Overview of Production and Nutrient Content of DDGS

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University of Minnesota
What is DDGS?

- **Distiller’s dried grains with solubles (DDGS)**
  - By-product of the **dry-milling** ethanol industry

- Nutrient composition is **different** between dry-mill, wet-mill and beverage alcohol by-products
  - DDGS – fuel ethanol
  - DDGS - whiskey distilleries
  - Corn gluten feed – wet mill
  - Corn gluten meal – wet mill
  - Brewer’s dried grains – beer manufacturing

- Nutrient content depends on the grain source used
  - **Corn DDGS - Midwestern US**
  - Wheat DDGS - Canada
  - Sorghum (milo) DDGS - Great Plains US
  - Barley DDGS
Comparison of Nutrient Composition (100% Dry Matter Basis) of Golden DDGS to Corn Gluten Feed, Corn Gluten Meal, Corn Germ Meal, and Brewer’s Dried Grains

<table>
<thead>
<tr>
<th></th>
<th>Golden DDGS (UM)</th>
<th>Corn Gluten Feed (NRC)</th>
<th>Corn Gluten Meal (NRC)</th>
<th>Corn Germ Meal (Feedstuffs)</th>
<th>Brewer’s Dried Grains (NRC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein, %</td>
<td>30.6</td>
<td>23.9</td>
<td>66.9</td>
<td>22.2</td>
<td>28.8</td>
</tr>
<tr>
<td>Fat, %</td>
<td><strong>10.7</strong></td>
<td>3.3</td>
<td>3.2</td>
<td>1.1</td>
<td>7.9</td>
</tr>
<tr>
<td>NDF, %</td>
<td>43.6</td>
<td>37.0</td>
<td>9.7</td>
<td>No data</td>
<td>52.9</td>
</tr>
<tr>
<td>DE, kcal/kg</td>
<td><strong>4011</strong></td>
<td>3322</td>
<td>4694</td>
<td>No data</td>
<td>2283</td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td><strong>3827</strong></td>
<td>2894</td>
<td>4256</td>
<td>3222</td>
<td>2130</td>
</tr>
<tr>
<td>Lys, %</td>
<td>0.83</td>
<td>0.70</td>
<td>1.13</td>
<td>1.00</td>
<td>1.17</td>
</tr>
<tr>
<td>Met, %</td>
<td>0.55</td>
<td>0.39</td>
<td>1.59</td>
<td>0.67</td>
<td>0.49</td>
</tr>
<tr>
<td>Thr, %</td>
<td>1.13</td>
<td>0.82</td>
<td>2.31</td>
<td>1.22</td>
<td>1.03</td>
</tr>
<tr>
<td>Trp, %</td>
<td>0.24</td>
<td>0.08</td>
<td>0.34</td>
<td>0.22</td>
<td>0.28</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.06</td>
<td>0.24</td>
<td>0.06</td>
<td>0.33</td>
<td>0.35</td>
</tr>
<tr>
<td>Available P, %</td>
<td><strong>0.80</strong></td>
<td>0.54</td>
<td>0.08</td>
<td>0.17</td>
<td>0.21</td>
</tr>
</tbody>
</table>
Types of Distiller’s By-Products from Dry-Grind Ethanol Plants

- **Wet distiller’s grains**
  - Primarily beef, some dairy

- **Dry distiller’s grains**
  - Beef and dairy

- **Wet distiller’s grains with solubles**
  - Beef and dairy

- **Dried distiller’s grains with solubles**
  - Dairy, swine, poultry, some beef

- **Modified wet cake (blend of wet and dry distiller’s grains)**
  - Primarily beef, some dairy

- **Condensed distiller’s solubles**
  - Beef and dairy
  - Ontario, Canada - swine liquid feeding systems
Proportion of Distiller’s Grains Marketed Wet vs Dry

- Wet: 40%
- Dry: 60%
Samples of High Quality, Golden Corn DDGS

VeraSun - Aurora, SD          CVEC - Benson, MN       Al-Corn - Claremont, MN         MGP – Lakota, IA
CMEC - Little Falls, MN      Agri-Energy - Luverne, MN   LSCP - Marcus, IA      DENCO – Morris, MN
Dry-Milling Average Ethanol Yield Per Bushel (25.4 kg) of Corn

- Ethanol: 10.2 liters
- DDGS: 8.2 kg
- CO$_2$: 8.2 kg

Slide courtesy of Ms. Kelly Davis, CVEC, Benson, MN
North American Ethanol Plants

Source: Scott Amendt (Land O’ Lakes)
U.S. DDGS Production

Source: Steve Markham – Commodity Specialists Company
Estimated DDGS Usage in U.S. Swine Feeds 2001-2004 (Metric Tonnes)
U.S. DDGS Exports Are Increasing

