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Distillers Grain Coproducts for Beef Cattle

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Kentucky is known for its rich distilling history. For more than a century, distilleries across the state have taken grains from area farmers and converted them into bourbon. The process of making bourbon yields both spirits and livestock feed. This same process is at the foundation of today's fuel ethanol industry. With the rapid expansion of fuel ethanol production capacity in the early 2000s, approximately 35 percent of the corn grown is currently being utilized for the production of ethanol. This increased production has led to increased availability of grain-based ethanol coproduct feedstuffs. In the past, corn and soybean meal were the standard energy and protein sources in livestock diets. Today, coproduct feedstuffs provide unique opportunities to develop more cost-effective diets that provide similar performance for beef cattle. Discussing the distilling process will provide some insight on the grain by-products that are commonly used as livestock feed.

Milling Processes

The dry milling process is very similar to the processes utilized by feed mills and individuals who grind their own feed on the farm. Typically, the grains are received at the plant and then ground through a hammermill to achieve a very fine grind. The ground grain is then sent to a tank where it is combined with water. The temperature is increased and the pH adjusted to a range favorable for enzymes involved in the conversion of starch to smaller sugars. This conversion is known as "liquefaction" in the fuel industry and as "mashing" by the liquor industry. The mash temperature is raised to kill off wild yeast and other less desirable microorganisms that may reduce the ethanol yield. The mash is then cooled to a temperature favorable to both enzyme activity and yeast, which metabolize the sugars to ethanol and carbon dioxide during the fermentation.

This fermented mixture of yeast, ethanol, and spent grains is referred to as "beer." After the fermentation period, the beer is sent to the distillation area or still. The beer is heated, volatilizing the ethanol and leaving the spent grains and water, referred to as "whole stillage." The whole stillage may be centrifuged or passed through an auger with screens separating the larger grain particles from the liquid. This liquid fraction is known as "thin stillage" and is often sent to condensers to evaporate water and concentrate the nutrients, yielding *corn condensed distillers solubles* (CCDS). Some of the thin stillage may be reused and sent back to the beginning of the process for the next fermentation or, as in many bourbon distilleries, the thin stillage, commonly referred to as "slop," which contains about 6 percent dry matter, may be sold to local farmers.

The larger grain particles that were separated are often referred to as "wet cake." Most plants and distilleries add the condensed solubles to the wet cake. This combination is then often sold as *wet distillers grains with solubles,* which typically has a dry matter content of 28 to 35 percent. The product may be dried to produce a dry (approximately 90 percent dry matter) feedstuff known as *corn distillers dried grains with solubles* (DDGS). Some plants partially dry the wet cake with solubles to create a product called *modified distillers grains with solubles,* commonly 42 percent to 50 percent dry matter. Little difference exists in the chemical analysis of the wet, modified or dried distillers grains with solubles other than the amount of moisture. However, some feeding trials have shown the wet products to have a higher feeding value compared to the dry product.

Nutrient Content of Distillers Grains

Corn is comprised of approximately two-thirds starch, which is readily fermented by yeast to predominately ethanol and carbon dioxide. There is limited utilization of the other nutrients in corn during the fermentation process, which results in approximately a three-fold increase in the density of the remaining nutrients. For example, on a dry matter basis, the average crude protein of corn is near 9 percent; corn-based distillers grains often are near 30 percent. Fat increases from near 4 percent to 10 to 12 percent; phosphorus increases from 0.3 percent to 0.9 percent; and the neutral detergent fiber is concentrated from 10 percent to 30 percent.

The nutrient content of various corn-derived coproducts is listed in Table 1. It is important to note that a large degree a variation in nutrient content of distillers grains can occur. Multiple researchers have sampled various plants and reported the within-plant and across-plant nutrient variability for distillers grains. This large amount of variation can make it a challenge to properly balance diets for cattle. This variation also provides justification for obtaining or requesting a nutrient analysis for each load of coproduct obtained to allow for diet adjustments. In Table 2, information for dried distillers grains samples analyzed by Dairy One forage laboratory services is presented to demonstrate the range of nutrient concentration that can be observed for this feedstuff.

