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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.

In the last 30 years, alcohol's use as an alternative fuel has increased significantly.

This increased demand has led to the development and expansion of ethanol production plants in North Dakota and the upper Midwest.

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 produce 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, which contains small particles of grain, yeast and soluble nutrients.

These two products are further processed into the following four dried or partially dried coproducts:

- Distillers dried grains (DDG)
- Distillers dried solubles (DDS)
- Distillers dried grains with solubles (DDGS)
- Condensed distillers solubles, 30 to 40 percent dry matter (CDS)

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 in which corn was the primary grain used.

Other sources in the future will include sugar beets. Also, processes are being developed to use cellulose from agricultural residues, switchgrass and garbage.

The milling process **(Figure 1)** is relatively simple: Corn (or other starch sources) is ground and the starch is fermented to produce 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 threefold 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.

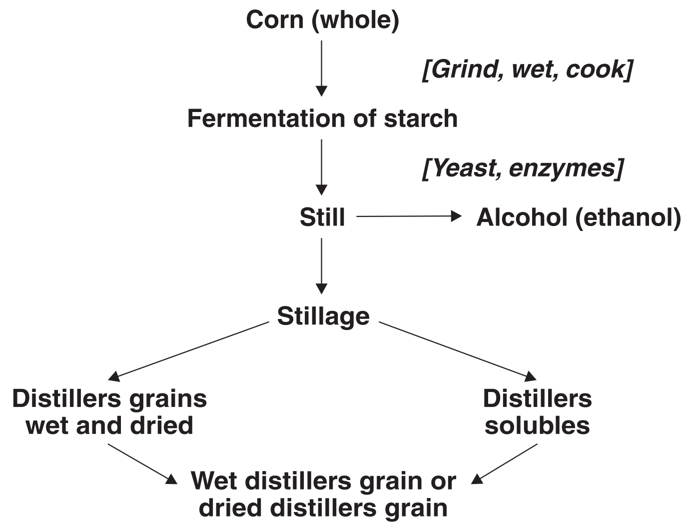

Figure 1. Schematic of the dry-milling industry and the feed products produced.

Nutrient Composition

In general, distillers grains are almost devoid of starch, but nonetheless they are 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 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 (for example, greater than 80 percent of CP), checking for heat-damaged, undigestible protein also may be advisable. **Table 1** provides a summary of the composition of various distillers coproducts from corn.

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

Nutrient[2]	Distillers Grains	Distillers Grains Plus Solubles	Condensed Distillers Solubles
Dry matter, %	94	92	93
Crude protein, %	23	25	30
RUP3, % 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 mostly consist of small particles, so distillers grain coproducts are considered to contribute less than 15 percent of physically effective fiber to the diet. NDF from long particles is necessary to stimulate rumination health.

Questions often arise as to the maximum amount of distillers grains 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 formulated properly.

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

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:

- Maintain a proper ratio of forage sources to reduce dietary crude protein
- Provide supplemental sources of lysine if corn silage constitutes the majority of the forage
- Avoid adding excessive fat to the diet

The total CP in the diet appears to determine the 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 formulated properly.

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 inch).[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 inch in length. These larger particles stimulate rumination (cud chewing).

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 have 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.

Conclusive evidence appears to show that animal performance is diminished in some manner when heat-damaged protein feeds are fed.

The exact level of ADIN in DDG or DDGS that causes a depression in animal performance is unknown. However, the color of distillers grains appears to be associated with the amount of ADIN. Good, high-quality distillers grains will be honey gold to caramelized gold. Colors progressing toward dark coffee grounds are 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 typically are limiting in lysine.

However, subsequent experiments by the same researchers also have shown no additional production when the corn distillers grains diet was supplemented with RPLM. Also, production was not significantly higher when cows were 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 improved upon easily. Corn distillers grains can be used easily 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 (NEL) of DWG were 1.81, 1.63 and 1 megacalories per pound (Mcal/lb) DM, respectively. These values are 7 to 11 percent higher than previously published values (NRC, 1989). The NEL values (0.85 to 0.89 Mcal/lb) calculated via methods used in the 2001 dairy NRC likely would be proportionately lowered for all feeds but still would 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 feeding it wet in situations where the other ration ingredients are dry may be advantage because it minimizes sorting and improves ration palatability.

The main considerations in deciding whether to use the wet versus dried distillers grains are handling and costs.

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

Here are several factors to consider when feeding DWG that are not concerns when feeding DDG and DDGS:

- The product will not remain fresh and palatable for extended periods of time; five to seven 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 three weeks under cool conditions. The best option is to obtain a fresh supply of product approximately every five to seven days.
- A spoiled product will be quite unpalatable, especially to some cows. Surface molds occasionally occur, and these spoiled materials should not be fed.

Thus, some feed usually is lost. However, this is not a problem 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?

The general recommendation is 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. These amounts usually cause no palatability problems, and you usually can 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 likely can replace most, if not all, of the protein supplement such as soybean meal and a significant amount of the corn that normally would be in the grain mix.

In diets that contain higher proportions of corn silage, even greater amounts of DDGS may be useable. However, you may need to provide other protein supplements because of poor protein quality (for example, lysine limitation) and a high phosphorus (P) concentration in distillers grains. 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 of an amount typically is 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 (National Research Council, 2001). Palatability also may 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 likely will limit total dry-matter intake.

Note that fewer off-feed problems may occur 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 National Research Council (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 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 the cost per unit of protein, energy, fiber or any other nutrient. The information required includes only the feedstuff cost and its nutrient content.

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

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 1,780 = 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 cost/nutrient methodology has some weaknesses. Feeds should be evaluated on their most valuable nutrient, whether it is protein, energy or some other nutrient. Distillers grains

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.

are difficult to evaluate with this method because they supply energy and protein. They are also a good source of RUP, which usually is 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, differences occur 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/bushel corn and $190/ton soybean meal (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, are relatively easy to handle and store. Feeding the products in this form will minimize 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 typically are 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 priced competitively in the future. This should allow distillers grains to become common components in North Dakota dairy rations.

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For more information on this and other topics, see www.ag.ndsu.edu

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