Fractionation, Feed Ingredient Allocation, and Environmental Balance of Corn to Ethanol

Fuel Ethanol Workshop
June 14-16, 2010
Updated for IGQI Advisory Committee

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Iowa State University
University Extension
## Corn Composition

<table>
<thead>
<tr>
<th></th>
<th>Starch</th>
<th>Protein</th>
<th>Oil</th>
<th>Ash</th>
<th>Sugar</th>
<th>Fiber</th>
<th>Total</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Corn</td>
<td>73.4</td>
<td>9.1</td>
<td>4.4</td>
<td>1.4</td>
<td>1.9</td>
<td>9.8</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Endosperm</td>
<td><strong>87.6</strong></td>
<td>8.0</td>
<td>0.8</td>
<td>0.3</td>
<td>0.6</td>
<td>2.7</td>
<td>100</td>
<td>82.9</td>
</tr>
<tr>
<td>Germ</td>
<td>8.3</td>
<td>18.4</td>
<td><strong>33.2</strong></td>
<td>10.5</td>
<td>10.8</td>
<td>18.8</td>
<td>100</td>
<td>11.0</td>
</tr>
<tr>
<td>Bran</td>
<td>7.3</td>
<td>3.7</td>
<td>1.0</td>
<td>0.8</td>
<td>0.3</td>
<td><strong>86.9</strong></td>
<td>100</td>
<td>6.1</td>
</tr>
</tbody>
</table>

**Why Fractionate?**
- ✔ Improved fermenter efficiency
- ✔ Reduced energy usage
- ✔ Reduced water usage
- ✔ Diversified product stream (? +/-)
- ✔ Policy justification/more EtOh

After: 2009 FEW Conference presentation by Reg Ankrom (CPT)
## Percentage of Total Nutrients in Corn Fractions

<table>
<thead>
<tr>
<th></th>
<th>Endosperm</th>
<th>Germ</th>
<th>Bran</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch</td>
<td>99</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Protein</td>
<td>73</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>Oil</td>
<td>15</td>
<td>83</td>
<td>1</td>
</tr>
<tr>
<td>Ash</td>
<td>18</td>
<td>83</td>
<td>3</td>
</tr>
<tr>
<td>Sugar</td>
<td>26</td>
<td>63</td>
<td>1</td>
</tr>
<tr>
<td>Fiber</td>
<td>23</td>
<td>21</td>
<td>54</td>
</tr>
<tr>
<td>Lysine</td>
<td>47</td>
<td>32</td>
<td>21</td>
</tr>
<tr>
<td>Lysine % product</td>
<td>0.18</td>
<td>0.90</td>
<td></td>
</tr>
<tr>
<td>Lysine % protein</td>
<td>2.2</td>
<td>4.9</td>
<td></td>
</tr>
</tbody>
</table>
Overall = 2.1 bu/a/yr; Last 10= 3.5 bu/a/yr; Seed industry = 4-6 bu/a/yr (forward)
~400-500 million bu/year increase
Nitrogen use: 1.0-1.1 lb/bu down to 0.7 lb/bu
Corn Use

Billion bushels


Source: USDA
Based on the pace over the 1st 2 months of 2010,

Ethanol:
- 2010: 7.0 Billion gallons
- 1980: 0.0 Billion gallons
- 1982: 0.0 Billion gallons
- 1984: 0.0 Billion gallons
- 1986: 0.0 Billion gallons
- 1988: 0.0 Billion gallons
- 1990: 0.0 Billion gallons
- 1992: 0.0 Billion gallons
- 1994: 0.0 Billion gallons
- 1996: 0.0 Billion gallons
- 1998: 0.0 Billion gallons
- 2000: 0.0 Billion gallons
- 2002: 0.0 Billion gallons
- 2004: 0.0 Billion gallons
- 2006: 0.0 Billion gallons
- 2008: 0.0 Billion gallons
- 2010: 0.0 Billion gallons

Corn:
- 2010: 6.0 Billion bushels
- 1980: 0.0 Billion bushels
- 1982: 0.0 Billion bushels
- 1984: 0.0 Billion bushels
- 1986: 0.0 Billion bushels
- 1988: 0.0 Billion bushels
- 1990: 0.0 Billion bushels
- 1992: 0.0 Billion bushels
- 1994: 0.0 Billion bushels
- 1996: 0.0 Billion bushels
- 1998: 0.0 Billion bushels
- 2000: 0.0 Billion bushels
- 2002: 0.0 Billion bushels
- 2004: 0.0 Billion bushels
- 2006: 0.0 Billion bushels
- 2008: 0.0 Billion bushels
- 2010: 0.0 Billion bushels

Sources: Renewable Fuels Association, Energy Information Administration
## Iowa Ethanol Production and Corn Usage

