Corn Ethanol Byproducts

Lou Armentano
University of Wisconsin-Madison
Limits to Feeding DGS

- Has been successfully fed in research up to 30% of TMR DM
  - (= about 15# DM/day)!!
  - Field feeding rates much lower
- Limitations:
  - oil (limitation if other high oil feeds fed)
  - protein
    - consider total RDP, RUP, and RUP-Lysine
    - undegradable (zein) protein is lowest in Lysine which is a problem, complement with blood meal
  - Phosphorous
    - not a performance problem but could violate nutrient management plans
Whole Corn
Corn Gluten Feed Pellet
Corn Gluten Meal- 60% CP
Corn Gluten Feed- Loose
Dried Distillers Grain
Distillers Grain - solubles
Corn Grain

Corn Grain (Caryopsis)

- endosperm
- cotyledon
- coleoptile
- plumule
- radicle
- coleorhiza

{Starch trapped in Zein Protein ‘net’}

Germ:
primarily
fat and
protein

Bran (pericarp): mainly Fiber
### Mass and composition of corn grain fractions

<table>
<thead>
<tr>
<th></th>
<th>Grain</th>
<th>Germ</th>
<th>bran</th>
<th>endosperm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kernel DM</td>
<td>100%</td>
<td>11.1%</td>
<td>6.1%</td>
<td>82.9%</td>
</tr>
<tr>
<td>Starch</td>
<td>73.4%</td>
<td>8.3%</td>
<td>7.0%</td>
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<tr>
<td>Protein</td>
<td>9.1%</td>
<td>18.4%</td>
<td>4.5%</td>
<td>8.0%</td>
</tr>
<tr>
<td>Oil</td>
<td>4.4%</td>
<td>33.2%</td>
<td>1.1%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Ash</td>
<td>1.4%</td>
<td>10.5%</td>
<td>0.9%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Sugars</td>
<td>1.9%</td>
<td>10.8%</td>
<td>0.5%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Residual</td>
<td>9.8%</td>
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<td>2.7%</td>
</tr>
<tr>
<td>Phosphorous</td>
<td></td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiber</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Lysine</td>
<td>Low</td>
<td>Average</td>
<td>Very Low</td>
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</tr>
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</table>

Corn Chemistry and Technology S.A. Watson and P.E. Ramstad (via QTI)
‘Extraction’ computations

<table>
<thead>
<tr>
<th></th>
<th>Grain - Starch</th>
<th>Germ - oil</th>
<th>endosperm - starch</th>
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<tbody>
<tr>
<td></td>
<td>DGS?</td>
<td>Germ meal</td>
<td>Gluten meal?</td>
</tr>
<tr>
<td>Starch</td>
<td>0%</td>
<td>14.6%</td>
<td>0%</td>
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<tr>
<td>Protein</td>
<td>34.2%</td>
<td>32.4%</td>
<td>64.5%</td>
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<tr>
<td>Oil</td>
<td>16.5%</td>
<td>0%</td>
<td>6.5%</td>
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<tr>
<td>Ash</td>
<td>5.3%</td>
<td>18.5%</td>
<td>2.4%</td>
</tr>
<tr>
<td>Sugars</td>
<td>7.1%</td>
<td>19.0%</td>
<td>4.8%</td>
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<tr>
<td>Residual</td>
<td>36.8%</td>
<td>15.5%</td>
<td>21.8%</td>
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<tr>
<td>Phosphorous</td>
<td>High</td>
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</tr>
<tr>
<td>Lysine</td>
<td>Low</td>
<td>Average</td>
<td>Lower</td>
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Nutrient Content of Corn Distillers Grains and Corn Condensed Distillers Solubles

Jerry Shurson, U of Minnesota
Slide by Bob Kaiser
Classic Wet Milling

• separation (independent of fermentation) of
  ◦ bran $\rightarrow$ gluten feed
  ◦ germ
  ◦ endosperm starch
  ◦ endosperm protein (zein) $\rightarrow$ gluten meal
• Germ can be ‘crushed’
  ◦ oil
  ◦ germ meal
• Starch can be:
  ◦ sold as starch
  ◦ converted enzymatically to sugars (corn syrup)
  ◦ or fermented and distilled to Ethanol
    • this is NOT the recent or projected growth in Ethanol
Classic Dry Milling for Ethanol production

