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Using Distillers Grains in the Dairy Ration

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The affect of distillers grains (DG's) and other corn by-product feed on milk production and quality, the optimal component levels for these products in the feed ration, and the health and nutritional impact on the dairy cow is an important area of research. DG's are available in either wet (WDG) or dry (DDG) form and solubles may also (WDGS/DDGS) be added. Research in this area thus far is mixed, however as the corn by-product industry continues to expand, there will be a greater demand for more research in this area. The following summary provides an overview and key points of the research to date with some general conclusions about the economics of feeding DDGS in the lactating cow ration.

Distillers Grains

Distiller's grains may be available in two forms, with or without solubles added back to the grain. Distillers dried grains with solubles (Feed Industry Red Book, 1994) is the product obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture by condensing and drying at least three-fourths of the solids of the whole stillage by methods employed in the grain distilling industry. Most distilleries add the liquid solubles to the grains and do not produce dried solubles. Condensed distillers solubles is obtained after the removal of ethyl alcohol by distillation from the yeast fermentation of a grain or grain mixture by condensing the thin stillage fraction to a semisolid (Shaver).

The booming ethanol industry is producing large quantities of distiller's grains that may be fed to livestock. Briefly, the corn ethanol process takes a bushel of corn (56 lbs.) and produces about 2.75 gallons of ethanol and 17 pounds of distiller's grains. The starch from the corn is converted to ethanol. The remainder of the corn kernel is condensed into the distiller's grains (in a dry-grind plant). The resulting distiller's grains typically have more protein, energy (from the fat), and more concentrated nutrients than corn. The distiller's grains, whether wet or dry, present a number of challenges and economic issues for dairy producers that are detailed further below.

Table 1 contains the protein and net energy for lactation (NE_L) content of DG's and selected other feeds, as reported by the National Research Council for lactating dairy cows (NRC, 2001).

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DG's are reported to contain 30 percent crude protein, well more than corn. Energy content is reported to be 0.89 Mcal/lb., slightly below the 0.90 for corn.

Replacing some corn in the ration with DG's has been found to increase the amount of fermentable fiber in the lactating cow diet. As a result of the increased fiber inclusion, the incidence of acidosis may be reduced. The energy content of the fiber results in a higher NE_L than is contained in the current National Research Council (NRC) listing. Many ration-balancing programs use the NRC listings for the nutrient value of the feeds. A recalibration of programs and NRC guidelines may be necessary as more is known about feeding DG's to dairy cows. According to current research, crude protein levels in DDGS's may range from 25-35 percent, fat 10-12 percent, Non-Detergent Fiber (NDF) 40-45 percent, and phosphorus 0.8-1.0 percent. Not only can the amount of these nutrients in the feed vary, but their availability to the cow can vary as well (Schroeder, 2003).

Today's distiller's grains appear to have more nutritional value than those reported in the NRC guidelines. Research has indicated that the digestible energy (DE), metabolizable energy (ME), and NE_L of WDG 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 NE_L for corn distiller's grains than the older values (Schroeder).

Inclusion Rates of Wet and Dry Distillers Grains

According to Anderson, et. al., WDG's fed in place of all of the soybean meal and nearly one-half of the corn improved the efficiency of converting feed to milk as was illustrated by similar milk production, even though Dry Matter Intake (DMI) was lower. Milk protein percentages decreased with the addition of WDG to the diet, possibly reflecting the higher fat content of the WDG diet. Milk fat from cows fed WDG contained more long-chain and unsaturated fatty acids, changes that would positively influence processing properties and the marketability of milk products. (Anderson, Schingoethe, Kalscheur, and Hippen).

Comparing the feeding of distiller's 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.

Feeding Distillers Grains

Questions often arise as to the maximum amount of distillers that can be fed. South Dakota State University research suggests that a maximum of 20 percent distiller's grains could be included in the ration on a DM basis. At levels greater than 20 percent, potential palatability and excessive protein consumption problems often exist. Feed amounts may approach 30 percent when diets are properly formulated (Schroeder).

