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Feeding Coproducts of the Ethanol Industry to Beef Cattle

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Ethanol is a biofuel that is produced from cereal grains such as corn, sorghum or wheat. Corn is by far the most common feedstock used. For the purposes of this publication, only coproducts produced from corn ethanol production will be discussed.

Distillers grains are the primary coproduct that is widely used as feed for livestock. It is marketed as dry distillers grains with solubles (DDGS), modified distillers grains with solubles (MDGS) or wet distillers grains with solubles (WDGS). Condensed distillers solubles (CDS or corn syrup) also are marketed from some plants.

The purpose of this publication is to provide information on the feeding value of these coproducts for beef cattle and give beef cattle producers guidelines for the inclusion of these coproducts in beef cattle rations.

The ethanol industry in the U.S. produces substantial amounts of feed to domestic and international livestock markets. According to the latest data available, approximately 42 percent of distillers grains is fed to dairy cattle, 42 percent to beef cattle, 11 percent to swine and 5 percent to poultry. North Dakota produces more than 1.3 million tons of distillers grains and associated coproducts annually.

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Ethanol Coproducts

Corn contains approximately 61 percent starch, 3.8 percent oil, 8 percent protein, 11.2 percent fiber and 15 percent moisture. During ethanol production, starch is converted to ethanol, and the other constituents of the corn kernel become coproducts. Each bushel of corn produces 2.7 to 2.8 gallons of ethanol, approximately 18 pounds of distillers grains plus solubles and 18 pounds of carbon dioxide.

Wet and Dry Distillers Grains

Figure 1 diagrams the ethanol production process in a dry milling operation. Coproducts resulting from this process can include dry distillers grains with solubles (DDGS), modified distillers grains plus solubles (MDGS), wet distillers grains with solubles (WDGS), and condensed distillers solubles (CDS). Virtually all distillers grains include some level of solubles. The market does not distinguish among various levels of solubles that might be included in the distillers grains products.

WDGS are approximately 30 to 35 percent dry matter (DM; 65 to 70 percent moisture), while DDGS are approximately 90 percent DM. MDGS are approximately 50 percent DM and produced by partially drying WDGS.

Wet coproducts (WDGS or MDGS) have greater energy than the dry product (DDGS) because some fermentation products are volatilized during the drying process and wet products may have improved digestibility. However, protein quality does not seem to be affected by proper drying, but it can shift the site of digestion.

Normally, DDGS are golden yellow. Darker-colored DDGS may indicate possible heat damage during drying.

Because of the high moisture content of some of the coproducts and the possibility for variation in moisture content, comparisons should be made using delivered cost of nutrients on a dry-matter basis. This method would account for differences in moisture content, transportation expenses and nutrient composition.

