DDGS: An Evolving Commodity

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Animals Require Nutrients on a Daily Basis
Feed Ingredients Supply Nutrients in Different Amounts and Forms

- **Fat**: 9 kcal, 1 gram
- **Carbohydrates**: 4 kcal, 1 gram
- **Protein**: 4 kcal, 1 gram

**Energy Breakdown**
- **Gross Energy in Feed**
  - Energy
  - Digestible (70%)
  - Metabolizable (60%)
- **Losses**
  - Energy
  - Losses in urine (5%)
  - Losses in gas (5%)
  - Loss in feces (30%)
- **Net Energy** (40%)
  - Losses as heat (20%)
  - 1. fermentation
  - 2. nutrient metabolism
  - 3. heat to keep warm
  - Net energy for production
  - 1. reproduction
  - 2. growth
  - 3. milk
  - Net energy for maintenance
  - 1. basal metabolism
  - 2. activity
  - 3. heat to keep warm
Nutritionist’s Job: Develop the least expensive “recipe” of feed ingredients that will meet an animal’s nutrient requirements.
All Corn Co-Products are “Packages of Nutrients” of Varying Composition and Value

DDGS  Corn Gluten Feed  Corn Gluten Meal  Corn Germ Meal
Why Are Ethanol Co-Products Changing?

- $$$
  - Narrow margins for ethanol cause implementation of technology to:
    - increase efficiency
    - reduce costs
    - increase diversity and revenues from co-products
Dry-Grind Ethanol and Co-Product Production
Front-End Fractionation

A closer look at the composition of a corn kernel.

The pericarp is the outer covering that protects the kernel and preserves the nutrient value inside. It resists water and water vapor — and is undesirable to insects and microorganisms.

The germ is the only living part of the corn kernel. The germ contains the essential genetic information, enzymes, vitamins and minerals for the kernel to grow into a corn plant. About 25 percent of the germ is corn oil — the most valuable part of the kernel, which is high in polyunsaturated fats and has a mild taste.

The endosperm accounts for about 82 percent of the kernel’s dry weight and is the source of energy (starch) and protein for the germinating seed. Starch is the most widely used part of the kernel and is used as a starch in foods — or as the key component in fuel, sweeteners, bioplastics and other products.

The tip cap is the attachment point of the kernel to the cob, through which water and nutrients flow — and is the only area of the kernel not covered by the pericarp.

- High Protein DDGS
- Corn Bran
- Dehydrated Corn Germ
- De-hulled, De-germed Corn
- De-oiled DDGS
Back-End Oil Extraction

Reduced-oil DDGS (5 to 9% crude fat)
Oil Extraction in the U.S. Ethanol Industry

- Industry adoption
  - ~ 60 to 70% of ethanol plants are extracting oil

- Oil uses
  - > 50% in biodiesel production
  - < 50% in blended feed-fats (primarily by the poultry industry)

- Impact on DDGS
  - Reduced MT of DDGS
  - Reduced energy content and feeding value
    - Crude fat ranges from 5 to 13%
    - Most reduced-oil DDGS is 8 to 9% crude fat
  - Research is being conducted to evaluate this impact
“Back-End” Oil Extraction Process

Approximately 30% of corn oil may be removed with Method 1.

Method 1 and 2 will remove ~65-70%.

- **Corn** → **Fermentation**
  - Ethanol
  - **Thin stillage** ← **Whole stillage**
    - **Extraction Method 1**
      - Crude Corn Oil
      - Bran for Feed
    - **Extraction Method 2**
      - Corn Oil
      - Feed
      - Syrup
How Does Oil Extraction Affect Energy and Feeding Value of Reduced-Oil DDGS?
Impact of Reduced-Oil DDGS on ME Content for Swine
What Have We Learned?

- **Crude fat content DOES NOT accurately estimate ME in reduced oil-DDGS**

- **Fiber is a significant determinant of ME** but its measurement is highly variable

- **ME prediction equations have been developed** for reduced-oil DDGS:
  
  - ME kcal/kg DM = (0.90 × GE, kcal/kg) – (29.95 × % TDF)
  
  - ME kcal/kg DM = (0.94 × GE, kcal/kg) – (23.45 × % NDF) – (70.23 × % Ash)
  
  - ME kcal/kg DM = 4,548 – (49.7 x % TDF) + (52.1 x % EE)
  
  - ME kcal/kg DM = 3,711 – (21.9 x % NDF) + (48.7 x % EE)
  
  - ME kcal/kg DM = 4,132 – (57.0 x % ADF)
Impact of Reduced-Oil DDGS on AME Content and Performance for Poultry
# Reduced-Oil DDGS Nutrient Profiles