<table>
<thead>
<tr>
<th>Summary Statistics May-2010</th>
<th>n</th>
<th>Ethanol Produced mil gal/ yr</th>
<th>Corn Used mil bu/ yr</th>
<th>DGS 000 tons/ yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Dry-grind Plants</strong></td>
<td>34</td>
<td>3,280</td>
<td>1170</td>
<td>10,237</td>
</tr>
<tr>
<td><strong>Expansions and new construction</strong></td>
<td>1</td>
<td>277</td>
<td>98</td>
<td>857</td>
</tr>
<tr>
<td><strong>Wet Mills</strong></td>
<td>4</td>
<td>500</td>
<td>178</td>
<td>1,557</td>
</tr>
<tr>
<td><strong>Nearby Iowa</strong></td>
<td>11</td>
<td>636</td>
<td>227</td>
<td>1,986</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50</td>
<td>4,693</td>
<td>1,673 (69% of 2009)</td>
<td>14,637</td>
</tr>
</tbody>
</table>
Are We Running Out of Corn?

U.S. Corn Ending Stocks
(million bushels)

Sources: USDA - National Ag Statistics Service and Economic Research Service
What's in an Acre of Corn?

- Protein (lb/acre)
- Oil (lb/acre)
- Ethanol (gal/acre)

What's in an Acre of Corn?

Lysine (lbs/acre)


Lysine
Typical Fractionation Products

- Ethanol (less); 2% ↓ = 0.06 gal/bu
- DDGS @ 42-47% protein; lower quality but more digestible (IL, SD studies)
- Bran
- Oil; ~1.4 lb/bu @ 80% extraction of germs (up to 0.6 - 0.7 bgy of biodiesel @ 80% conversion on 4 bln bu of corn)
Drying Costs

- EPA estimates (2007): 32,300 BTU/gal
- Equates to 2636 BTU/lb of water
  - 70% moisture DDGS dried to 12%

Impact of Fractionation

<table>
<thead>
<tr>
<th>Lb DDGS/ bu</th>
<th>BTU/bu</th>
<th>% of Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.8</td>
<td>90440</td>
<td>43%</td>
</tr>
<tr>
<td>13.5</td>
<td>68785</td>
<td>33%</td>
</tr>
</tbody>
</table>
Capital Costs

- Range from $10 million to $40 million for a 50 million gallon ethanol plant
- The inclusion of corn oil extraction technologies moves costs to the higher end of the spectrum
- Most vendors point to a payback period of under 3 years

Variable Costs

- Decreased energy needs per gallon for:
  - Liquidification and cooking
  - Distillation
  - Drying of distillers grains and solubles
- Possible energy generation from bran
- Could reduce energy demand by nearly 50%
Product Streams - Example

Corn costs: $3.48 per bushel, Illinois ethanol plant report (USDA-AMS, as of May 28, 2010)

Traditional ethanol plant:
- 2.8 gallons of ethanol @ $1.58/gallon = $4.42
- 17.75 lbs. of DDGS @ $116.71/ton = $1.04
- Revenues per bushel = $5.46

Ethanol plant w/ fractionation:
- 2.72 gallons of ethanol @ $1.58/gallon = $4.30
- 13.5 lbs. of high protein DG @ $127/ton = $0.86
- 5 lbs. of germ @ $148/ton = $0.37
- 3 lbs. of bran @ $65/ton = $0.10
- Revenues per bushel = $5.63
Summary

• Fractionation:
  – Improves energy efficiency and water use
  – Creates more and different products
  – Strengthens justification for corn to ethanol
  – Makes more material available to monogastric animals (swine, poultry, people)

• Need
  – Update of policy information; complete system
  – Analytics and feed formulation
  – Marketing strategies; cost analysis
  – Financing justification
Cooperation with fractionation companies

3-4 companies have offered to work with us to help us analyze and describe the possible co-products from a dry-grind ethanol plant that incorporates front-end fractionation. It will also describe efficiencies gained (or lost) by incorporating fractionation and changes in GHG generation.

A recent discussion with engineers from one of the companies raised the following questions:
• Will fractionation help reduce the sulfur content in distillers grains?
• Will fractionation help reduce phosphorus levels in distillers grains?
• In what fractions would mycotoxins be accumulated?
• Can fractionation help reduce the need for antibiotics in the fermenters?

This company’s justification for adding fractionation greatly depends on the value of food-grade oil. We propose to assume that oil will be fuel-grade and focus more on the value of the nutrients in the various fractions.
Where To Find Us…

Iowa Grain Quality Initiative

Grain Quality Laboratory

www.iowagrain.org

www.grainlab.org

Analytical Programs
Quality Management Systems

Iowa State University
University Extension