CORN BY-PRODUCTS IN DAIRY COW RATIONS

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Grain corn, corn silage and corn by-products are a predominant part of most dairy rations. Increasing amounts of corn being are used by other industries to manufacture products such as ethanol, corn syrup and oil. The by-products from these industries can be an excellent source of protein and energy for dairy cows.

Alternative Corn Products:

**Snaplage** – Snaplage differs from high moisture ear corn (HMEC) as it contains the grain, cob and husk parts of the cob. HMEC contains only the kernel and the cob. Snaplage is higher in fiber and lower in energy and protein compared to high moisture grain or ear corn. Even though snaplage is higher in fiber, it is not an effective fiber source due to its small particle size. Snaplage needs to be harvested and stored at a higher moisture to ensure good fermentation (~38% moisture). Packing snaplage is also more difficult due to the lower density of the cob and husk. If it is not packed adequately there is an increased risk of mold and mycotoxin development. Due to its’ husk content, snaplage will have a lower feeding value than corn.

<table>
<thead>
<tr>
<th></th>
<th>High Moisture Shelled Corn</th>
<th>High Moisture Ear Corn</th>
<th>Snaplage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn %</td>
<td>100%</td>
<td>80-84%</td>
<td>72-78%</td>
</tr>
<tr>
<td>Cob %</td>
<td>-</td>
<td>16-20%</td>
<td>16-19%</td>
</tr>
<tr>
<td>Husk %</td>
<td>-</td>
<td>-</td>
<td>6-8%</td>
</tr>
<tr>
<td>Dry Matter %</td>
<td>72</td>
<td>72</td>
<td>62</td>
</tr>
<tr>
<td>Crude Protein % of DM</td>
<td>10</td>
<td>8.9</td>
<td>8.7</td>
</tr>
<tr>
<td>NDF, % of DM</td>
<td>11</td>
<td>27</td>
<td>32</td>
</tr>
<tr>
<td>Nel (MJ/kg)</td>
<td>8.5</td>
<td>7.4</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Michigan State University and the University of Nebraska

**Corn Cannery Waste** – Corn cannery waste is a by-product from the sweet corn industry. It consists primarily of the husk, cob, cull ears and missed kernels. The nutrient content (on a dry matter basis) is similar to that of poorly eared field corn silage. It is a very wet product (dry matter generally varies from 20 to 25%). Due to the high moisture content acidity is generally higher with this by-product (resulting in a low pH for the product). This can result in lower dry matter intake in cows. Nutrient composition of the product can be highly variable. Like corn silage, it is low in protein and minerals. Cannery waste is best used in diets for low producing cows and older replacement heifers and can be fed up to 15 kg as fed/head/day.

**Corn Screenings** – Corn screenings consists of small whole corn grain, broken kernels, grain dust and chaff. Good quality screenings have a similar nutrient content to shelled corn. Consistency can also be a
concern. Screenings with a high level of grain husk will have a lower feeding value than a product that contains more grain. They are generally fine enough that they do not need any additional processing. One concern is mycotoxins. Screenings consist mostly of damaged corn kernels, which often contain higher levels of mold and mycotoxins. The chaff is also a major source of mycotoxins. Consequently, screenings should be tested for mycotoxins prior to feeding to cattle. Maximum feeding rate for corn screenings is 8 kg/head/day.

Industry Corn By-Products:

Corn is the main ingredient for the production of ethanol, corn starch and syrup. The by-products from these industries make excellent products that can be fed to dairy cows. Depending on the product they can be used to supply protein and/or energy in the ration.

There are four parts to the corn kernel: The pericarp, endosperm, germ and the tip cap.

The main function of the pericarp (also known as the seed coat) is to protect the kernel. It consists of the bran component of the kernel (hull & fiber). The endosperm represents 80% of the kernel. It consists mostly of starch (70% of the kernel) and the gluten fraction. The gluten fraction is high in protein. The germ fraction is high in oil. The milling industry processes and extracts different parts of the corn kernel to produce their main products. The remaining product is available for the cattle industry. There are two main industry processes that are responsible for producing corn by-products for the dairy industry: dry and wet milling.