It is important to note that some of the variability associated with the coproduct feeds are a function of the variability of the raw ingredients themselves. Corn protein concentrations, for example, can

vary from variety to variety and year to year. Further, the type of grain used will impact the nutrient composition of the coproducts. The protein concentration of wheat-derived distillers grains will be greater than that of corn as wheat is higher in protein than corn. In addition, for Kentucky, the use of barley in the grist for the production of bourbon will alter the nutrient content slightly as the barley husk will increase the fiber concentration and slightly lower the digestibility and energy content compared to straight corn-based distillers grains.

Feeding Considerations

The nutrient content of distillers coproducts classifies these feedstuffs as both high-protein and high-energy alternatives. A large amount of research has been conducted studying the feeding value of these coproducts. With respect to energy, distillers grains have equal to slightly greater feeding value in comparison to corn. Also, the majority of research suggests that when used as a protein source it is equivalent to soybean meal and other sources of protein for beef cattle diets.

The nutrient profile of distillers grains, however, does result in the need for some caution. The high fat content of some of these grain coproducts limits their inclusion rates on forage-based diets and is discussed below in more depth. The use of sulfur dioxide and sulfuric acid in the process can yield feeds that exceed the reported maximum tolerable level of dietary sulfur of 0.40 percent. High feeding rates of these coproducts can increase the total dietary sulfur concentrations near the maximum tolerable level, increasing the risk of cattle developing polioencephalomalacia (PEM). In Kentucky, this risk is further exacerbated by sulfur spring water or high sulfate concentrations in water sources for cattle. The combined feed and water sulfur intake can increase the risk of PEM. Most bourbon sources of distillers coproducts will be lower in sulfur than the currently available fuel ethanol coproducts. Bourbon distillers grains typically average near 0.40 percent sulfur. Thus, caution is warranted when feeding these coproducts containing elevated sulfur levels to cattle, especially those that have access to high-sulfate water.

When feeding moderate rates of distillers coproducts, the mineral supplementation program will need to be modified. The high level of phosphorus in distillers coproducts will cause an imbalance in the calcium to phosphorus ratio. Using a low to near 0 percent phosphorus mineral supplement that is also higher in calcium (20 percent or greater) will help to achieve a proper calcium to phosphorus ratio. Many companies today offer coproduct mineral packages that are higher in calcium in an attempt to balance this ratio; they often include thiamine to assist in reducing the risk to PEM. In many situations, the addition of feed grade limestone or calcium carbonate will be required to balance the calcium to phosphorus ratio when feeding moderate levels of distillers grains if a balancer mineral product is not used. Inclusion rates of limestone are often low and less than 2 percent of the total diet dry matter. Fortunately, feed grade limestone is inexpensive and adds little cost to the overall diet.

In most situations, the level of protein in the distiller grains products eliminates the need for other protein sources. Research has demonstrated that diets containing distillers grains perform similarly to diets containing other sources of protein such as soybean meal and urea. Use of soybean meal for lightweight calves and starter feeds to meet individual amino acid requirements may be necessary, but a portion of the dietary protein can come from distillers grains.

Beef Cows and Low-Quality Forage

Most of the coproducts discussed can be utilized effectively as a supplement to beef cows. Recent research demonstrated beef cows consuming low-quality forage offered corn condensed distillers solubles at levels up to 0.4 percent of body weight on a dry matter basis, corresponding to a level of 15 percent of the diet dry matter or 20 pounds as-fed, had improved body weight gains compared to cows that did not receive the coproduct. When CCDS was offered to steers consuming poor quality hay (5 percent crude protein, 40 percent acid detergent fiber), feeding rates up to 15 percent of the diet on a dry matter basis were found to improve overall diet digestibility. Use of corn condensed distillers solubles can be difficult to handle at approximately 70 percent water. Work in Iowa demonstrated that CCDS could be fed using lick tanks with wheels. Beef cows had intakes ranging from 3.4 pounds up to 7.0 pounds per day with intakes increasing as pasture availability became limiting.

