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Distillers Grains *as a* PROTEIN *and* ENERGY SUPPLEMENT for Dairy Cattle

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Distillers grains are coproducts produced from the fermentation of grains for alcohol.

Traditionally, alcohol was produced mainly for the beverage liquor industry, but in the last 25 years its use as an alternative fuel has increased significantly.

This increased demand has led to the development of ethanol production plants in North Dakota and the surrounding region.

With production increasing, the opportunity exists for using a substantial quantity of distillers grains in dairy rations.

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When grains are fermented to alcohol, approximately one-third of the dry matter (DM) is recovered in coproducts. The two basic products at the end of the fermentation process are coarse, unfermented grains and a liquid fraction known as thin stillage containing small particles of grain, yeast, and soluble nutrients. These two products are further processed into the following four dried or partially dried coproducts: 1) distillers dried grains (DDG), 2) distillers dried solubles (DDS), 3) distillers dried grains with solubles (DDGS), and 4) condensed distillers solubles, 30 to 40 percent dry matter (CDS). Both the CDS and DDS are made from thin stillage through partial (CDS) or complete (DDS) drying. Distillers dried grains with solubles is produced by adding a portion of the thin stillage back to the unfermented grain fraction at the time of drying.

Alcohol can be produced from one or any combination of cereal grains. The most commonly used grains are corn, milo, wheat, barley, and rye. The grain used in the largest quantity is used to name the resulting product. For example, corn distillers grains would be produced from a fermentation batch where corn was the primary grain used.

The milling process (**Figure 1**) is relatively simple; corn (or other starch sources) is ground and the starch is fermented to ethanol and carbon dioxide. Approximately one-third of the DM remains as the feed product following starch fermentation. As a result, all the nutrients are increased three-fold because most grains contain approximately two-thirds starch. For example, if corn used in the dry milling operation is 4 percent oil, distillers wet grains (DWG) or DDG will contain approximately 12 percent oil.

Nutrient Composition

In general, distillers grains are almost devoid of starch, but nonetheless a good source of energy, protein, fiber, and phosphorus. Distillers grains are a good source of ruminally undegradable protein (RUP). The reported values of 55 percent of CP as RUP is used in most cases, with most reported values ranging from 47 to 63 percent RUP. Often the assumption is made that DWG has lower concentrations of RUP than the dried form, but the differences are slight. Ohio researchers reported 47 percent RUP for DWG and 54 percent RUP for DDG, a realistic difference in RUP for the wet versus the dried products. Most of the proteins have been degraded by heat during the fermentation process, so the protein remaining in the DDG is going to be proportionately higher in RUP than in the original grain. However, if RUP values for DDG are quite high (e.g. > 80% of CP), it may be advisable to also check for heat damaged, undigestible protein. **Table 1** provides a summary of the composition of various distillers co-products from corn.

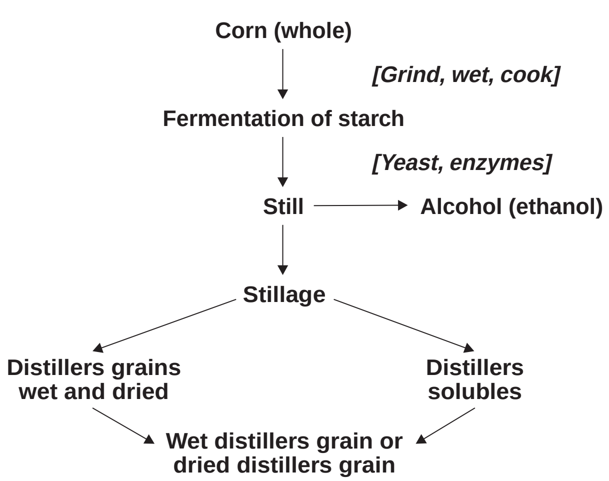

Figure 1. Schematic of the dry milling industry and the feed products produced.

Table 1. Nutrient composition of ethanol-processed coproducts.[1]

Nutrient[2]	Distillers Grains	Distillers Grains plus Solubles	Condensed Distillers Solubles
Dry matter, %	94	92	93
Crude protein, %	23	25	30
RUP[3], % of CP	47-63	47-63	47-63
Net energy for lactation, Mcal/lb	.90	.93	.93
TDN, %	86	88	88
Fat, %	10	10	9
ADF, %	17	18	7
NDF, %	43	44	23

[1] Adapted from NRC, 2001 and 1989. Nutrient Requirements of Dairy Cattle.
[2] All nutrients except DM expressed on a DM basis.
[3] Ruminally undegradable protein

Distillers Grains for Dairy Cows

Most research has focused on distillers grains as an alternative protein for soybean meal, the most widely used protein supplement today. However, in addition to their protein content, corn coproducts are also an excellent source of energy, attributed to their high content of digestible neutral detergent fiber (NDF) and fat. Distillers grains contain 40 to 45 percent NDF, which is highly digestible, thus it can replace other dietary starch and reduce the risk of ruminal acidosis because of its added fiber. But, despite its fiber content, distillers grains is comprised of mostly small particles, so distillers grain coproducts are considered to contribute less than 15 percent physically effective fiber to the diet. NDF from long particles is necessary in order to stimulate rumination health.