Source: Commodity Specialists Company
Major U.S. DDGS Importing Countries (84% of Total Exports)

- Ireland: 24.0%
- UK: 22.6%
- Canada: 11.0%
- Spain: 9.3%
- Mexico: 9.2%
- Portugal: 8.3%
Asian Countries Importing U.S. DDGS (4.5% of Total Exports)
Comparison of Proximate Analysis of High Quality U.S. Golden Corn DDGS with Chinese DDGS (100% Dry Matter Basis)

U.S. Avg. = average of values obtained from samples from 10 “New Generation” dry-mill ethanol plants (Spiehs et al., 2002)
China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003
China-Korea  = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005
Comparison of Calculated Digestible Energy, Metabolizable Energy for Swine of U.S. “New Generation” DDGS to Chinese DDGS (100% Dry Matter Basis)

U.S. Avg. = average of calculated values obtained from DDGS samples from 10 “New Generation” ethanol plants (Spiehs et al., 2002)
China-Taiwan = calculated values from actual proximate analysis of a sample of Chinese DDGS obtained from Taiwan in 2003
China-Korea = calculated values from actual proximate analysis of a sample of Chinese DDGS obtained from S. Korea in 2005
Comparison of Amino Acid Analysis of U.S. “New Generation” DDGS with Chinese DDGS (100% Dry Matter Basis)

U.S. Avg. = average of values obtained from samples from 10 “New Generation” dry-mill ethanol plants (Spiehs et al., 2002)
China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003
China-Korea  = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005
Comparison of Macro-mineral Analysis of U.S. “New Generation” DDGS with Chinese DDGS (100% Dry Matter Basis)

U.S. Avg. = average of values obtained from samples from 10 “New Generation” dry-mill ethanol plants (Spiehs et al., 2002)

China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003

China-Korea = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005
Comparison of Trace Mineral Analysis of U.S. “New Generation” DDGS with Chinese DDGS (100% Dry Matter Basis)

U.S. Avg. = average of values obtained from samples from 10 “New Generation” dry-mill ethanol plants (Spiehs et al., 2002)

China-Taiwan = actual analyzed values of a Chinese DDGS sample collected in Taiwan in 2003

China-Korea = actual analyzed values of a sample of Chinese DDGS obtained from S. Korea in 2005
Ethanol Plants are Developing New Distiller’s By-Products

- DDG – Winnebago
- High protein DDGS – Dakota Commodities
- De-germed or partial de-germed DDGS
- “Quick fiber”
- Removing P
- Others
Comparison of Nutrient Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)
Comparison of Amino Acid Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)
Comparison of Mineral Content of Dakota Gold DDGS with High Protein Dakota Gold (100% DM Basis)
Proximate Analysis and Calculated Swine Energy Values Among 27 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>31.0</td>
<td>28.7 – 32.9</td>
</tr>
<tr>
<td>Fat, %</td>
<td>10.6</td>
<td>8.8 – 12.4</td>
</tr>
<tr>
<td>Fiber, %</td>
<td>7.2</td>
<td>5.4 – 10.4</td>
</tr>
<tr>
<td>Ash, %</td>
<td>6.1</td>
<td>3.0 – 9.8</td>
</tr>
<tr>
<td>ADF, %</td>
<td>13.6</td>
<td>8.0 – 18.1</td>
</tr>
<tr>
<td>Swine DE, kcal/kg</td>
<td>4053</td>
<td>3737 – 4319</td>
</tr>
<tr>
<td>Swine ME, kcal/kg</td>
<td>3790</td>
<td>3504 – 4048</td>
</tr>
</tbody>
</table>
### Amino Acid Analysis Averages and Ranges Among 27 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>Arg, %</td>
<td>1.31</td>
<td>1.01 – 1.48</td>
</tr>
<tr>
<td>His, %</td>
<td>0.84</td>
<td>0.71 – 0.98</td>
</tr>
<tr>
<td>Ile, %</td>
<td>1.17</td>
<td>1.01 – 1.31</td>
</tr>
<tr>
<td>Leu, %</td>
<td>3.58</td>
<td>2.91 – 3.96</td>
</tr>
<tr>
<td>Lys, %</td>
<td>0.89</td>
<td>0.61 – 1.06</td>
</tr>
<tr>
<td>Met, %</td>
<td>0.65</td>
<td>0.54 – 0.76</td>
</tr>
<tr>
<td>Cys, %</td>
<td>0.68</td>
<td>0.61 – 0.76</td>
</tr>
<tr>
<td>Phe, %</td>
<td>1.51</td>
<td>1.36 – 1.72</td>
</tr>
<tr>
<td>Thr, %</td>
<td>1.15</td>
<td>1.01 – 1.28</td>
</tr>
<tr>
<td>Trp, %</td>
<td>0.25</td>
<td>0.18 – 0.28</td>
</tr>
<tr>
<td>Val, %</td>
<td>1.58</td>
<td>1.31 – 1.80</td>
</tr>
</tbody>
</table>
## Mineral Analysis Averages and Ranges Among 27 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>Ca, %</td>
<td>0.08</td>
<td>0.02 – 0.12</td>
</tr>
<tr>
<td>P, %</td>
<td>0.75</td>
<td>0.42 – 0.99</td>
</tr>
<tr>
<td>K, %</td>
<td>0.96</td>
<td>0.45 – 1.27</td>
</tr>
<tr>
<td>Mg, %</td>
<td>0.29</td>
<td>0.14 – 0.38</td>
</tr>
<tr>
<td>S, %</td>
<td>0.62</td>
<td>0.34 – 1.05</td>
</tr>
<tr>
<td>Na, %</td>
<td>0.15</td>
<td>0.04 – 0.52</td>
</tr>
<tr>
<td>Zn, ppm</td>
<td>62</td>
<td>38 – 105</td>
</tr>
<tr>
<td>Mn, ppm</td>
<td>19</td>
<td>9 – 27</td>
</tr>
<tr>
<td>Cu, ppm</td>
<td>6</td>
<td>3 – 10</td>
</tr>
<tr>
<td>Fe, ppm</td>
<td>133</td>
<td>77 – 239</td>
</tr>
</tbody>
</table>
### Nutrient Composition of High Quality U.S. Corn DDGS for Ruminants