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Normal DDGS</th>
<th>Medium Oil DDGS</th>
<th>Low Oil DDGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein, %</td>
<td>28.9</td>
<td>28.3</td>
<td>27.5</td>
</tr>
<tr>
<td><strong>Crude fat, %</strong></td>
<td><strong>11.2</strong></td>
<td><strong>7.3</strong></td>
<td><strong>5.6</strong></td>
</tr>
<tr>
<td>Crude fiber, %</td>
<td>7.4</td>
<td>6.9</td>
<td>6.8</td>
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<tr>
<td>Lysine, %</td>
<td>1.00</td>
<td>0.86</td>
<td>0.83</td>
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<tr>
<td>Methionine, %</td>
<td>0.55</td>
<td>0.58</td>
<td>0.55</td>
</tr>
<tr>
<td>Cysteine, %</td>
<td>0.74</td>
<td>0.70</td>
<td>0.57</td>
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<tr>
<td>TSAA, %</td>
<td>1.19</td>
<td>1.28</td>
<td>1.12</td>
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<tr>
<td>Phosphorus, %</td>
<td>0.98</td>
<td>0.84</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Source: Purdum and Kreifels (2012)
What Have We Learned?

- **NO EFFECT on layer performance** when feeding reduced-oil DDGS vs. “typical” DDGS.
  - % Egg production
  - Egg weight
  - Feed conversion

- **Feed intake slightly increases** (2 to 2.4 g/d) when fed reduced-oil DDGS diets.

- **Layers will be less affected than broilers** when fed reduced-oil DDGS because of lower diet ME requirements.

- **AME\textsubscript{n} can be estimated** by using the following equation:

  \[ \text{AME}_n (\text{kcal/kg DM}) = 3,517 - (33.27 \times \% \text{ hemicellulose}) + (46.02 \times \% \text{ crude fat}) - (82.47 \times \% \text{ ash}) \]  
  \[ \text{Rochelle et al. (2011)} \]
Impact of Reduced-Oil DDGS on Milk Production of Lactating Dairy Cows
What Have We Learned?

- Feeding diets containing up to 30% de-oiled DDGS (3.5% fat):
  - **Had no effect on:**
    - Dry matter intake
    - Crude protein intake
    - Nitrogen efficiency
    - Milk yield
    - Milk protein yield
  - **Increased:**
    - Milk production efficiency
    - Milk fat % and milk fat yield
    - Milk protein % (quadratically)
    - Milk total solids %
Impact of Reduced-Oil DDGS on Performance and Carcass Composition of Beef Cattle
What Have We Learned?

- Feeding reduced-oil DDGS (6.7% crude fat):
  - Growth performance and carcass quality
    - Reduced-oil DDGS = corn
    - Reduced-oil DDGS < “typical” DDGS (12.9% crude fat)
  - 1 percentage point ↓ in oil content = 1.3% ↓ in NE$_g$
What Are the Future Co-Product Possibilities?
Blends of various non-traditional corn co-products produced in small amounts (i.e. hominy feed, corn gluten, dried liquids) will be combined with DDGS to add value.

Branded corn co-products that have unique feeding applications, value, and are distinctly different than “commodity” co-products may become available.

Co-product “value enhancers” which may consist of enzymes, probiotics, or other additives may be added to DDGS to increase nutritional value for specific feeding applications.
New Yeast Strains Used in Ethanol Production May Alter Co-Product Composition

More complete carbohydrate conversion to ethanol will reduce starch and fiber content (energy value).
Isobutanol Co-products – Will They Be Different Than DDGS?
Moving Toward Advanced Cellulosic Ethanol Production

Fuel Biorefinery

- Daily processing of 2,200 dry tons of corn stover ($65/MT) produces:
  - 131 million L of ethanol
    - 51% of revenue
  - 129,000 tons of dried feed yeast
    - 42% of revenue with a price of $0.70 to $1.20/kg
    - Current market for feed yeast is $0.80 to $3.00/kg
  - 168,000 tons of lignin-rich “green coal”
    - 7% of revenue
Dried Yeast Co-Product

High protein (46%) and high digestible amino acid source
New Co-Products from Advanced RIN

Several non-traditional feedstocks may be used to produce ethanol and co-products under the Advanced RIN (Renewable Identification Number) designation.
MycoMeal - Fungi for Feed

- **Produced from thin stillage** (van Leeuwen, 2012)
  - 0.1 to 0.15 lbs DM per gallon of thin stillage
  - Reduces ethanol production energy cost by reducing cost of evaporation

- Contain **2x energy content of corn and DDGS**

- **High amino acid content**
  - allows replacement of soybean meal and fish meal in diets

- Soon to be available for sale through MycoInnovations
Other Potentially Evolving Co-Products

- Dried condensed solubles
- Dried liquid extractives
- Low fiber DDGS
- Reduced phosphorus DDGS
- Algae co-products
Final Thoughts

- The more things change...
  - As the co-product composition changes, **research is needed** to determine:
    - Benefits and limitations
    - Optimal dietary inclusion rates
    - Which animal species obtains the highest value

- The more they stay the same...
  - **Ethanol co-products have always had value in animal feeds**
    - Value depends on energy, protein (amino acid), and phosphorus content
    - Value varies by animal species