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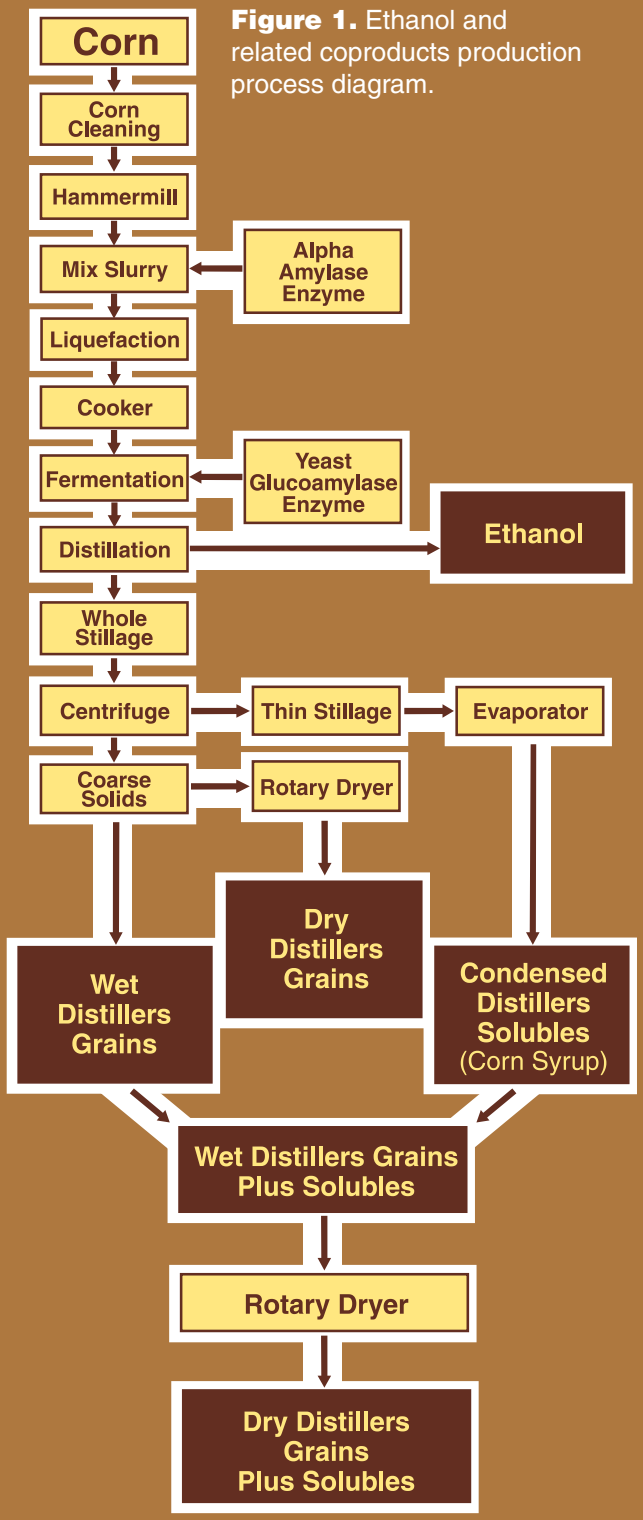

Figure 1. Ethanol and related coproducts production process diagram.

Condensed Distillers Solubles (CDS)

Whole stillage, the liquid fraction remaining after fermentation of the mash and removal of the ethanol by distillation, is centrifuged to remove coarse solids (wet distillers grains). Thin stillage is the liquid (5 percent DM) product that remains after centrifugation, which removes the coarse solids. Thin stillage is further condensed through heat-induced evaporation to produce condensed distillers solubles (CDS).

CDS varies from 30 to 50 percent DM and 20 to 30 percent crude protein (DM basis). CDS typically are added back to wet distillers grains and the resulting product is marketed as WDGS or MDGS. The WDGS also can be dried and sold as DDGS.

In some plants, CDS also are offered as a separate liquid product. This syruplike product can be used to control dust and condition dry rations (similar to liquid molasses products). In most cases, CDS should be limited to 10 percent or less of the diet (DM basis; approximately 8 to 10 pounds per head on a wet basis). Liquid CDS also can be pumped on the top of silage bunkers to "seal" the pile and reduce spoilage while adding more nutrients.

Condensed distillers solubles work well as a supplement for low-quality forage diets. NDSU researchers, as well as producers, have used CDS successfully in mixed rations with low-quality forages.

Condensed distillers solubles can be highly variable within a plant and among plants. We recommend laboratory analysis prior to feeding to determine nutrient content and proper levels to include in the ration.

Anecdotal evidence and NDSU research indicates the product can be offered free choice, but that is not a recommended practice. Ensuring that each animal is getting the recommended level is easier if the product is fed in a total mixed ration (TMR). In addition, the sulfur content of CDS can be quite high, and offering it free choice may increase the likelihood that sulfur is overconsumed.

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Nutrient Content of Ethanol Coproducts

Table 1 gives the average nutrient content for WDGS, MDGS, DDGS and CDS. Distillers grains plus solubles are relatively high in crude protein, contain modest amounts of fat and are an excellent source of protein and energy for beef cattle. Distillers grains have a fermented aroma and are very palatable.

Escape Protein

The protein in corn distillers grains contains a high proportion of escape protein (also referred to as bypass protein or rumen undegradable protein; 50 to 60 percent of the crude protein in distillers grains plus solubles is escape protein). Escape protein is not metabolized in the rumen but is digested by the animal in the small intestine.