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>% of Dry Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein</td>
<td>30.1</td>
</tr>
<tr>
<td>Ruminally undegradable protein (% of CP)</td>
<td>55.0</td>
</tr>
<tr>
<td>$N\text{E}_{\text{maintenance}}$ (Mcal/kg)</td>
<td>2.07</td>
</tr>
<tr>
<td>$N\text{E}_{\text{gain}}$ (Mcal/kg)</td>
<td>1.41</td>
</tr>
<tr>
<td>$N\text{E}_{\text{lactation}}$ (Mcal/kg)</td>
<td>2.26</td>
</tr>
<tr>
<td>NDF</td>
<td>41.5</td>
</tr>
<tr>
<td>ADF</td>
<td>16.1</td>
</tr>
<tr>
<td>Ether extract</td>
<td>10.7</td>
</tr>
</tbody>
</table>
Comparison of Energy Values of DDGS for Swine (88% DM Basis)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DE, kcal/kg</td>
<td>3488</td>
<td>3528</td>
<td>3409</td>
<td>3449</td>
</tr>
<tr>
<td>Range</td>
<td>3418-3537</td>
<td>2975-4086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME, kcal/kg</td>
<td>3162</td>
<td>3367</td>
<td>3098</td>
<td>2672</td>
</tr>
<tr>
<td>Range</td>
<td>3087-3215</td>
<td>2820-3916</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Corn (NRC, 1998): DE (kcal/kg) = 3484  
ME (kcal/kg) = 3382
Comparison of DE and ME Estimates of DDGS for Swine (88% DM)

<table>
<thead>
<tr>
<th>Source</th>
<th>DE, Mcal/kg</th>
<th>ME, Mcal/kg</th>
<th>NE, Mcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>U of M – Golden DDGS (1999)</td>
<td>3.49</td>
<td>3.37</td>
<td>No data</td>
</tr>
<tr>
<td>U of M – Traditional (1999)¹</td>
<td>3.41</td>
<td>3.10</td>
<td>No data</td>
</tr>
<tr>
<td>Hanor-Hubbard-Ajinomoto (2004)⁴</td>
<td>No data</td>
<td>3.25</td>
<td>2.42</td>
</tr>
<tr>
<td>NRC (1998)</td>
<td>3.45</td>
<td>2.67</td>
<td>No data</td>
</tr>
</tbody>
</table>

¹ Calculated values
² Determined by growth and metabolism trials (source Dakota Gold)
³ Not DDGS but corn gluten from a NE ethanol plant
⁴ Determined by growth trials (source Dakota Gold)
## Comparison of Energy Values of Golden Corn DDGS for Poultry (88% DM Basis)

<table>
<thead>
<tr>
<th></th>
<th>Golden DDGS</th>
<th>NRC (1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AME, kcal/kg</td>
<td>2260</td>
<td>2480</td>
</tr>
<tr>
<td>Range</td>
<td>2090-2418</td>
<td></td>
</tr>
<tr>
<td>TME, kcal/kg</td>
<td>2850</td>
<td>3097</td>
</tr>
<tr>
<td>Range</td>
<td>2650 - 3082</td>
<td></td>
</tr>
</tbody>
</table>

Comparison of Amino Acid Composition of DDGS (88% dry matter basis)