Extensive heating of distiller's grains during the drying process has raised questions about the nutrient availability, especially protein, in DDG and DDGS. A number of studies have shown that excessive heating of distiller's grains does reduce the protein availability when included in the dairy ration. 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. However, color of distiller's grains appears to be associated with the amount of ADIN. Good, high quality distiller's 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 (Schroeder).

The high level of fat in DDGS's may require limiting DDGS's in the dairy ration diet. Research suggests the fat content in the diet may have an effect on milk fat if the amount of

DDGS in the ration is at too high a level. However, some research has shown that milk production was unaffected or increased by DDGS inclusion as a protein supplement. Similar increases in milk and milk protein have been observed in other research studies when DDGS were included in the lactating cow diet (Shaver).

It is generally recommended that dairy producers feed distillers grains up to a maximum of 20 percent of ration dry matter. With typical feed intakes of lactating cows, this would be about 10 to 12 pounds of DDG or 33 to 37 pounds of WDG per cow daily. There are usually no palatability problems and producers can usually formulate nutritionally balanced diets up to that level of distiller's grains in the diet. For instance, with diets containing 25 percent of the dry matter 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 as distiller's grains, but that high of an amount is typically not recommended. Total dry matter intake may be decreased because the total ration may be too wet when using WDG. 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.

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 distiller's grains and corn contain similar amounts of energy, the energy in distiller's 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.

Excessive excretion of nitrogen (N) and phosphorus (P) can be a problem when diets with large amounts of co- products are fed. Corn milling co-products 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 co product 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. Higher levels of inclusion of corn distiller's grain will increase P 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 (Schroeder).

Comparative Cost of DGS and Corn in the Ration

Values for CP and Mcal, including corn and distiller's grain are provided in Table 1 below. including corn and distiller's grain. Note, however, that those values as well as the price relationship between corn and distiller's grains has changed and would need to be adjusted to current market values and price levels. 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. Distiller's grains are difficult to evaluate with this method as they supply both energy and protein. They are also a good source of rumen undegradable protein (often abbreviated as RUP), which is usually required to sustain high 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 (Schroeder).

Table 2 (below) contains feed costs given the inclusion of distiller's grains in the ration for three levels of milk production (Garcia and Taylor). These results indicate that, potentially, more than a 10 percent reduction in feed costs can be achieved by the inclusion of distiller's grains in the ration

Distiller's grains can be priced based on protein and energy, using respectively the prices of soybean meal and corn as standards for both nutrients. The following formula is generally used to determine an affordable purchase price for DGS:

$/cwt of DG = ($/cwt of corn x 0.531) + ($/cwt of soybean meal x 0.514)[2]

The constants in the above equation are feed evaluation factors for estimating the dollar value of feeds based on energy and protein levels. In this example, corn would be priced at $4.11 per cwt and soybean meal at $9.25 per cwt. Therefore, the formula would be:

($4.11 x 0.531) + ($9.25 x 0.514) = $6.94/cwt or $138.80 per ton

This indicates that as long as dry DGS are priced below $139 per ton they are economical to include in dairy rations. For wet DGS this would translate into a maximum of $48 per ton as fed, which should also include delivery, storage, handling, and a correction for possible spoilage.

Table 3 (below) indicates delivered prices for DDGS at various corn and soybean meal prices per ton. For example, if corn is $180 per ton and soybean meal is $220 per ton the maximum economic price for DDGS would be $182 per ton (Linn & Chase).

Nutritionists can look at ration balancing from several different angles. Four scenarios and the associated savings in feed costs by substituting DDGS for corn and protein supplements are outlined below. These values are based on a ration for a 1400-pound cow producing 90 pounds of milk per day with 3.5 percent butterfat and 3.2 percent milk protein. The results are summarized in Table 3 below.

Scenario A compares relative value and feed savings based on current energy and crude protein values for steam flaked corn and 44 percent soybean meal (SBM).