Questions often arise as to the maximum amount of distillers that can be fed. South Dakota State University researchers suggest that a maximum of 20 percent distillers grains should be included in the ration (DM basis). At levels greater than 20 percent of the diet, potential palatability and excessive protein consumption problems often exist. Amounts may approach 30 percent when diets are properly formulated.

Factors to consider when setting upper limits for incorporating distillers grains into lactating dairy cow diets are summarized in **Table 2**.

Table 2. Factors to consider when using distillers grains in rations for dairy cattle.

1. Maintain a particle length of the TMR (at least 6 to 8% of particles less than 0.75 inches).1
2. Ensure adequate CP, RUP, and RDP using the Dairy NRC software (2001).
3. Avoid a lysine deficiency.
4. Avoid CP greater than 18%.
5. Avoid fat greater than 6%.
6. Avoid excessive excretion of nitrogen and(or) phosphorus. Develop a nutrient management plan.

[1] If using the Penn State Particle Separator, particles retained on the top screen should be greater than 0.75 inches in length. These larger particles stimulate rumination (cud chewing). *Adapted from Grant, 2002.*

Research suggests herd managers follow these long-term considerations when feeding high levels of corn distillers grains, the most common source of distillers on the market: 1) a proper ratio of forage sources to reduce dietary crude protein, 2) supplemental sources of lysine if corn silage comprises the majority of the forage, and 3) avoiding adding excessive fat to the diet. It appears that total CP in the diet will determine upper limits of the amount of distillers grains that can be incorporated into the ration; 20 to 30 percent DWG or DDG (DM basis) is feasible if the ration is properly formulated.

Evaluating Protein Quality

Extensive heating of distillers grains during the drying process has raised questions about the nutrient availability, especially protein, in DDS and DDGS. The effects of excessive heating on reducing protein availability to animals has been well documented. Acid detergent insoluble nitrogen (ADIN) or the amount of nitrogen in the acid detergent fiber (ADF) fraction has been used as an indicator and measure of the protein unavailability in a feed due to heat damage. The use of ADIN as a method to estimate heat damaged protein in distillers grains and other coproducts, although not perfect, can be a good "index" for measuring heat damage in feeds.

There appears to be conclusive evidence that animal performance is diminished in some manner when heat damaged protein feeds are fed.

The exact level of ADIN in DDG or DDGS where a depression in animal performance occurs is unknown. However, color of distillers grains appears to be associated with the amount of ADIN. Good, high quality distillers grains will have a honey golden to caramelized golden color. Color progressing towards dark coffee grounds is an indicator of excessive heating during the drying process and the potential for high levels of ADIN.

Protein Quality

Several experiments evaluated the protein quality of corn distillers grains and how additional protein or amino acid supplementation can be used to improve the productivity of lactating cows. In the trial by Nichols et al. (1998), production increased when cows were fed ruminally protected lysine and methionine (RPLM). Wisconsin researchers observed similar increases with lysine supplementation. This response was expected because the protein in diets based on corn products are typically limiting in lysine. However, subsequent experiments by the same researchers have also shown no additional production when the corn distillers grains diet was supplemented with RPLM. Also, production was not significantly higher when fed a blend of several high quality protein supplements instead of corn distillers grains as the only protein supplement.

These studies illustrate that distillers grains from corn is a good quality protein source and that it cannot be easily improved upon. Corn distillers grains can be easily used as the only source of supplemental protein in many dietary situations.

Energy in Corn Distillers Grains

Research has indicated that the digestible energy (DE), metabolizable energy (ME), and net energy for lactation (NE_L) of DWG were 1.81, 1.63, and 1.00 Mcal/lb DM, respectively. These values are 7 to 11 percent higher than previously published values (NRC, 1989). The NE_L values (0.85 to 0.89 Mcal/lb) calculated via methods used in the 2001 dairy NRC would likely be proportionately lowered for all feeds, but would still indicate more NEL for corn distillers grains than the older values.

Wet Versus Dried Distillers Grains

Comparing the feeding of distillers wet and dry grains, recent research conducted at the University of Nebraska found no differences in feed intake or milk production. However, on-farm observations indicate that there may be an advantage to feeding it wet in situations where the other ration ingredients are dry, thus minimizing sorting and improving ration palatability.

