Distillers Grains for Dairy Cattle[1]

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The feeding of distillers grains to dairy cattle is nothing new; such products have been fed cattle for more than a century. The research article by Loosli et al. (1952) referenced an 1895 Vermont Agricultural Experiment Station Bulletin that reported on the feeding of distillers grains to lactating cows. In many respects, one might say that responses to feeding distillers grains today should be similar to those older studies. That may be correct except for some differences in both distillers grains and cows today versus yesterday. The distillers grains are different today, primarily containing more protein and energy, and today's cows produce much more milk than was produced by their ancestors.

This presentation reports the results of recent studies in which distillers grains were fed to dairy cattle. While the emphasis of this presentation is on dried distillers grains, research conducted with both wet and dried products will be reviewed. Generally, one is referring to corn distillers grains (CDG) because that is what most of the studies in recent years have used; results with distillers grains from other grains would likely be similar. In most cases, the CDG used is dried distillers grains plus solubles (DDGS).

The composition of CDG today, especially products coming from the "new generation" ethanol plants in the Midwest, contain more protein and energy than older "book" values. For instance, the CDG, both wet and dried, that was used in our SDSU research contained 30 to 36% or more crude protein on a dry matter (DM) basis versus the 23% CP for CDG and 25% CP for DDGS values reported in the 1989 nutrient requirements of dairy cattle (NRC, 1989). The new dairy NRC (2001) lists 29.7% CP for DDGS, a number that is closer to reality. The net energy for lactation (NE_L) in today's CDG is about 10% higher (~ 1.03 Mcal/lb) than the 0.90 Mcal/lb reported in NRC (1989; 2001). Contents of fat (10% or more), neutral detergent fiber (~ 39%), and acid detergent fiber (~ 19%) are only slightly different from the NRC values. Improved efficiencies in fermenting more of the starch that was in the corn to ethanol is likely the reason for these observed changes in the composition of CDG.

Another nutritional consideration when feeding distillers grains or many other co-product feeds is the phosphorus content. Dried CDG contains approximately 0.43% P and DDGS contains approximately 0.83% P, reflecting the high P content (1.37%) of distillers solubles. This high P content can be an advantage because it can allow one to decrease the amount of supplemental P normally added to the diet. Or, it can be a disadvantage if nutrient management concerns about high P content of manure can't be avoided by decreasing amounts of P from other feed sources.

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Protein in Corn Distillers Grains

Corn distillers grains is a good source of ruminally undegradable protein (RUP). The reported values of 55% of CP as RUP is probably an appropriate figure to use in most cases. Most reported values range from 47% to 57% RUP although we obtained somewhat higher values (Brouk et al., 1994). One often assumes that wet CDG has lower concentrations of RUP than does dried CDG, but the differences are slight. Firkins et al. (1984) reported 47% RUP for wet CDG and 54% RUP for the dried product, which probably represents a realistic difference in RUP for the wet versus the dried products. Most of the readily degradable proteins in corn have been degraded during the fermentation process, so the protein remaining in the CDG is going to be proportionately higher in RUP than in the original corn. However, if RUP values for dried CDG are quite high (e.g. > 80% of CP), it may be advisable to check for heat damaged, undigestible protein.

The quality of protein in CDG is fairly good. As with most corn products, lysine is the first limiting amino acid in CDG for lactating cows. More will be said about protein quality below in discussions about production responses to CDG.

Production Response When Fed Corn Distillers Grains

Table 1 summarizes milk production from several experiments in which cows were fed CDG. In experiments that compared CDG to soybean meal as the protein supplement, production was similar (Schingoethe et al., 1983; 1999) when fed wet CDG or higher (Nichols et al., 1998) when fed dried CDG than when fed soybean meal. With DDGS, production was similar to with soybean meal in a Nebraska study (Owen and Larson, 1991) and in a Florida study (Powers et al., 1995) in which the DDGS was dark and possibly heat damaged. When fed lighter colored DDGS from whiskey or from fuel-ethanol preparations, production was higher ($P < 0.05$) than when fed soybean meal (Powers et al., 1995). Some ethanol plants are striving to consistently produce improved quality DDGS products.

Several experiments evaluated the protein quality of CDG and how additional protein or amino acid supplementation can be used to improve 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 (L. Armentano et al., 1997, unpublished results) observed similar increases with lysine supplementation. This response was expected because the protein in diets based on corn products are typically limiting in lysine. The greater production with CDG-based diets than with soybean-based diets was impressive but not entirely expected based on previous research with other corn-based products such as corn gluten meal. A multi-university study (Polan et al., 1991) observed lower production when fed corn gluten meal in place of soybean meal, even when the corn gluten meal was supplemented with RPLM.