Scenario B compares relative value and feed savings based on current energy and rumen undegradable protein (RUP) values for steam flaked corn and 44 percent SBM. RUP values are not a fixed number with the current 2001 NRC model. The current NRC model projects a very low percentage by pass for conventional 44 percent SBM. Relative feed values and projected feed savings are too high with this scenario.

Scenario C compares relative value and feed savings based on current energy and RUP values for steam flaked corn and high by pass SBM (examples Soy plus and Soy Best). RUP values are not a fixed number with the current 2001 NRC model.

Scenario D compares relative value and feed savings based on current energy and crude protein values for steam flaked corn and canola meal.

[2] (Garcia and Taylor 2006)

Based on the results, summarized below in Table 4, Scenario B generates the largest feed cost savings, or net differential. But, it should be noted that each of these scenarios use steam flaked corn, which is a more expensive, more highly processed.

Projecting feed savings from feeding higher levels of corn distillers is problematic. DDGS can replace energy from corn and rumen undegradable protein (RUP) from multiple protein supplements, and cottonseed. At high DDGS feeding rates, additional RDP (rumen degradable protein) may be needed, for example urea (Norell).

Product Storage Concerns

Dried products can be stored for extended periods of time, can be shipped greater distances more economically and conveniently than wet products, and can be easily blended with other dietary ingredients. However, feeding distillers wet grains avoid 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 WDG 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 typical. 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 co products. The addition of preservatives, such as propionic acid or other organic acids may extend the storage period of the wet product, but scientific documentation of such results is difficult to find (Schroeder).

Advantages and Disadvantages of Feeding Distillers Grains

As with almost any feedstuff, a list of advantages and disadvantages can be assembled. Distiller's grains are no different. Even though more attention has been made of its disadvantages, which is common whenever a new feed becomes readily available, there are some advantages to feeding DGS to dairy cows, as well.

Advantages

- The first advantage is that DDGS or WDGS provide an additional feed source to compete with other components in the lactating cow feed ration. Interestingly, DDGS are not really a new feed to many dairy producers. Many producers located near distiller-type operations (i.e. alcohol breweries) have long fed distiller's grains and brewer's grains that were by-products of those industries. An additional feed source, such as DDG's may often provide cheaper rations at times when other feeds are in short supply.
- The fiber content available in DDGS's may allow for the substitution of lower quality hay although it may be lower in price in the lactating cow feed ration. This aspect may provide a more cost effective approach for reducing the lactating cow feed ration, as hay often accounts for the largest component of a dairy operation's overall cost structure.
- Its composition as a protein, fiber, and energy source may offset a number of other feeds in the feed ration, as well.

Disadvantages

- If the product is wet, there is much concern on how to incorporate it into a mixer wagon for the feed ration. If the product requires another truck, an additional cost will occur.

Not only will more equipment need to be added, but feeding time will also increase, which may require additional labor as well.

- A key concern is rapid spoilage of the wet product. However, for a large dairy (typically 1,000 head or larger) delivery of the product may be scheduled, on an as needed basis. For example, a 3,000 cow dairy might feed five pounds of WDG's per day, on an as fed or dry matter basis. Thus, in three days the dairy would feed 45,000 pounds or approximately a truckload of WDG's.
- Variability of product is a concern for maintaining high milk production. If, as some research suggests, variability is greater between different suppliers than different loads from the same supplier, then contracting with a sole supplier may mitigate the variability issue. Other research has suggested wide variability of product even within individual suppliers; so continuous feed testing will be necessary.
- Additional storage space may be needed to store the product. Depending on the exact type of corn co-product and how dry it is, different types of storage space may be necessary. Additional storage facilities will add to the operations fixed costs.
- A review of the dairy's Nutrient Management Plan will be necessary. Depending on how the DGS's, and particularly how the phosphorus is utilized by the cow will determine any changes in the manure composition and whether or not any nutrient management changes will need to be made.
- Given that aflatoxin is concentrated three times in the DG's, there may be times when aflatoxin could cause a problem. The source of the DG's may determine the likelihood of aflatoxin, but again, on-going feed testing may become more important to the dairy.