The main considerations between the use of wet versus dried distillers grains are handling and costs.

Dried products can be stored for extended periods of time, can be shipped greater distances more economically and conveniently than wet, and can be easily blended with other dietary ingredients. However, feeding distillers wet grains avoids the costs of drying the product. Some have indicated difficulty in pelleting mixes that contained substantial amounts of DDGS.

There are several factors to consider when feeding DWG that are not concerns when feeding DDG and DDGS. First, the product will **not** remain fresh and palatable for extended periods of time; 5 to 7 days is the norm. Storage time will vary somewhat with environmental temperature. Products will spoil and become unpalatable more rapidly in hot weather, but may be kept in an acceptable form as long as 3 weeks under cool conditions. A fresh supply of product is best obtained approximately every 5 to 7 days.

When a spoiled product is obtained, it will be quite unpalatable, especially to some cows. Surface molds occasionally occur and these spoiled materials should not be fed. Thus, there is usually some feed lost; a problem that is not a consideration with the dried coproducts. The addition of preservatives, such as propionic acid or other organic acids may extend the shelf life of the wet product, but scientific documentation of such results is difficult to find.

How Much Distillers Grains Can Be Fed?

It is generally recommended that dairy producers feed up to a maximum of 20 percent of ration DM as distillers grains. With typical feed intakes of lactating cows, this would be about 10 to 12 pounds of DDG or 33 to 37 pounds of DWG per cow daily. There are usually no palatability problems and one can usually formulate nutritionally balanced diets up to that level of distillers grains in the diet. For instance, with diets containing 25 percent of the DM as corn silage, 25 percent as alfalfa hay, and 50 percent concentrate mix, the DG can likely replace most, if not all, of the protein supplement such as soybean meal and a significant amount of the corn that would normally be in the grain mix.

In diets that contain higher proportions of corn silage, even greater amounts of DDGS may be useable. However, the need for other protein supplement because of poor protein quality (e.g. lysine limitation) and high phosphorus (P) concentration may become factors to consider. In diets containing higher proportions of alfalfa, less DDGS may be needed to supply the protein required in the diet, and the cow may not be able to utilize as much DDGS.

Some researchers have fed as much as 30 percent or more of the ration dry matter as distillers grains, but that high an amount is typically not recommended. Total dry matter intake may be decreased because the total ration may be too wet when using DWG. Total dry matter intake may decrease when the diet is less than 50 percent dry matter, especially when fermented feeds are included in the total diet (NRC, 2001). Palatability may also become a problem with excess wet or dried DG in the diet. Excess feed protein is likely with 30 percent DG in the diet, unless forages are all or mostly corn silage and/or grass hay.

If DWG is fed with a high corn silage diet, the high water content of the diet will likely limit total dry matter intake.

It is noteworthy that there may be fewer off-feed problems when feeding distillers grains than when feeding corn based on research with beef cattle. Even though distillers grains and corn contain similar amounts of energy, the energy in distillers grains is primarily digestible fiber and fat; in corn most of the energy is starch. Ruminal starch fermentation is more likely to result in acidosis, laminitis, and fatty liver.

Nutrient Management

Excessive excretion of nitrogen (N) and P can be a problem when diets with large amounts of coproducts are fed. Corn milling coproducts accentuate the issue because they are higher in P than corn. The average P content of corn grain is 0.3 percent of DM, but the P content of distillers grains is 0.7 to 0.8 percent. A traditional diet containing no coproduct will have 18 percent CP, 1 percent calcium (Ca), and 0.4 percent P. The Dairy NRC (2001) recommends approximately 0.38 to 0.39 percent P for lactating dairy cows. **Table 3** shows higher levels of inclusion of corn distillers grain will increase phosphorus content in the diet. Herd managers will need to consider the impact of this and other feeds in order to strike a balance between nutritional benefits and potential environmental concerns related to the access of sufficient land base for manure application.

Table 3. Typical crude protein, calcium, and phosphorus content of a ration containing distillers grains versus requirements.[1]

	Requirement[1]	Standard diet[2]	30% wet distillers grain
Crude protein	18.0	18.0	18.0
RUP3	6.3	6.3	6.3
Calcium	0.66	0.66	0.66
Phosphorus	0.38	0.40	0.50

[1] Requirement for a 1,350-pound dairy cow producing 100 pounds of 4% fat corrected milk.

[2] Standard diet contains 50% of a 1:1 mixture of alfalfa and corn silage plus a concentrate with soybean meal and corn. The 30% corn distillers diet replaced a portion of both the forage and concentrate with WDG.

[3] RUP = rumen undegradable (escape) protein.