Escape protein is important in situations where high levels of performance are expected or where less than optimum levels of escape protein are provided in the diet. Distillers grains are typically the most readily available and cost-effective source of escape protein. Work with your nutritionist or Extension personnel to determine if your rations contain adequate levels of escape protein.

Fat Removal

To improve economic returns, almost all ethanol plants are removing corn oil (fat) from distillers grains and selling it to higher-value markets. This potentially results in somewhat lower energy levels. Full-fat distillers grains plus solubles typically contain about 12 percent fat. Plants that are removing some corn oil generally are producing distillers grains with solubles that contain 7 to 9 percent fat, depending on the fat removal process. Eight to 9 percent fat is most common in the region. Producers should check with the plant they are purchasing product from for the most recent laboratory analysis.

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Minerals

Ethanol coproducts are high in potassium, phosphorus and other minerals. Feeders should reduce or eliminate supplemental phosphorus, potassium and sulfur when high levels of these coproducts are fed. Supplemental calcium (calcium carbonate) may be required to keep the calcium-to-phosphorus ratio in the diet at 1.5-to-1.

Elevated levels of phosphorus in these coproducts may contribute to high levels of phosphorus in the manure and increase in the amount of land required for proper nutrient management. If excess protein is fed, manure may contain more nitrogen than typical, making the manure more valuable as fertilizer.

High-sulfate Water

In areas where high-sulfate water is a problem, or when high levels of these coproducts are fed in the ration, the high sulfur levels in ethanol coproducts may create problems with polioencephalomalacia (PEM). This metabolic disease affects the neurological system. While experimental evidence for the use of increased copper and thiamine is limited, producers may want to consider elevating supplemental levels of copper and thiamine if diets high in ethanol coproducts will be fed.

Sampling and Analysis

The type and nutrient content of coproducts produced by ethanol plants will vary. We recommend routine sampling and laboratory analysis to use these coproducts effectively. The moisture level in the wet coproducts also varies; consequently, a DM (moisture) analysis is one of the most important routine analyses to conduct.

Producers also may ask the plant for a recent laboratory analysis. The analyses given in this publication are a range of published values and industry laboratory analyses and may not accurately represent what a particular plant is producing at any given point in time.

Samples of each load should be kept on hand for a short period following feeding. If a problem is encountered, routine analysis may be helpful in pinpointing the source of the problem.

Table 1. Nutrient composition of ethanol coproducts.

Nutrient	Dried Distillers Grains Plus Solubles	Modified Distillers Grains Plus Solubles	Wet Distillers Grains Plus Solubles	Condensed Distillers Solubles (corn syrup)
DM, %	90	50	35	30 to 50
	DM Basis			
TDN, %	86 - 88	87 - 95	88 - 98	75 - 110
NEm, Mcal/lb	0.98 - 1.00	0.90 - 1.10	0.99	1.00 - 1.15
NEg, Mcal/lb	0.68	.69	0.70	0.80 - 0.93
CP, %	30 - 32	30 - 32	30 - 32	20 - 30
DIP, % of CP[a]	43 - 53	45 - 53	45 - 53	80.0
UIP, % of CP[a]	47 - 57	47 - 57	47 - 57	20.0
Fat, %[b]	7.5 - 9.0	7.5 - 9.0	7.5 - 9.0	9.0 - 25.0
Calcium, %	0.10 - 0.20	0.02 - 0.03	0.02 - 0.03	0.03 - 0.17
Phosphorus, %	0.40 - 0.80	0.50 - 1.42	0.50 - 0.80	0.32 - 1.40
Potassium, %	0.87 - 1.33	0.70 - 1.00	0.50 - 1.00	1.75 - 2.25
Sulfur, %	0.37 - 0.70	0.38 - 0.70	0.40 - 0.70	0.37 - 0.70

[a] DIP is "degradable intake protein" metabolized in the rumen; UIP is "undegradable intake protein" that bypasses or escapes rumen digestion and is absorbed in the lower gut.

[b] Fat levels can vary considerably by plant based on different processes used to removal corn oil.