Dry Milling

The dry milling industry produces ethanol from corn (however, other grains such as wheat, barley, rye and sorghum can be used). In the dry milling process corn is cleaned and ground into a coarse flour (see appendix 2 for dry milling process). Water and enzymes are then added to convert the corn starch to sugar. This product is then cooked and sterilized. After cooling, yeast is added to convert the sugar to ethanol and carbon dioxide. The resulting mash is sent to distillation where the ethanol is extracted. The remaining products can be used for cattle feed. These products include:

1. **Distillers grains** are produced by separating the resultant coarse grain fraction from the thin stillage. It can be dried to produce dry distillers grain or left wet producing wet distillers grains.
Wet distillers grains contain approximately 65-75% moisture. Typical nutrient analysis is in appendix 1. Distillers grains (both wet and dry) are over 50% rumen undegradable protein and are high in fat. Dried distillers grains can be fed up to 2.5 kg/head/day. Wet distillers can be fed up to 10-11 kg/head/day.

2. **Distillers solubles** is produced by condensing the thin stillage fraction and centrifuging it to a semi solid state. The dry matter content can range from 8 to 26%. Maximum intake of distillers solubles is 3.5 kg/head/day. In the majority of cases the solubles are added back to the distillers grain at the ethanol plant.

3. **Distillers dried grains with solubles** is most common by-product. The solubles left over from the fermentation are added back into the grain. They are a good source of rumen undegradable protein and can be fed at 2.5 kg/head/day.

In an ethanol plant for every 25 kg of corn produces approximately 10-11 liters of ethanol, 8.2 kg of dry distillers grains with solubles and 8.2 kg of carbon dioxide. Distillers are a very palatable product. However, if distillers grains are heat damaged during the drying process they will have a lower feeding value as they are generally less palatable and digestible. Usually heat damaged distillers will have a dark colour with a burnt odour.

**Wet Milling**

The wet milling industry produces corn oil and syrup. In the wet milling process (appendix 3 for process) the corn kernel is initially cleaned. The corn is steeped (by adding water and sulfur dioxide to the corn) for 30 to 35 hours to soften the kernel for further processing. In the soaking process nutrients migrate into the water (the liquid product is called steep liquor). When the steeping is complete, this liquor is drawn off and concentrated. The corn germ is separated from the kernel and processed to remove the oil. The remaining portion of the kernel (consisting of the bran, gluten and starch) is screened and the bran is removed. The bran is mixed with steep liquor producing wet corn gluten feed. If the product is dried, dry corn gluten feed is produced. Approximately 5.5-6 kg of dry corn gluten feed is produced per 25 kg of corn. The gluten fraction is removed producing corn gluten meal. The starch is further processed to make syrup.

**Corn Gluten Feed** – The protein content of corn gluten feed ranges from 19 to 25% protein (see appendix 1 for typical nutrient analysis). It consists of corn bran (approximately 2/3 of the product) and steep liquor (remaining portion ~1/3). Corn gluten feed is very high in degradable protein (about 80% of the crude protein). It is low in starch, calcium and potassium and is high in phosphorus relative to corn. It is also high in sulfur. It has an energy level comparable to barley. Corn gluten feed can vary in colour. Corn gluten feed darkens with increased drying time and increasing levels of steep water added. Extremely dark corn gluten feed having a burnt smell may be a sign of heat damage. This product is less palatable and may have a lower nutrient availability.

Corn Gluten Feed can either be fed in the dry or wet form. The dry matter of wet corn gluten is about 45%. Dry corn gluten feed can be fed up to 2.5 kg/head/day. Feeding higher levels will decrease palatability of the ration. Wet corn gluten feed can be fed up to 8 kg/head/day as fed.