Economics of Feeding Distillers Grains

Price and nutrient content should be considered before purchasing alternative feeds. The following is a simple method for calculating cost per unit of protein, energy, fiber, or any other nutrient. The information required includes only the feedstuff cost and its nutrient content.

An example of the computations to calculate the cost per pound of protein (CP) from a ton of purchased feed follows:

(% CP, DM basis/100) x [(% DM/100) x 2,000 lbs/ton) = lbs CP/ton, DM

Example: DDG with a CP content of 30% and 89% DM:

(30 ÷ 100) x [(89 ÷ 100) x 2,000] =
0.30 x 1780 = 534 lbs CP/ton, DM

The cost per pound of CP calculated from the cost per ton of DDG delivered at $95/ton:

$/ton ÷ lb CP/ton = $/lb CP

$95 ÷ 534 lbs = $0.178/lb CP, DM

The protein and energy content and an estimation of the cost per pound of protein and per Megacalorie (Mcal) of net energy of lactation (NE_L) of some common feedstuffs are in **Table 4**.

There are some weaknesses in the cost/nutrient methodology. Feeds should be evaluated on their most valuable nutrient, whether it is protein, energy, or some other nutrient. Distillers grains are difficult to evaluate with this method as they supply both energy and protein. They are also a good source of RUP which is usually required to sustain higher milk production levels. Other factors not accounted for in this calculation are feed palatability, digestibility, and quality. In the cost/nutrient method, all feeds are treated equally when in reality there are differences in those factors.

When priced competitively on relative feed value, distillers grains can be a cost-effective addition to dairy rations. What is a competitive price? Distillers grains can be priced based on protein and energy using the prices of soybean meal and corn as standards for both nutrients. The following formula determines the price you can afford to pay for distillers grains:

$/hundredweight (cwt) of DDG = ($/cwt of corn x 0.531) + ($/cwt of soybean meal x 0.514)

The constants in the above equation are feed evaluation factors for estimating the dollar value of feeds based on energy and protein levels (Linn et al,). Using $2.35/bu corn and $190/ton soybean meal

Table 4. Nutrient content and cost per nutrient supplied of selected feeds.

Feed/Main Nutrient Supplied	DM	CP	NEL	$/Ton as Fed	$/Ton DM	$/lb of CP	$/Mcal of NEL
	(%)	(%)	(Mcal/lb)			(DM)	(DM)
Energy							
Barley	88	12.4	0.84	83	95	0.38	0.056
Corn	89	9.0	0.90	71.4	80	0.44	0.044
Oats	89	13.2	0.80	132	148	0.56	0.093
Protein							
Canola Meal	90	39.0	0.76	125	139	0.18	0.091
Soybean Meal	90	54.0	1	185	206	0.19	0.103
Protein (RUP)							
Corn Gluten Meal	87	65.0	1	270	310	0.24	0.155
Blood Meal	90	90.0	1	330	367	0.20	0.184
Protein and Energy							
Distillers Grains	90	30.0	0.89	90	100	0.17	0.056

[1] Nutrient values from Nutrient Requirements of Dairy Cattle, NRC, 2001.

(delivered cost), corn would be valued at $4.20/cwt and soybean meal at $9.50/cwt (delivered):

($4.20 x 0.531) + ($9.50 x 0.514) = $7.11/cwt
or $142.26/ton (as fed)

This indicates that as long as DDG is priced and delivered below $142/ton, it is economical to include in dairy rations. When pricing distillers grains in the wet form, usually 35 percent dry matter, this would translate into $57 per ton on a wet basis. Using the above assumption that DDG at $142 per ton is 88 percent, it would be valued at $161.69 when adjusted to 100 percent DM. Therefore, DWG at 35 percent dry matter (65 percent moisture) would be worth about $56.59 per ton delivered. Remember, this should include costs associated with delivery, storage, handling, and a correction for possible spoilage.

Storage Costs and Availability

Distillers dried grains, liked shelled corn or soybean meal, is relatively easy to handle and store. Feeding the products in this form will minimize both handling and storage costs.

Storage losses for DWG can be expected to be greater. Typically DWG is 30 to 50 percent DM and has an average storage life of five to seven days, depending upon the time of year. Conversely, losses for dry material stored in bulk bins is typically in the range of 2 to 5 percent. Storing DWG in a 9- or 12-foot sealed bag can extend its storage life. Bagging expenses are estimated to be approximately $5 to $8 per ton, including the rental cost of a dump table bagging machine, bags and fuel.

With new ethanol plants going up across many parts of the region, availability of distillers grains should increase.

These coproducts should be competitively priced in the future. This should allow distillers grains to become common components in North Dakota dairy rations.

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