



# Opportunities and Challenges of Feeding Distillers Grains to Dairy Cows

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## Topics include:

Production and storage of distillers grains  
Nutrient composition of distillers grains  
Cow performance when fed distillers grains

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## Reviewed by:

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## INTRODUCTION

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Current feeding practices on Pennsylvania dairy farms consist of providing a substantial portion of dietary dry matter as corn grain. Given the growing demand for renewable fuel production and the current reliance on corn for meeting this demand, the cost of corn for Pennsylvania dairy farm feed may become prohibitive. The recent expansion of fuel ethanol production capacity has resulted in an increased availability of ethanol byproducts for dairy cattle feed. Availability of corn distillers grains (DG), often called distillers grains, has increased substantially and, consequently, the interest in using these feeds in dairy cattle diets has also increased. New ethanol plants in the eastern part of the US including Pennsylvania, eastern Ohio and western New York state will increase the availability and potential cost

effectiveness of wet and dried distillers grains in our typical Pennsylvania dairy rations. While byproducts of corn fermentation to ethanol have been used for ruminant diets for many years, interest and research in feeding distillers grains to dairy cows has increased in parallel with overall fuel ethanol production.

Along with most of the feeds that can be utilized to provide nutrients to the dairy cow, distillers grains present the dairy farmer and nutritionist with unique opportunities and challenges that must be evaluated on an individual farm basis. The current paper will review data related to feeding distillers grains to lactating dairy cows and the challenges that may arise due to their inclusion.

## PRODUCTION AND STORAGE OF DISTILLERS GRAINS

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Traditionally, distillers grains (DG) have been produced in conjunction with distilling alcohol for human consumption. While the procedures involved in traditional and modern DG production are generally similar, the advancement of technology, difference of ethanol consumer, and the recognition of livestock producers as important byproduct consumers have resulted in a new generation of DG. As a result, it is important to realize that the old analyses for DG as found in the NRC (2001) are not accurate due to the more recent systems being used to make ethanol.

Ethanol can be fermented from any high carbohydrate substrate such as sugarcane, corn, and switchgrass with varying degrees of efficiency. Currently in the United States, the primary carbohydrate used for this fermentation is corn starch. The primary method for corn ethanol production is dry

grinding (Kalscheur et al., 2008). With this process, corn grain is ground to a medium-fine particle size and water and enzymes are added to degrade the starch into glucose. This mixture is cooked and sterilized to kill bacteria. The sterilized mash is then cooled and inoculated with yeast that will ferment glucose to ethanol and carbon dioxide. Ethanol is then distilled and the remaining solids and water are processed into wet distillers grain (**WDG**) and distillers solubles. The solubles are typically recombined with the WDG to result in WDG with solubles (**WDGS**). The **WDGS** can be dried to yield dried distillers grains with solubles (**DDGS**). Each of these byproducts has been feed to dairy cattle.

The most easily transported and stored byproduct of ethanol production is **DDGS**. Since this form is dry, it can be shipped to any location from any location in the

country and can be stored under reasonable conditions indefinitely. Drying DG requires energy and time and costs money; as a result DDGS are more expensive than WDGS on a dry matter basis. However, WDGS are less efficient to ship due to the requirement to ship water and more difficult to store due to more favorable conditions for spoilage. As a consequence, WDGS are usually only available for feed on farms in close proximity to an ethanol plant and with the ability to feed each delivery of the byproduct rapidly. Spoilage may occur within 5 to 7 days after production but this depends on the ambient temperature. Facilities for storing WDGS can also be

problematic due to its high moisture content (typically 35% DM). Storage losses can be very high with WDGS. The shelf-life of WDGS may be extended by limiting oxygen during storage, although storing in combination with other feeds such as soybean hulls or with the inclusion of a preservative may also extend the duration of storage. Research in optimal storage conditions for WDGS is still a very active area; with some looking at adding forages or other dry feeds to the WDGS prior to ensiling or bagging to improve packing ability. However at this time few recommendations exist.

## **NUTRIENT COMPOSITION OF DISTILLERS GRAINS**

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Since fuel ethanol in the United States is produced by removal of starch from corn, the composition of DG is, for the most part, predictable from the composition of corn. As a general conversion rule, with the exception of starch (which is primarily removed), the nutrient composition of DG will be roughly 3 times as concentrated as it is in corn grain. This is because the weight of starch is approximately 2/3 the weight of corn. If the conversion of the nutrient composition of corn to DG was always true, the nutrient composition of DG would have low variability since the nutrient composition of corn has low variability. This has not generally been the case however, both within and between ethanol plants. Reasons for differences in nutrient composition can be related to small differences in any of the processes within plants over time and processes between plants. Additionally, solubles are added back to DG in variable proportions, increasing the chemical variation in both WDGS and DDGS. These factors can create notable differences in DDGS coming from each individual ethanol manufacturing plant.