However, when one has obtained good results in an experiment, one shouldn't repeat it. The next step in our efforts to improve the quality of protein in diets of cows was to compare CDG as the only protein supplement to a blend of proteins that included CDG (Liu et al., 2000); both diets were fed with or without RPLM. Supplemental proteins fed in the BLEND diet were 25% from CDG, 25% from fish meal, and 50% from soybean meal. Theoretical evaluations of these diets (Schingoethe, 1996; O'Connor et al., 1993) indicated that the BLEND diet contained

a more desirable array of amino acids and should have supported greater production than the CDG diet. However, this time there was no additional production when the CDG diet was supplemented with RPLM. Also, production was not significantly higher when fed a blend of several high quality protein supplements instead of CDG as the only protein supplement.

The above studies illustrate that CDG 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

Some speculated that the CDG available today might contain more energy than indicated by the "book" values. Therefore, we (Birkelo et al., 1994) conducted an experiment to determine the energy value of wet CDG for lactating cows. The research indicated that the digestible energy (DE), metabolizable energy (ME), and net energy for lactation (NE_L) of wet CDG were 1.86, 1.52, and 1.03 Mcal/lb DM, respectively. These values are 10 to 15% higher than published in the dairy NRC (2001) for DDGS. This likely reflects a higher energy value for newer generation distillers grains and does not necessarily reflect higher energy in wet than in dried CDG; that would have to be a separate comparison which has not been made.

Wet versus Dried Distillers Grains

One of the objectives of this presentation is to provide information about DDGS, but so far the presentation has contained information almost interchangeably about both wet and dried distillers grains. That is because the nutrient content of the dry matter is essentially the same for both wet and dried CDG except for possibly slightly lower RUP values for wet than for dried CDG (Firkins et al., 1984). I am not aware of any trials with lactating cows that directly compared wet versus dried CDG. The minimal amount of data comparing wet versus dried CDG with beef cattle would indicate that animal performance when fed wet CDG is just as good as or slightly better than when fed dried CDG. Likewise, I am not aware of direct comparisons between distillers grains versus distillers grains plus solubles. Again, I would expect similar animal performance with both products.

The main considerations between the uses of wet versus dried CDG 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 CDG, and can be easily blended with other dietary ingredients. However, feeding wet CDG avoids the costs of drying the product.

There are several factors to consider when feeding wet CDG that are not concerns when feeding DDGS. First, the product will not remain fresh and palatable for extended periods of time; 5 to 7 days is the norm. This storage time span will vary somewhat with environmental temperature as 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. Surface molds occasionally occur thus, there is usually some feed lost; a problem that wouldn't be a consideration with dried CDG, or DDGS. The addition of preservatives such as propionic acid or other organic acids may extend the shelf life of wet CDG, but scientific journal publications that document such results are difficult to find. In recent research, we at SDSU (Kalscheur et al., 2002, 2003, 2004) successfully stored wet CDG for more than six months in silo bags. The

wet CDG was stored alone or blended with soyhulls (Kalscheur et al., 2002) or with corn silage (Kalscheur et al., 2003). Some field reports indicate successful preservation of wet distillers grains for more than a year in silo bags.

How Much Distillers Grains can be Fed?

I recommend that dairy producers feed up to a maximum of about 20% of ration DM as distillers grains. With typical feed intakes of lactating cows, this would be about 10 to 12 lb of dried CDG or 33 to 37 lb of wet CDG per cow daily. There are usually no palatability problems and one can usually formulate nutritionally balanced diets with up to that level of distillers grains in the diet. For instance, with diets containing 25% of the dry matter as corn silage, 25% as alfalfa hay, and 50% concentrate mix, the CDG 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 some other protein supplement, protein quality (e.g. lysine limitation), and 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 in fact the diet may not be able to utilize as much DDGS. When feeding more than 20% distillers grains, one is likely to feed excess protein, unless forages are all or mostly corn silage and/or grass hay.

In previous research (Schingoethe et al., 1999) we fed slightly more than 30% of the ration DM as wet CDG with decreased DM intake but no decrease in milk production. However, recent research by our group (Hippen et al., 2003; 2004) in which as much as 40% of ration dry matter was fed as CDG indicated problems when the CDG provided more than 20 to 25% of the ration DM. With wet CDG (Hippen et al., 2003), DM intake decreased when diets contained more than 20% wet CDG with a corresponding decrease in milk production also. Gut fill may have limited DM intake of these wet diets because total DM intake may decrease when the diet is less than 50% DM, especially when fermented feeds are included in the diet (NRC, 2001). However, when dried CDG (DDGS) was fed, (Hippen et al., 2004) DM intake and milk production were still decreased when diets contained 27 or 40% dried CDG. Milk fat percentages also decreased when fed more than 13% DDGS. We don't know why that occurred because milk fat percentages were not adversely affected by distillers grains in our previous research (Liu et al., 2000; Nichols et al., 1998; Schingoethe et al., 1999) in which 20 to 30% distillers grains were fed.