- Common in older beverage and most recent fuel plants
- No physical separation of corn grain parts (germ, bran, endosperm) prior to fermentation
  - grinding without separation
- Enzymatic digestion of starch to sugars
- Yeast ferment sugar to Ethanol
- Liquid with suspended and dissolved material (thin stillage) separated from ‘cake’
- produces solubles (S) and cake (DG)
- usually marketed together as DGS either wet (DWGS) or dried (DDGS)

Corn
  ↓
  grinding and hydrolysis
  ↓
  Mash
  ↓
  fermentation
  ↓
  Carbon Dioxide Ethanol Whole Stillage Solids + Solubles
  ~1/3
  ~1/3
  distillation

  ↓
  Carbon Dioxide Ethanol Whole Stillage Solids + Solubles

Centrifuge

Thin Stillage
  ↓
  Evaporators

Distillers Grains
  ↓
  Condensed solubles

Drier

Distillers Grains w solubles
  rare

Condensed solubles
  rare
New processes

- Add separation prior to fermentation
  - bran
  - germ
  - endosperm
- Entire endosperm (and only endosperm) is fermented
  - low fiber stillage results
- Bran, germ meal, oil, high protein DG, and solubles may be recombined in numerous ways!!
3 Players in New ‘prefermentation’ separations

• Broin B-frac process
  ◊ A dry process front end to Broin Plants
    • Dakota Gold HP™
    • Bran plus syrup → Dakota Bran™
    • Corn Germ Dehydrated

• Solaris (Corn Value Products) (AMG+Centrisys+QTI)
  ◊ wet front end to existing dry ethanol plants
  ◊ bran → Nutrafiber
  ◊ bran + solubles → Probran
  ◊ solids from fermentation → Glutenol XP
  ◊ solids and solubles from fermentation → Glutenol
  ◊ bran + solubles + solids → Energia™
  ◊ products listed above have no germ
    • therefore low in fat and P
3 players continued

• Renessen
  ◊ Cargill + Monsanto Partnership
  ◊ combined dry pre-fermentation processing + corn genetics
    • Mavera hi-lysine (.4%), hi-oil (6.8%), protein enriched (9.9%) corn
    • will mean more $/lb starch bought by plant but premilling puts hi-starch endosperm stream in fermentors
  ◊ emphasis on germ meal for swine and oil for food or biodiesel
  ◊ lower fat, lower P DDGS should result
  ◊ NDF? maybe lower
Solaris-QTI initial estimates (90% DM basis)

<table>
<thead>
<tr>
<th></th>
<th>nutra fiber</th>
<th>probran</th>
<th>glutenol</th>
<th>energia</th>
<th>common DDGS</th>
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<tr>
<td>CP</td>
<td>6.8</td>
<td>9.5</td>
<td>45.0</td>
<td>30.0</td>
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<tr>
<td>Fat</td>
<td>1.5</td>
<td>2.0</td>
<td>3.3</td>
<td>2.5</td>
<td>8.8</td>
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<tr>
<td>Fiber (Crude)</td>
<td>17.1</td>
<td>16.6</td>
<td>3.8</td>
<td>8.2</td>
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<tr>
<td>P</td>
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## Broin Products (% of DM)

<table>
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<tr>
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<td>0.92%</td>
<td>0.50%</td>
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<td>1.02%</td>
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<td>3.42%</td>
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*note milk protein is ~7% Lysine*
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Distillers vs. brewers grains

• Brewers grains is partly or completely from barley
• Barley used for beer:
  ◊ Malt sprouts (from malt house)
  ◊ Brewers grains (from brewery)
    • no fermentation
    • brewers grains spun out of fermented mash
    • we drink liquid mash (no solubles stream)
    • If Barley used for ethanol get Barley DG or DGS
  ◊ Brewers yeast
  ◊ Spent hops
  ◊ May include residue from other starch sources (corn, rice etc.)
• Brewers grains often sold wet as well
A totally tangential slide

- Wheat and Barley are the oldest cultivated grains
- Wheat was selected to make bread and other baked goods
  ◊ bred to easily shed the hull
- Barley bred for Beer production
  ◊ if keeps hull firmly attached it is easier to filter from beer!