Nutrient Content and Quality of DDGS

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What is DDGS?
- By-product of the dry-milling ethanol industry
- Nutrient composition is different from wet-mill and beverage alcohol by-products
  - 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 (maize) DDGS - Midwestern US
  - Wheat DDGS - Canada
  - Sorghum (milo) DDGS - Great Plains US
  - Barley DDGS

Corn Dry-Milling Process Overview

Dry-Milling Average Ethanol Yield Per Bushel (25.4 kg) of Corn
- Ethanol 10.2 liters
- DDGS 8.2 kg
- CO2 8.2 kg

“New Generation” Ethanol Plants are Located in the Western “Corn Belt” of the U.S.

U.S. DDGS Production is Rapidly Increasing

Source: Commodity Specialists Company
Comparison of Macro-mineral Analysis of U.S. Golden Corn DDGS to Wheat DDGS (100% Dry Matter Basis)

U.S. Corn: average of values obtained from samples from 9 “New Generation” dry-mill ethanol plants (Shurson and Whitney, 2004)

U.S. – SD = actual analyzed values of DDGS produced by a South Dakota ethanol plant that was exported to Taiwan

China Act = actual analyzed values of a sample of Chinese DDGS obtained from Taiwan

Samples of Golden Corn DDGS from Various U.S. Ethanol Plants

- VeraSun - Aurora, SD
- CVEC - Benson, MN
- Al-Corn - Claremont, MN
- MGP – Lakota, IA
- CVEC - Little Falls, MN
- Agri-Energy – Luverne, MN
- LSCP - Marcus, IA
- DENDCO – Morris, MN

Corn DDGS Color and Smell are Indicators of Digestibility for Monogastrics

- Color varies among sources
  - ranges from dark to golden (Cromwell et al., 1993)
  - golden color of corn DDGS is correlated with higher amino acid digestibility in swine and poultry
- Smell varies among sources
  - ranges from burnt or smoky to sweet and fermented (Cromwell et al., 1993)
  - golden DDGS has a sweet, fermented smell
  - smell may affect palatability

“Old Generation” vs. “New Generation” DDGS

- Lower Quality, Less Digestible DDGS
- High Quality, Highly Digestible DDGS

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

\[ R^2 = 0.71 \]

\[ R^2 = 0.74 \]
Fig. 2. Regression of digestible cys (%) and color (L*, b*)

$R^2 = 0.66$

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

$R^2 = 0.37$

"Old Generation" vs. "New Generation" DDGS

Quality Assessment of "New Generation" DDGS

1. NIR
2. Smell
3. Color
4. Mycotoxins
5. Fat stability

Proximate Analysis of "New Generation" DDGS (100% Dry Matter Basis)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>&quot;New Generation&quot; DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter, %</td>
<td>89.2</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>31.6</td>
</tr>
<tr>
<td>Fat, %</td>
<td>11.5</td>
</tr>
<tr>
<td>Crude fiber, %</td>
<td>6.2</td>
</tr>
<tr>
<td>Ash, %</td>
<td>7.8</td>
</tr>
<tr>
<td>NFE, %</td>
<td>42.8</td>
</tr>
<tr>
<td>ADF, %</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Physical Characteristics of "New Generation" DDGS

- Bulk density (16 "new generation" plants)
  - 35.7 ± 2.79 lbs/ft³
  - Range 30.8 to 39.3 lbs/ft³

- Particle size (16 "new generation" plants)
  - 1282 ± 305 microns
  - Range 612 to 2125 microns
NIR Calibrations for DDGS

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>R</th>
<th>Rmsep, %</th>
<th>R²</th>
<th>CV, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine</td>
<td>0.89</td>
<td>0.064</td>
<td>.79</td>
<td>16.2</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.81</td>
<td>0.044</td>
<td>.66</td>
<td>14.2</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.73</td>
<td>0.046</td>
<td>.53</td>
<td>6.2</td>
</tr>
<tr>
<td>Energy</td>
<td>0.87</td>
<td>37</td>
<td>.76</td>
<td>1.9</td>
</tr>
</tbody>
</table>

R = correlation between actual and predicted values
Rmsep = prediction error
R² = proportion of the total variation explained by calibrations
CV, % = coefficient of variation among DDGS samples

DDGS Color and Smell

- Color varies among sources
  - ranges from dark to golden (Cromwell et al., 1993)
  - "new generation" DDGS is more golden and color is less variable
  - golden color is correlated with higher amino acid digestibility in swine and poultry

- Smell varies among sources
  - ranges from burnt or smoky to sweet and fermented (Cromwell et al., 1993)
  - "new generation" DDGS has a sweet, fermented smell
  - smell may affect palatability

Mycotoxins

- Risk of mycotoxin contamination in "new generation" DDGS is very low
  - Poor quality corn = poor ethanol yields
  - Com supplied to ethanol plants is produced locally
  - Corn produced in upper Midwest has a low risk for mycotoxins

- Must use thin layer chromatography (TLC) or HPLC for testing mycotoxins in DDGS
  - ELISA and other methods result in false positives

Fat Stability of DDGS

- Limited data

- Mexico
  - DDGS monitored during transit and storage for 16 weeks in a commercial feed mill in Jalisco, Mexico
    - Temperature ranged from 2 to 28 degrees C
    - Average high temperature 25 degrees C
    - Average low temperature was 8.4 degrees C
  - No rancidity was detectable

Fat Stability of DDGS in Taiwan

- Study conducted at Lin-Fong-Ying Dairy Farm
  - a commercial dairy farm located about 20 km south of the Tropic of Cancer
  - DDGS was shipped from Watertown, SD to Taiwan in a 40 ft. container
  - Upon arrival in Taiwan, DDGS was re-packaged in 50 kg feed bags with a plastic lining
  - DDGS bags were stored in a covered steel pole barn for 10 weeks during the course of the dairy feeding trial
Temperature-Humidity-Index (THI) During the Taiwan DDGS Fat Stability Trial

Fat Stability of DDGS in Taiwan

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Week 1</th>
<th>Week 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peroxide value, mEq/kg</td>
<td>0.70</td>
<td>0.60</td>
</tr>
<tr>
<td>Free fatty acids, % as oleic</td>
<td>11.2</td>
<td>16.2</td>
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</tbody>
</table>

Peroxide values < 5 mEq/kg are considered acceptable for fat quality and there is no oxidative rancidity.

U of M DDGS Web Site
www.ddgs.umn.edu

We have developed a DDGS web site featuring:
* research summaries
  - swine, poultry, dairy, & beef
  - DDGS quality
* presentations given
* links to other DDGS related web sites
* international audiences