Chemical composition and variation of DDGS from different ethanol plants are shown in Table 1. Distillers grains is primarily considered to be a supplemental source of crude protein (CP), especially rumen undegradable protein (RUP). From Table 1 it can be seen that, along with CP, DG contain an equally high level of neutral detergent fiber (NDF) and a relatively high level of ether extract (EE) and phosphorus (P). Additionally, concentration of sulfur (S) may exceed 1% of DM—the concentration of this nutrient is higher than expected based on its concentration in corn and is quite variable due to the addition of sulfuric acid during the production process.

The NDF in DG has a rapid rate and a high extent of digestion. By contrast, the CP of DG is slowly degraded in the rumen due to being comprised primarily of the protein zein. Consistent with the absence of lysine in zein, the amino acid composition of CP is similar to that of corn, in that lysine is often a limiting amino acid for milk production.

**Table 1. Nutrient composition of dried distillers grains with solubles<sup>1</sup>**

<b>Nutrient</b>	<b>Average</b>	<b>Min</b>	<b>Max</b>
Crude protein <sup>2</sup> , %DM	32.0	30.6	33.5
Rumen undegradable protein, %CP	64.5	59.1	71.7
RUP Digestibility <sup>3</sup> , %RUP	68.1	59.2	76.8
NDICP, %CP <sup>4</sup>	45.0	38.2	49.5
Neutral detergent fiber, %DM	32.9	29.5	37.4
Ether extract, % DM	10.6	10.5	10.8
Ash, % DM	5.0	4.5	5.5
Phosphorus, %DM	0.86	0.79	0.90

<sup>1</sup> Chemical composition values from 5 sources of DDGS (except ether extract and phosphorus; Kleinschmit et al., 2007a) or 3 sources of DDGS (ether extract and phosphorus; Kleinschmit et al., 2006).

<sup>2</sup> CP = crude protein; DM = dry matter.

<sup>3</sup> Intestinal digestibility of rumen undegradable protein (RUP).

<sup>4</sup> Neutral detergent insoluble CP.

It is apparent that the variation between the maximum and minimum nutrient composition of DG is quite large for many of the components. This is especially true for crude protein and the protein fraction RUP, which is a fundamental reason to put DDGS in the dairy ration. This observation leads to the recommendation of securing a good supplier of DG that produces a consistent product over time as well as the need for frequent wet chemistry feed analyses of the product for use in ration balancing.

In most cases the specific plant that the DDGS originates from will have a specific

analysis due to that plant's specific ethanol manufacturing process. Influential characteristics of the process include plant design, processing or particle size of the grain, extent of fermentation and drying temperatures. In addition, field experiences have shown a large amount of variability in DDGS analysis can occur from batch to batch and year to year due to differences in the corn (source and quality) that is used. Some commercial DDGS products have been developed to minimize this variation problem and create a more uniform DDGS product for delivery to the feed mill or farm.

## **COW PERFORMANCE WHEN FED DISTILLERS GRAINS**

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### ***Crude Protein Quality***

Being a byproduct of corn, the CP of DG is relatively undegradable in the rumen. This is especially true of DDGS as the product has been reheated and dried, thus altering the protein fraction to being less available in the rumen. According to the analyses of the NRC (2001) and others (Hristov et al., 2005; Firkins et al., 2006), increasing RUP has a linearly increasing effect on milk and milk protein production when added to diets low in RUP. This result has been confirmed for RUP derived from DG (Pamp et al., 2006) when rumen degradable protein was provided at a constant concentration. In this and in an additional experiment (Pamp et al., 2007), when RUP was provided as DG instead of soybean-based protein, milk and milk protein production were greater for cows fed DG-based RUP.

Quality of the CP in DG is proposed to be limited by the amino acid lysine. Kleinschmit et al. (2007b) found that when DDGS was included at 15% of DM with corn silage, alfalfa hay, or an equal mixture of both comprising 50% of DM, milk production was increased with increasing levels of alfalfa in the forage component. Lysine was found to be the first-limiting amino acid for mammary gland extraction efficiency for the corn silage and the corn silage/alfalfa hay diets, whereas methionine was first-limiting for the alfalfa hay diet. It has been speculated that high corn silage diets may benefit from supplemental bypass lysine, although responses to date have been inconsistent when lysine and methionine were supplemented in diets containing alfalfa hay as a component of the forage (Nichols et al., 1998; Liu et al., 2000).

### ***Energy***

Although DG is typically fed as a source of CP, the energy concentration of DG is

equal to or greater than the concentration of corn (Birkelo et al., 2004). However, rather than coming from starch, the energy in DG is provided by fat, digestible fiber, and CP. This may positively affect the rumen environment and reduce the incidence of acidosis, as is commonly observed in beef cattle.