**Corn Gluten Meal** – Corn gluten meal contains the gluten fraction of the corn kernel from the wet milling process. There are two forms of corn gluten meal. The most common is a high protein product (60% protein) that is high in rumen undegradable protein. The other form is a 40% protein product. It
contains both the bran and gluten fraction of the kernel. The upper feeding limit for corn gluten meal is 1.5 kg/head/day. Palatability can be a problem when fed at higher levels.

**Hominy** – Another corn by-product that can be fed to dairy cattle is corn hominy. Hominy is a by-product of corn used for human consumption. Hominy consists of the bran, corn germ and a portion of the starch component of the corn kernel. It is higher in energy, protein, fat and fiber than the original corn grain. Fat levels can vary from 5-12%. Hominy is lower in starch. The NDF level is higher than corn but the effective NDF is low because of its fine particle size. Hominy is a very palatable product and can be fed at the same level as regular corn. Due to the high fat content there is an increased risk of rancidity during hot weather.

**Considerations in Feeding Corn By-products:**

Corn by-products can be an economical commodity to feed. However, their use needs to be managed properly to get the best performance from them. Product availability is important. If a by-product is not available on a consistent basis it should not be used. Some other things to consider when using corn by-products include:

**Wet vs. Dry By-Products:**

When deciding what form to feed several factors should be considered. Distance from the plant, how much by-product is going to be fed, on farm storage facilities and handling equipment all need to be considered. Wet products generally do not store well for long periods of time (especially in hot weather). In the summer wet products need to be fed within 7-10 days to keep it fresh and prevent deterioration. In the winter wet by-products will last 2-3 weeks. Wet products are generally associated with higher shipping costs and are ideally suited for farms located relatively close to the by-product plant. Dry products are usually best suited for farms located further away. Shrink loss of the product also needs to be considered. Shrink losses are due to a number of things including: wind and water loss, type of product (i.e. wet vs dry), spoilage, runoff and vermin. For example, typical shrink loss for corn distillers would be:

<table>
<thead>
<tr>
<th></th>
<th>Open Uncovered Piles</th>
<th>Commodity Bay</th>
<th>Closed Bulk Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Distillers</td>
<td>15-22%</td>
<td>7-10%</td>
<td>3-6%</td>
</tr>
<tr>
<td>Wet Distillers</td>
<td>15-40%</td>
<td>15-40%</td>
<td></td>
</tr>
</tbody>
</table>

Wet products will have a higher shrink loss compared to dry products. Products stored in open uncovered piles will have significantly higher shrink loss than those stored in a protected environment. The amount of shrink can have a dramatic effect on the true cost of a by-product. Consider the use of dry corn distillers stored in a commodity shed as an example:

Buy 20 mt (20,000 kg) of distillers at $193/mt. This is 19.3 cents/kg. Farm has 300 cows consuming 1.75 kg/h/d of distillers on average. Then 1.75 kg x 300 cows = 525 kg/day of distillers being fed.
Shrink loss would be calculated by:
The load should last 20,000 kg/525 = 38 days. If the feed actually lasts only 35 days, then 3 days x 525 = 1575 kg is lost.
So 1575/20,000 = 7.9% of original load of distillers is lost as shrink.
The amount of distillers actually being fed is calculated as 1000 – 7.9% = 921 kg (or 92.1% or the original load).

The actual cost of shrink is calculated by:
The cost of distillers actually fed is $193/0.921 = $208.55/mt or 20.9 cents/kg (or an increase of 1.6 cents/kg or $16.55/mt)
Cost of distillers fed is 525 kg x 20.9 cents/kg = $109.73
Cost of distillers purchased is 525 kg x 19.3 cents/kg = $101.32
Difference is $8.41/day or 365 x 8.41 = $3070/year lost as shrink!!!

Over $3000/year is lost due to shrink (this is keeping shrink losses at 7.9%). If shrink losses are greater (as would be the case in storing products out in the open with no cover) the cost is going to be significantly greater. Minimizing shrink loss is critical to getting the best economical benefits from by-products.