Table adapted from:

1. Galen E. Erickson, Crystal D. Buckner, Terry J. Klopfenstein. 2010. Feeding Corn Milling Co-Products to Feedlot Cattle. www.nebraskacorn.org/wp-content/uploads/2010/07/2010BeefCoProducts_Manual.pdf. 3rd edition.
2. Tjardes and Wright. 2002. Feeding Corn Distiller's Coproducts to Beef Cattle. South Dakota State University. ExEx. 2036.
3. NRC. 2000. Nutrient Requirements of Beef Cattle, 7th revised edition.
4. NRC, 2001. Nutrient Requirements of Dairy Cattle, 7th revised edition.
5. Iowa Renewable Fuels Association. www.iowarfa.org/ethanol_coproducts.php. Accessed April 9, 2014.

The analyses in this table are a range of published values and regionally available laboratory analyses. Products vary and this information may not represent what a particular plant is producing at any given time.

Results From Feeding Trials

Numerous research trials have evaluated DDGS, MDGS, WDGS and CDS as ration ingredients for beef cattle. Distillers grains plus solubles are most commonly fed as a protein source but also are an excellent energy source for ruminants. Based on multiple research trials, WDGS are higher in energy than DDGS, and MDGS tends to be intermediate between WDGS and DDGS.

The reasons for more energy in WDGS could include 1) inclusion of some residual ethanol and other fermentation products in the wet product, 2) a reduction in subacute acidosis when MDGS or WDGS are included in the diet or 3) heat damage occurring during drying. Moisture in the WDGS or MDGS also may improve feed intake by making the ration more palatable.

Ruminant animals can utilize the volatile fatty acids and other fermentation products that are volatilized during drying. The estimated energy content of WDGS varies depending on the basal diet and inclusion rates.

With 10 percent inclusion rates, research indicates that WDGS are approximately 150 percent the value of dry rolled corn. When WDGS are included at 50 percent of the diet, the energy value is approximately 110 percent of the value of dry rolled corn. When fed as a protein source, distillers grains have more value per unit, ranging up to 140 percent the value of corn.

In NDSU studies in which DDGS were fed at 20 percent of the diet DM, reducing fat levels in DDGS (from 12.96 percent [full fat] to 8.05 and 5.47 percent) did not alter animal performance in finishing rations but did result in reduced carcass marbling scores. Higher fat level in DDGS (12.96 percent) improved gains in higher forage growing diets, compared with lower fat (8.05 and 5.47 percent) levels.

Research with CDS at the University of Nebraska indicates that this liquid coproduct has greater energy content than corn. Including CDS in the diet improves ruminal fermentation by increasing the numbers of starch and lactic acid-utilizing bacteria. This suggests CDS improve animal performance by altering ruminal fermentation and enhancing starch digestion while reducing acidosis. NDSU research indicates CDS improve fiber digestion and forage intake in some situations but not in others. More research with this product is needed to determine when responses may be expected.

Feeding Recommendations

Backgrounding and Finishing Diets

Distillers grains plus solubles can be fed at 10 to 15 percent of the diet (DM basis) as a source of supplemental protein in backgrounding and finishing diets. When fed at levels greater than 15 percent of the diet, distillers grains are also an energy source, replacing corn or other grains in the diet.

Dried distillers grains plus solubles can be fed at levels up to 40 percent the diet DM. However, in most cases, the optimum level is generally less than 30 percent. Wet distillers grains can be included in backgrounding and finishing diets at levels up to 40 percent the diet DM.

In addition, at these levels, sulfur becomes a concern. Most research data indicates the optimum level of wet distillers grains plus solubles to meet protein requirements is 25 to 30 percent of the diet DM when used in dry-rolled corn-based diets.

Condensed distillers solubles can be used as a conditioning agent and source of energy or protein. As a conditioning agent in the ration, CDS can be included at 5 to 10 percent of the diet DM. This level will help control dust and improve palatability of dry rations and increase energy and protein content of the diet. Although generally not included at levels above 10 percent of the diet DM, CDS are a good source of supplemental protein and energy in the diet.