Table 1. Typical composition of coproduct feedstuffs derived from corn.

Coproduct	%DM	%CP	%Fat	%TDN	NEm, Mcal/cwt	NEg, Mcal/cwt	%Ca	%P	%S
Condensed Solubles	30-50	18-35	5-25	88-91	100-125	69-89	0.07	1.8	1.6
Wet Distillers Grains w/solubles	30-35	30-35	5-15	88	100	68	0.05	0.8	0.7
Modified Distillers Grains w/solubles	40-50	30-35	5-15	88	100	68	0.05	0.8	0.7
Distillers Dried Grains w/solubles	90	30	10-12	88	100	68	0.04	0.8	0.7
Corn gluten feed	90	22	2-3.5	78	87	57	0.15	0.9	0.4
Corn gluten meal	90	60-65	2-3	89	100	68	0.06	0.6	0.8
Corn bran	90	14	9	88	100	68	0.05	0.7	0.8
Corn germ meal	91	15	17	74	80	51	0.02	1.6	0.2

Source: Values based on several sources including company literature, National Research Council publications, and United States-Canadian Tables of Feed Composition. Averages reported on a dry matter basis; actual analysis for a lot or load will vary.

Table 2. Nutrient concentrations for dried distillers grains, 2000-2010.

	Average Concentration	Normal Range		Standard Deviation
Dry Matter (%)	88.1	81.7	94.6	6.4
Crude Protein (%)	31.1	26.9	35.3	4.2
Fat (%)	12.7	9.5	15.8	3.1
NDF (%)	33.9	29.3	38.4	4.6
Ca (%)	0.08	0.00	0.29	0.20
P (%)	0.88	0.72	1.04	0.16
S (%)	0.64	0.46	0.82	0.18

Source: Reported for samples analyzed by Dairy One over the period of 5/01/2000 through 4/30/2010. Accessed 5/2/2011.

Excessive intake of CCDS has the potential to negatively impact fiber digestion as well as increase the risk of PEM. Therefore, general recommendations from the National Corn Growers Association are to limit the rate of CCDS to not more than 6.5 percent of the diet dry matter or approximately 5 to 7 pounds as-is for a product containing 30 percent dry matter. Additional caution is warranted to avoid mixing high sugar- or starch-containing feedstuffs such as molasses-based feeds with CCDS that may contain active yeast. These sugars can be converted to ethanol and cases of ethanol toxicity have been documented by the diagnostic laboratory from this exact scenario.

Distillers grains with solubles can be fed to beef cows as both an energy and a protein supplement. The moisture content, fat level and sulfur concentrations will limit the recommended feeding rates. Supplementation of low-quality fescue hay can often be accomplished at rates of 20 to 30 percent of the diet dry matter with minimal impacts on fiber digestion. The total dietary fat level in the diet is recommended not to exceed 6 percent to prevent detrimental impacts on fiber digestion. The upper feeding rate based on recommended fat level is calculated to be roughly 30 to 40 percent or 8 to 10 pounds of distillers grains with solubles on a dry-matter basis. The level of sulfur in the drinking water and in the coproduct may limit the amount recommended as well. Determine the quality of the water cattle have access to before trying to feed moderate to high levels of these coproduct feeds.

Growing and Finishing Cattle

The inclusion level of distillers grains often will be limited by cost. However, the elevated sulfur levels in these products may limit inclusion rates for growing and finishing cattle as well. Research has demonstrated that inclusion rates of distillers grains with solubles up to 40 percent on a dry matter basis allow for similar performance with no detriments. Use of CCDS is lower and it is recommended to keep feeding rates to 15 percent or less on a dry-matter basis. Again, the amount to be fed daily will need to be adjusted from the targeted dry matter inclusion rate. This feeding rate will differ depending upon the amount of moisture in the distillers grains product on-hand.