There may be fewer off-feed problems when feeding distillers grains than when feeding corn, based on research with beef cattle. That is because, even though the distillers grains contains similar amounts of energy as corn, the energy in distillers grains is primarily in the form of digestible fiber and fat; in corn most of the energy is as starch. Ruminal starch fermentation is more likely to result in acidosis, laminitis, and fatty liver.

Distillers Grains Blended with Other Feeds

Several experiments have been recently conducted at SDSU in which wet CDG was blended with other high fiber feeds. Such approaches may be helpful in times when forage supplies are limited or expensive. For instance, a 70:30 (DM basis) blend of wet CDG and

soyhulls reduced the dustiness of soyhulls, reduced the seepage that is common with wet CDG, provided more desirable protein (21% CP) and P (0.6%) contents, and yet provided a high energy, high fiber feed (Kalscheur et al., 2002). Growth rates of heifers fed the blend were similar (2.7 to 2.8 lb/d) to gains when fed conventional diets (Kalscheur et al., 2004). When heifers were fed a blend of wet CDG (69% of DM) and corn stalks (31%), weight gains were less (2.3 lb/d) than when fed conventional diets (2.8 lb/d). Ensiling wet CDG alone or in combination with corn silage indicated that preservation of each could be enhanced by combining the feedstuffs with a 50:50 blend likely optimal (Kalscheur et al., 2003).

Other Corn Products as Feeds

There are several other corn products such as corn gluten meal, corn gluten feed, and corn distillers solubles that can also be fed to dairy cattle. I won't spend a lot of time talking about corn gluten meal and corn gluten feed, except for a sentence or two about each, because they are not included in the major thrust of this presentation. Corn gluten meal is a high protein (60% CP) and high RUP (55% of CP) feed that is a very good protein supplement but is best fed in combination with other protein supplements (Polan et al., 1991). Corn gluten feed is a good overall feed that is medium in protein (25% of CP), low in RUP (25% of CP), a good energy source (NE_L = 0.86 Mcal/lb), and sometimes priced competitively with other feed sources.

Corn distillers solubles will be discussed more extensively because they are a part of the same process that produces CDG. Distillers solubles are usually blended in with the distillers grains before drying to produce DDGS, but the solubles may be fed separately also. We (DaCruz et al., 1996) conducted one experiment with lactating cows in which condensed corn distillers solubles (CCDS) were fed at 0, 5, and 10% of total ration DM. The CCDS contained 28% DM and that DM contained 18% CP, 21.5% ether extract (fat), 12.5% minerals, and approximately 0.91 Mcal NE/lb. Milk production (75.2, 78.3, and 78.9 lb/d for 0, 5, and 10% CCDS diets) increased when fed the CCDS. Milk fat percentages (3.54, 3.33, and 3.43) were slightly lower ($P < 0.05$) when fed CCDS while milk protein percentages (2.93, 2.97, 2.95) were unaffected by diets. The added energy from fat in the CCDS likely contributed to the increased milk production but may have also caused the observed slight milk fat depression. Dry matter intakes (54.7, 53.8, and 49.6 lb/d) were similar for control and CCDS diets, although intake tended ($P < 0.10$) to be lower when fed 10% rather than 5% CCDS. It was concluded that feeding CCDS at 5% of ration DM is effective and profitable for dairy producers. There was no additional advantage to feeding CCDS at 10% of ration DM.

Conclusions

Corn distillers grains is a good protein and energy feed to include in rations for dairy cattle. The nutrient content of the dry matter in CDG is essentially the same for both wet and dried CDG. Nutrient content is also similar whether or not the solubles are added to the distiller grains to make DDGS, with the exception of the higher P content with the solubles added.

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Table 1. Milk production response to diets containing corn distillers grains as the supplemental protein source.

	Protein supplement					
Experiment	SBM	SBM RPLM	CDG	CDG +RPLM[1]	BLEND	BLEND +RPLM
	(milk, lb/d)					
Schingoethe et al., 1983	59.5	---	60.8[3]	---	---	---
Schingoethe et al., 1999	67.7	---	67.9[3]	---	---	---
Nichols et al., 1998	75.6	75.0	77.8[4]	80.9[3]	---	---
Liu et al., 2000	---	---	71.9[4]	69.9	72.3	72.3
Owen & Larson, 1991	74.5	---	75.6[5]	---	---	---
Powers et al., 1995	59.1	---	61.1[6*]	---	---	---
Powers et al., 1995	59.1	---	61.3[7*]	---	---	---
Powers et al., 1995	59.1	---	59.3[8]	---	---	---

[1]RPLM: ruminally protected lysine and methionine
[2]BLEND: supplemental protein was approximately 25% from CDG, 25% from fish meal, and 50% from soybean meal (SBM).
[3]Wet CDG
[4]Dried CDG
[5]Dried CDG plus solubles
[6]Whiskey dried CDG plus solubles
[7]Fuel-ethanol dried CDG plus solubles
[8]Darker fuel-ethanol dried CDG plus solubles
[*]Production was greater than with SBM, $P < 0.05$