Forage-based Diets for Beef Cows

In forage-based diets for beef cows, distillers grains plus solubles can be used as a source of supplemental protein and energy. The amount fed depends on the desired performance and nutrient content of the basal forage. In most cases, this would mean feeding up to 4 pounds of distillers grains plus solubles per head per day on a DM basis. DDGS often are included in range cake formulations, but making durable large pellets with DDGS can be a challenge due to the fat content of DDGS.

Condensed distillers solubles can be used as a source of supplemental protein for beef cows fed low-quality hay. Mixing CDS with chopped hay is the most effective way of ensuring uniform intake. Producers also may consider pouring it on top of hay bales in the feeder or other delivery mechanisms. Condensed distillers solubles mix well with other dietary ingredients or supplements and enhance the palatability of mixed rations.

High variability in intake can be expected if CDS are fed separately and cattle allowed to consume it free choice. Anecdotal evidence indicates cows will consume as much as 60 pounds (as is) of CDS daily if allowed to consume it free choice.

Creep Feeds

DDGS can be used as an ingredient in creep feeds. The flavor, aroma and nutrient characteristics make them an excellent addition to creep feeds. Best results are obtained when DDGS are included at no more than 35 to 40 percent of the creep feed to achieve a 16 percent crude protein creep feed (DM basis). In addition, DDGS contain highly fermentable fiber rather than starch, which is beneficial and safer in creep feeds, compared with higher levels of starch from cereal grains.

Other Considerations

- Ethanol coproducts contain high levels of phosphorus (P), potassium and sulfur. In some cases, the phosphorus and potassium may be needed in the diet. However, in most backgrounding and finishing diets, supplemental calcium (Ca) will be needed to maintain the optimum Ca-to-P ratio.
- High sulfur (S) levels in ethanol coproducts have been implicated in increased incidence of polioencephalomalacia (PEM or polio). Dietary levels above 0.4 percent S as recommended by Nutrient Requirements of Beef Cattle (NRC), 2001, can be problematic. Remember that sulfur in water sources (sulfates) also contributes to the sulfur level the animal consumes. We recommend testing of water sources to determine the sulfur level prior to feeding high levels of ethanol coproducts.
- Be sure to work with a reputable trucking firm. Feed can become contaminated due to improper cleanout between loads or handling of hazardous materials as backhauls.
- Some liquid coproducts can separate during longer-term storage. Be sure to watch for signs of settling or separation. Cases of digestive upset or mortality can occur when components (for example, fat) settle out or separate and get fed at higher than planned amounts.

Storing Wet, Modified and Dry Distillers Grains

The surface of WDGS and MDGS will mold rapidly during the summer (approximately seven days) but the interior will remain in good condition indefinitely. Cattle feeders should plan on feeding enough to use a truckload on a weekly basis during the summer to minimize spoilage problems.

During the colder winter months, spoilage develops at a much slower rate, extending the storage time. However, storage should not exceed three to four weeks unless plastic silage bags or other oxygen-limiting structures are used to limit spoilage. Covering WDGS or MDGS piles with 6 to 12 inches of chopped forage will insulate the piles from the cold and reduce the amount of frozen product.

At certain times of the year, particularly in the summer months, the price for coproducts is attractive enough to warrant stockpiling and storage. WDGS plus solubles and MDGS can be stored in an oxygen-limiting environment, such as plastic silage bags, as a means of prolonging storage by limiting oxygen penetration.

However, filling the bags can be difficult. If bags are packed too tightly, they can split as the WDGS or MDGS settle. Take care to not pack the bags too tightly. Holes should be patched or covered promptly to prevent spoilage.

Wet distillers grains plus solubles can be stored in bunker-type silos and covered with plastic; however, some spoilage should be expected with this storage method. WDGS can be difficult to pack in a bunker or pile; one approach to address that problem has been to mix about 80 percent WDGS and 20 percent low-quality roughage on an as-fed basis to provide more bulk. Storing and packing MDGS can be done without roughage because of the lower moisture content. Research conducted at the University of Illinois indicates bunker storage with a white salt covering (1 pound per square foot) will result in a very acceptable storage method for MDGS.