<table>
<thead>
<tr>
<th></th>
<th>Golden DDGS</th>
<th>Traditional DDGS</th>
<th>DDGS (NRC, 1998)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine, %</td>
<td>0.75 (17.3)</td>
<td>0.47 (26.5)</td>
<td>0.59</td>
</tr>
<tr>
<td>Methionine, %</td>
<td>0.63 (13.6)</td>
<td>0.44 (4.5)</td>
<td>0.48</td>
</tr>
<tr>
<td>Threonine, %</td>
<td>0.99 (6.4)</td>
<td>0.86 (7.3)</td>
<td>0.89</td>
</tr>
<tr>
<td>Tryptophan, %</td>
<td>0.22 (6.7)</td>
<td>0.17 (19.8)</td>
<td>0.24</td>
</tr>
<tr>
<td>Valine, %</td>
<td>1.32 (7.2)</td>
<td>1.22 (2.3)</td>
<td>1.23</td>
</tr>
<tr>
<td>Arginine, %</td>
<td>1.06 (9.1)</td>
<td>0.81 (18.7)</td>
<td>1.07</td>
</tr>
<tr>
<td>Histidine, %</td>
<td>0.67 (7.8)</td>
<td>0.54 (15.2)</td>
<td>0.65</td>
</tr>
<tr>
<td>Leucine, %</td>
<td>3.12 (6.4)</td>
<td>2.61 (12.4)</td>
<td>2.43</td>
</tr>
<tr>
<td>Isoleucine, %</td>
<td>0.99 (8.7)</td>
<td>0.88 (9.1)</td>
<td>0.98</td>
</tr>
<tr>
<td>Phenylalanine, %</td>
<td>1.29 (6.6)</td>
<td>1.12 (8.1)</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Values in ( ) are CV’s among plants
## Standardized Ileal True Digestible Amino Acid Levels and Coefficients of Corn DDGS for Swine (10 Sources of Golden DDGS)

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>True Dig. Amino Acid, %</th>
<th>Digestibility Coefficient, %</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.30 – 0.54</td>
<td>44 – 61</td>
<td>57</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.48 – 0.60</td>
<td>74 – 85</td>
<td>79</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.61 – 0.76</td>
<td>62 – 71</td>
<td>67</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.13 – 0.14</td>
<td>74 – 80</td>
<td>77</td>
</tr>
</tbody>
</table>

Source: Stein et al., 2005. Unpublished data.
## True Digestible Amino Acid Levels of Golden Corn DDGS for Poultry (5 Sources)

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>True Dig. Amino Acid, %</th>
<th>Average</th>
<th>Digestibility Coefficient, %</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methionine</td>
<td>0.35 – 0.53</td>
<td>0.43</td>
<td>86 - 90</td>
<td>88</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.28 – 0.57</td>
<td>0.40</td>
<td>66 - 85</td>
<td>76</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.37 – 0.74</td>
<td>0.53</td>
<td>59 - 83</td>
<td>71</td>
</tr>
<tr>
<td>Arginine</td>
<td>0.73 – 1.18</td>
<td>0.93</td>
<td>80 - 90</td>
<td>86</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.14 – 0.21</td>
<td>0.18</td>
<td>76 - 87</td>
<td>82</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.61 – 0.92</td>
<td>0.74</td>
<td>67 - 81</td>
<td>75</td>
</tr>
</tbody>
</table>

Fig. 1. Regression of digestible lys (%) and color (L*, b*)

\[ R^2 = 0.71 \]

\[ R^2 = 0.74 \]

Source: Dr. Sally Noll (2003)
Fig. 2. Regression of digestible cys (%) and color (L*, b*)

- $R^2 = 0.66$
- $R^2 = 0.67$

Cys (%) vs. L*, b* score

- Linear (L*)
- Linear (b*)
Fig. 3. Regression of digestible thr (%) and color (L*, b*)

\[ R^2 = 0.37 \]

\[ R^2 = 0.40 \]
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>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total P, %</td>
<td>0.78</td>
<td>0.79</td>
<td>0.73</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Range 0.62-0.87</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P Availability, %</td>
<td>90</td>
<td>No data</td>
<td>77</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Range 88-92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.70</td>
<td>No data</td>
<td>0.56</td>
<td>0.03</td>
</tr>
</tbody>
</table>
**Comparison of Phosphorus Level and Relative Availability of DDGS for Poultry (88% dry matter basis)**

<table>
<thead>
<tr>
<th></th>
<th>Golden DDGS</th>
<th>NRC (1994)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total P, %</td>
<td>0.74</td>
<td>0.72</td>
</tr>
<tr>
<td>P Availability, %</td>
<td>61</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Range 54 - 68</td>
<td></td>
</tr>
<tr>
<td>Available P, %</td>
<td>0.45</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Source: 2003 Lumpkins, Dale, and Batal, University of Georgia. Abstract.
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
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