### ***Neutral Detergent Fiber***

The primary carbohydrate fraction in DG is NDF. Feeding high levels of DG will increase the concentration of NDF in the diet. Several experiments have shown that the DG is comparable to forage as a source of effective fiber. These experiments have only fed up to 15% of DM as DG. Due to particle size considerations it is likely that with higher levels of DG inclusion, the ability of DG to replace the effective fiber of forages will be limited.

An opportunity may exist to replace a portion of the corn and protein supplement with DG, and this is what most experiments have tested. Although the NDF concentration of these diets will be greater than diets containing corn, as discussed later, milk production is equal to or greater than diets containing no DG.

### ***Fat***

High levels of fat are present in DG. Rations must be balanced to keep dietary levels of fat less than 5% of ration DM (excluding bypass fat) to avoid inhibiting rumen function. Variability in fat levels can be problematic with DDGS and must be controlled for normal rumen function. If other feed sources containing fat (whole cottonseeds or soybeans) are used in the ration, the amount of DG that can be fed may be limited.

## ***Phosphorus and Sulfur***

Nutrient management plans are often designed around the excretion of nitrogen and phosphorus. The phosphorus concentration of DG is high relative to the requirement of the cow. The availability of phosphorus appears to be greater in DG than in corn, possibly due to the hydrolysis of phytate-phosphorus during fermentation. Given this, it has been suggested that supplementation of inorganic phosphorus may be reduced or eliminated with a diet containing adequate levels of DG (Mjoun et al., 2008). The level of phosphorus must be monitored in the final ration to meet nutrient management objectives. Typically DDGS has two times the phosphorus levels found in whole corn. High levels of DDGS feeding may increase phosphorus excretion by the herd.

Levels of sulfur are high and variable in DG. It is typically recommended that ruminant diets contain less than 0.3% of dry matter as sulfur. Diets are often formulated for higher concentrations of sulfur (especially when feeding anionic salts) without apparent problems. It is important to test and monitor the level of sulfur present in the final ration. In general DDGS has four times the sulfur of whole corn, which must be taken into account when balancing rations.

### ***Maximal Level of Distillers Grains***

The typically recommended maximum level of DG for dairy cattle is 20% of dietary dry matter. However, it is often recommended to limit the feeding level to 10 to 15% due to the other attributes and components of DDGS discussed in this paper.

Anderson et al. (2006) fed diets of DDGS or WDGS at 0, 10, or 20% of dry matter, where corn and soybean meal were replaced by DG. While dry matter intake tended to be

lower for cows consuming DG, milk, protein, and fat yield were greater for cows consuming diets containing DG. This resulted in improved efficiency of feed conversion (feed efficiency) for cows fed diets containing DG. Intake and production were not affected by level of DG inclusion, although numerical differences in the responses led to a tendency for increased feed efficiency for cows consuming 20% versus 10% DG.

Janicek et al. (2008) fed diets containing 0, 10, 20, and 30% DDGS or 0 and 30% DDGS in two experiments and evaluated productive responses. In these experiments, DDGS replaced both forages and concentrates. In the first experiment, dry matter intake and milk production increased with increasing inclusion of DDGS without affecting feed efficiency. In the second experiment, dry matter intake was increased for cows fed DDGS diets, but milk production and feed efficiency were unaffected.

Finally, it may be important to monitor the levels of mycotoxins in DG, especially during drought years. Like the nutrients that are present in corn fermented for ethanol, the concentration of mycotoxins can also be increased if present on the corn. Mycotoxins can contaminate DG and reduce animal performance and can also be transferred to milk if present at high levels.

Considering the information provided here, it appears that the maximum inclusion level for lactating dairy cow diets is limited by the resulting nutrient composition of the entire ration. Therefore, rations must be evaluated to provide an appropriate intake of energy, rumen degradable and undegradable protein, and phosphorus to meet production and nutrient management goals.

While some nutritionists will recommend higher levels and can have success with these high levels, at present we do not

recommend more than 10 to 15% inclusion in a lactating dairy cow diet. We do not recommend going above this level unless you are paying close attention to the nutrient content of the DDGS product being fed, as well as the herd ration and cow

performance. Fat level of the DDGS, protein quality, feed variability, phosphorus and sulfur levels are all concerns that must be accounted for when using this feed source at levels above 10 to 15%.

## CONCLUSIONS

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Feeding DG to dairy cows is a viable option for dairy farmers to provide supplemental rumen undegradable protein and energy to dairy cows, with equal or improved milk production. As with forages and many other by product or commodity feeds, having frequent and accurate nutrient

analyses for DG is important for ration balancing and nutrient management. When feeding DG to dairy cows, nutritionists and producers must pay close attention to dietary CP and RDP, P and S, and fat concentrations to obtain optimum rumen function, cow productivity, and nutrient excretion.

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