Nutrient Content:
Corn by-products are low in calcium and contain high levels of phosphorus. This needs to be considered when balancing the ration. Corn by-products are also low in the amino acid lysine. Other sources of protein (such as soybean meal, canola meal, feather meal etc.) should be fed to balance the ration and meet the protein and amino acid requirements of dairy cows. Meeting these requirements is essential in optimizing milk production.

Nutrient Variability:
There can be significant variation in the analysis of by-products. For example, crude protein levels in distillers grains can vary from 25 to 35%. By-products cannot only vary from different manufacturing facilities but also from load to load from the same facility. Ideally an analysis for each load of product is done to ensure that the ration is balanced properly. If there are significant variations between loads, by-products should be fed at a lower rate to reduce the risk of ingredient variability affecting animal performance.

In summary, corn by-products can be an excellent component of dairy rations. However there are some things to consider in getting the most from them including: proper storage and handling to minimize shrink loss and ingredient deterioration and factoring ingredient variability. With proper handling and feeding management corn by-products can be an excellent product to utilize on farm.

Appendix 1.
Average Nutrient Analysis of Corn By-Products (As Fed Basis)
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Dried Distillers Grains</th>
<th>Distillers Dried Grains with Solubles</th>
<th>Distillers Dried Solubles</th>
<th>Corn Gluten Meal (61%)</th>
<th>Corn Gluten Feed, Dry</th>
<th>Hominy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter (%)</td>
<td>92.5</td>
<td>91.0</td>
<td>95.0</td>
<td>90.0</td>
<td>90.0</td>
<td>90.5</td>
</tr>
<tr>
<td>Crude Protein (CP) %</td>
<td>27.0</td>
<td>27.0</td>
<td>28.5</td>
<td>62.0</td>
<td>22.0</td>
<td>10.6</td>
</tr>
<tr>
<td>Undegradable Protein (% of CP)</td>
<td>57.0</td>
<td>47.0</td>
<td>-</td>
<td>69.0</td>
<td>20.0</td>
<td>55.0</td>
</tr>
<tr>
<td>ADF %</td>
<td>16</td>
<td>18</td>
<td>7</td>
<td>5</td>
<td>8.4</td>
<td>12</td>
</tr>
<tr>
<td>Fat %</td>
<td>7.6</td>
<td>8.0</td>
<td>9.0</td>
<td>2.5</td>
<td>3.8</td>
<td>6.0</td>
</tr>
<tr>
<td>Calcium %</td>
<td>0.1</td>
<td>0.27</td>
<td>0.3</td>
<td>0.02</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Phosphorus %</td>
<td>0.37</td>
<td>0.77</td>
<td>1.3</td>
<td>0.54</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Magnesium %</td>
<td>0.07</td>
<td>0.25</td>
<td>0.65</td>
<td>0.06</td>
<td>0.29</td>
<td>0.17</td>
</tr>
<tr>
<td>Potassium %</td>
<td>0.16</td>
<td>0.65</td>
<td>1.75</td>
<td>0.45</td>
<td>0.6</td>
<td>0.63</td>
</tr>
<tr>
<td>Sulfur %</td>
<td>0.43</td>
<td>0.3</td>
<td>0.37</td>
<td>0.83</td>
<td>0.23</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Appendix 2. Overview of Dry Milling Process

**Corn**
Appendix 3: Overview of Wet Milling Process
Shelled Corn

Corn Cleaners

Steep Tanks

Germ Separators

Grind Mills

Washing Screens

Centrifugal Separators

Starch Washing Hydro-Clones

Starch and Nutritive Sweeteners

Steepwater (Steep liquor)

Germ

Germ Separators

Germ Extractors

Corn Oil

Gluten

Corn Gluten Meal

Corn Gluten Feed

Corn Germ Meal

Condensed Fermented Corn Extractives