Distillers grains with solubles work well as a supplement for grazing steers and heifers and for forage-based diets. Research has shown that under these situations distillers grains have equal or greater energy value than dry rolled corn or other more conventional feedstuffs. Work by the Noble Foundation reported that supplemented grazing cattle performed better when consuming dried distillers grains with solubles compared to more common supplements such as soybean hulls and corn gluten feed. This is likely a result of the higher level of fat contained in the distillers grains.

General feeding guidelines are presented in Table 3 based on current research findings. Cattle operations near ethanol plants or distilleries have the advantage of feeding higher rates of coproducts because of low transportation cost. With fuel costs on the rise, it is less cost effective to transport high-moisture feedstuffs long distances (in excess of 75 miles). Therefore, use of dried or modified distillers grains should be considered as the distance from the plant increases. It is important to note that the cost of distillers coproducts needs to be converted to a dry matter equivalent and compared to prices of locally available feeds to ensure that their use is economical.

Table 3. General feeding guidelines for distillers coproducts for various classes of beef cattle.

	Beef Cow[1]	Growing/Finishing Calf[2]	Receiving/Starter Diets[3]
Condensed Corn Distillers Solubles (30% DM)	4-12 lb as-fed 5-15% of diet DM	Up to 2.5 lb for 600 lb calf Up to 3.5 lb for 1,200 lb calf 5-15% of diet DM	5-10% of the diet DM
Dried Distillers Grains w/Solubles (90% DM)	Up to 8 lb as-fed Up to 30% of diet DM	Up to 6 lb for 600 lb calf Up to 10 lb for 1,200 lb calf Up to 40% of the diet DM	Up to 4 lb as-fed Up to 30% of diet DM
Modified Distillers Grains w/Solubles (45% DM)	Up to 16 lb as-fed	Up to 12 lb for 600 lb calf Up to 20 lb for 1,200 lb calf	Up to 8 lb as-fed
Wet Distillers Grains w/Solubles (35% DM)	Up to 20 lb as-fed	Up to 15 lb for 600 lb calf Up to 25 lb for 1,200 lb calf	Up to 10 lb as-fed

[1] Based on dry matter intake of 25 lb.
[2] Based on dry matter intake of 16 lb for 600 lb calf and 24 lb for 1,200 lb calf.
[3] Based on dry matter intake of 12 lb.

Moisture Considerations

You must know the moisture content of the various distillers grains with solubles products to adjust how much to actually offer the cows. If the dry matter content for dried, modified and wet distillers grains with solubles were 90 percent, 45 percent, and 35 percent, respectively, the upper recommended feeding rates of 8 to 10 pounds from above converted to as-fed would be 9 to 11 pounds for dried, 18 to 22 pounds for modified and 23 to 29 pounds for the wet product. Handling volume is much lower for the dried than the wet. The transportation cost needs to be considered. For instance, if one was targeting 5 pounds of distillers grains with solubles to be fed daily on a dry-matter basis and a 10-ton load was delivered to the farm, the cow feeding days calculated for these three products are 3636, 1801, and 1399 days. If one was supplementing 50 cows, the 10-ton load would last 72, 36, and 27 days, respectively, for the various sources. Shelf life of wet products is generally less in warmer weather than the dried product, and increasing fuel costs adds more expense to the wet feeds. There must be enough of a cost savings on the wet feeds to offset the additional shrink and transportation costs associated with them. Comparison of the products on a dry-matter equivalency is important when deciding which feed is the most cost effective.

Conclusion

Feeding distillers grains derived from the production of spirits or ethanol for fuel is an acceptable practice for beef cattle production. The use of these products as both an energy and a protein supplement has been beneficial as the cereal grain prices have increased making these coproducts more cost competitive. In most situations, inclusion rates up to 30 to 40 percent of the diet dry matter are recommended. Feeding high levels of distillers grains products can increase the risk of PEM. Use of moderate to high levels is not recommended when cattle also have access to water high in sulfates. Feeding moderate to high levels of distillers grain will also require an adjustment to the mineral supplementation program to ensure proper nutritional balance.

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