td>
<td>2636</td>
<td>2241</td>
<td>+395</td>
</tr>
<tr>
<td>5</td>
<td>3800</td>
<td>4.68</td>
<td>8.26</td>
<td>23.11</td>
<td>5.43</td>
<td>2645</td>
<td>2346</td>
<td>+299</td>
</tr>
<tr>
<td>6</td>
<td>3870</td>
<td>6.44</td>
<td>8.38</td>
<td>22.16</td>
<td>5.43</td>
<td>2698</td>
<td>2450</td>
<td>+248</td>
</tr>
</tbody>
</table>

Average       +257

Predicted NE values were determined using known composition of basal and individual DDGS samples.

Kerr and Shurson (2013)
Best Energy Prediction Equations for Reduced-Oil DDGS (kcal/kg DM) for Swine

\[
DE_{K1} = 1,601 - (54.48 \text{ TDF}) + (0.69 \text{ GE}) + (731.5 \text{ BD}) \quad R^2 = 0.91
\]
\[
DE_A = -4,144 + (1.71 \text{ GE}) - (21.47 \text{ TDF}) - (36.97 \text{ EE}) + (11.23 \text{ ST}) \quad R^2 = 0.88
\]
\[
DE_{K1} = 2,084 - (53.65 \text{ TDF}) + (0.67 \text{ GE}) \quad R^2 = 0.86
\]
\[
DE_A = -1,358 + (1.26 \text{ GE}) - (30.91 \text{ TDF}) - (33.14 \text{ EE}) \quad R^2 = 0.85
\]
\[
DE_A = -520 + (1.06 \text{ GE}) - (32.38 \text{ TDF}) \quad R^2 = 0.80
\]
\[
DE_{K2} = -1,583 + (0.92 \text{ GE}) + (0.63 \text{ Ash}) \quad R^2 = 0.79
\]
\[
ME_K = 4,558 + (52.26 \text{ EE}) - (50.08 \text{ TDF}) \quad R^2 = 0.85
\]
\[
ME_K = 2,939 - (73.30 \text{ ADF}) + (2,004 \text{ BD}) + (23.65 \text{ EE}) \quad R^2 = 0.85
\]
\[
ME_A = (0.90 \text{ GE}) - (29.95 \text{ TDF}) \quad R^2 = 0.72
\]
\[
ME_A = 167 + (0.87 \text{ GE}) - (30.11 \text{ TDF}) \quad R^2 = 0.72
\]
\[
ME_A = -223 + (0.98 \text{ GE}) - (23.33 \text{ NDF}) - (70.09 \text{ Ash}) \quad R^2 = 0.68
\]
\[
ME_A = (0.94 \text{ GE}) - (23.45 \text{ NDF}) - (70.23 \text{ Ash}) \quad R^2 = 0.68
\]

NE – no prediction equations could be developed due to lack of variability and a limited number (6) of reduced-oil DDGS samples

Kerr and Shurson (2013)
Challenges of Using ME Equations

- Accuracy has not been validated
- Are they representative of nutrient variability among sources?
- Some analytes required by equations (e.g. GE, TDF) are:
  - not routinely measured in commercial laboratories
  - expensive
- Analytical variability among labs and procedures affects accuracy (e.g. NDF).
- Adjustments for fat and fiber in some equations seem counterintuitive.
- Methods used to determine DE and ME content vary
- Methods used to develop regression equations vary
- Particle size of DDGS sources vary and influence DE and ME
How Does Oil Extraction Affect Amino Acid Digestibility of Reduced-Oil DDGS for Swine?
Amino Acid Digestibility of Low, Medium, and High-Oil DDGS in Growing Pigs

Means with different superscripts differ (P < 0.05)

Curry et al. (2013)
Does Feeding Reduced-Oil DDGS Affect Growth Performance and Carcass Characteristics?
Effects of Increasing Dietary Reduced-Oil (7.4%) DDGS Level on Growth Performance of Finishing Pigs

Graham et al. (2012)
Effects of Increasing Dietary Reduced-Oil (7.4%) DDGS on Carcass Characteristics of Finishing Pigs

Graham et al. (2012)
De-oiled DDGS level had no effect on ADG, ADFI, and G:F

Jacela et al. (2011)
Effects of Increasing Dietary De-Oiled (4.0%) DDGS Level on Growth Performance of Growing-Finishing Pigs

Jacela et al. (2011)
Effects of Increasing Dietary De-Oiled (4.0%) DDGS Level on Carcass Characteristics of Growing-Finishing Pigs

Jacela et al. (2011)
Comparison of the Rate of Increase in Belly Fat IV with Increasing Dietary Levels of High Oil\(^1\) vs. De-Oiled\(^2\) DDGS

\(^1\) Xu et al. (2009)
\(^2\) Jacela et al. (2011)

Data were adjusted to a common initial IV (0% DDGS)
The DDGS Market

• There are no marketing grades or standards for DDGS.
  – Currently no market differentiation

• There is a global shortage of feedstuffs
  – Quantity is a priority over quality

• DDGS has been trading at about 100% of corn price regardless of oil content.
More Thoughts About Pricing...

• Market “price” is disconnected to “value”
  – We buy on moisture, protein, fat, and fiber
  – We formulate on NE and SID amino acids

• No easy way for DDGS marketers to calculate change in value
  – Need chemical composition and applicable energy and digestible
    amino acid prediction equations
  – What publically traded commodity can value be compared?
Acknowledgements

• Funding provided by:
  – MN Corn Research and Promotion Council
  – USDA-ARS
  – National Pork Board
  – DDGS sources provided by Cenex Harvest States and POET