DDGS should be stored in flat storage, such as a commodity shed or building. Bridging can occur in conventional grain storage structures, so vibrators or other devices may be required to empty hopper bottom bins. DDGS should be allowed to cool to ambient temperatures before they are placed in a storage structure to reduce bridging problems.

We encourage producers to check with the ethanol plant personnel for specific storage recommendations. Moisture content, fat level and particle size can affect bridging. For long-term storage, the moisture level should be below 15 percent to minimize or eliminate spoilage.

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Material-handling Considerations for Liquid Coproducts

A liquid feed-handling system is required for storage and feeding of CDS. Most liquid-handling systems can be installed with a modest equipment investment. We recommend hoses (and pumps) of at least 2 inches in diameter for handling CDS.

Tanks and pumps should be housed indoors or tanks can be buried underground to prevent the liquid materials from freezing. Pumps need to be kept above freezing for winter operations.

Because some settling and separation can occur with these liquids, a recirculating or agitating pump is necessary to mix CDS if they are stored for longer periods of time. Mix and agitate CDS thoroughly before mixing them in the ration or feeding. In some cases, the addition of water may be necessary to increase the flow properties because CDS can become quite viscous. More information on equipment for handling liquid coproducts can be found in “Handling Liquid Feed Commodities,” publication AS1272 (www.ag.ndsu.edu/publications/landing-pages/livestock/handling-liquid-feed-commodities-as-1272).

Summary

Coproducts from the ethanol industry are useful feed ingredients for beef cattle producers. Corn distillers grains are high in energy and protein and can be fed wet or dry in many different types of rations. Extensive research information is available from several universities on specific uses of distillers grains in beef cattle diets.

Condensed distillers solubles are a protein and energy source as well as a ration conditioner in beef cattle diets. These coproducts can vary in nutrient content and moisture level, so we recommend regular sampling and laboratory analysis, and adjusting rations accordingly for optimum product use and nutrition.

More detailed information on the specific use of DDGS in beef cattle rations is available from research trials at NDSU and other universities, including this website at www.nebraskacorn.org/internally-linked-pages/corn-co-product-manuals/.

For additional information or assistance with feeding recommendations, contact the NDSU Animal Sciences Department at (701) 231-7641 or the Carrington Research Extension Center at (701) 652-2951.

Table 2. Sources of ethanol coproducts in North Dakota and the surrounding region.

North Dakota Ethanol Plants	Marketing Contact	Products Available
Blue Flint Ethanol Underwood, N.D.	(701) 442-7575	DDGS, MDGS,
Dakota Spirit AgEnergy Spiritwood, N.D.	(701) 442-7575	(Open in 2015) DDGS, MDGS
Hankinson Renewable Energy Hankinson, N.D.	(701) 242-9400	DDGS, MDGS, WDGS, CDS
Red Trail Energy Richardton, N.D.	(701) 974-3880 for MDGS (877) 776-4334 for DDGS	MDGS, DDGS
Tharaldson Ethanol Casselton, N.D.	(701) 347-3311 or (701) 347-3312	DDGS, MDGS, WDGS
South Dakota Ethanol Plants		
Red River Energy Rosholt, S.D.	(605) 537-4550	
Glacial Lakes Energy Watertown, S.D.	(605) 882-8480	
Glacial Lakes Energy Mina, S.D.	(605) 225-9900	
Heartland Grain Fuels Aberdeen, S.D.	(800) 774-6537, ext. 112	
Northern Lights Ethanol Big Stone City, S.D.	Dakota Commodities (888) 327-8799	
Poet Nutrition Groton, S.D.	(888) 327-8726, ext. 270	
Minnesota Ethanol Plants		
DENCO, LLC Morris, Minn.	(320) 589-2931	
Green Plains Renewable Energy Fergus Falls, Minn.	(402) 315-1628 Email: ddgs@gpreinc.com	

Distillers grains may be available from other plants in the region. This list is not meant as an endorsement or criticism of any company or product mentioned or not mentioned. Transportation costs should be factored in before purchasing coproducts and incurring excessive shipping costs, especially for wet or liquid products.

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