As with many feeds, DG's cannot be fed exclusively. There are limits to the amount that can be fed for proper cow nutrition and milk composition. Monitoring the total amount of feed on an as-fed basis and dry matter basis to make sure cows can actually consume that much product in a day will become a more important part of ongoing, normal cow nutrition program performed by the dairy operation.

Summary

The use of distillers grains in the lactating dairy cow ration is a not a new concept in the dairy industry. In fact, there have been other feed "revolutions" in the past; including soybean meal and animal by-product feeds. The use of DG's just happens to be the latest big thing. As with all feedstuffs, the feed ration will need to be closely monitored given product variability issues. Looking ahead, DG's is a feed that is going to become more readily available to dairy producers throughout the U.S. As the supply of DG's increases and its price declines it will definitely account for a larger portion of the lactating dairy cow ration.

Table 1. 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.

Table 2. Economic Impact of Including Distillers Grains in Dairy Rations.

Milk Lbs/day	Distiller's Grains % DM	Feed Cost ($/day)	Value of Milk ($/day)	Income Over Feed Costs ($/day)	Excess of Requirements, lbs.	
					Protein	Phosphorus
53	0	1.88	6.36	4.48	0.2	0.0
53	10	1.78	6.36	4.58	0.0	0.0
53	20	1.68	6.36	4.68	0.1	0.0
53	30	1.68	6.36	4.68	0.6	0.0
66	0	2.17	.92	5.75	0.1	0.0
66	10	2.06	7.92	5.86	0.0	0.0
66	20	1.96	7.92	5.96	0.0	0.0
66	30	1.92	7.92	6.00	0.2	0.0
79	0	2.45	9.48	7.03	0.0	0.0
79	10	2.35	9.48	7.13	0.0	0.0
79	20	2.24	9.48	7.24	0.0	0.0
79	30	2.16	9.48	7.32	0.0	0.0

DDG $90/T; Corn $2.30/BU; SBM $185/T; Limestone $7.25/cwt; DicalPhos $20/cwt; corn silage $25/T; Alf Haylage $45/T; Milk $12/cw;balanced using SPARTAN. Garcia & Taylor

Table 3. Value of Dry Distiller's Grains with Solubles at Various Corn & Soybean Meal Prices.

Corn	Soybean Meal ($/ton)											
($/ton)	80	100	120	140	160	180	200	220	240	260	280	300
80	84	94	104	114	125	135	145	156	166	176	186	197
100	89	99	109	120	130	140	151	161	171	181	192	202
120	91	105	115	125	135	146	156	166	176	187	197	207
140	100	110	120	130	141	151	161	171	182	092	202	213
160	105	115	125	136	146	156	167	177	187	197	208	218
180	110	120	131	141	151	162	172	182	192	203	213	223
200	115	126	136	146	157	167	177	187	198	208	218	229
220	121	131	141	152	162	172	182	193	203	213	224	234
240	126	136	147	157	167	177	188	198	208	219	229	239
260	131	142	152	162	173	183	193	203	214	224	234	244
280	137	147	157	158	178	188	198	209	219	229	240	250
300	142	152	163	173	183	193	204	214	224	235	245	255

Table 4. Savings in Feed Cost and Pounds of Corn and Protein Supplement Reduced for 10 lb. DDGS Included in Lactating Cow Feed Ration.

Assumptions	$/ton
Corn	125
44% SBM	
Hi by-pass	210
SBM	
Distillers	120
Grains	
Canola meal	172
DDGS lbs/day	10

Ration Costs

Scenario	Cost of Distillers	Savings in Corn	Savings in Protein supp	Cost Savings
A	$0.60	$0.27	$0.49	-$0.16
B	$0.60	$0.08	$0.90	-$0.38
C	$0.60	$0.35	$0.37	-$0.13
D	$0.60	$0.17	$0.62	-$0.19

Reduced Corn and Protein Feed, lbs per day

Scenario	Corn	Protein
A	4.3	5.25
B	1.25	8.57
C	5.67	3.56
D	2.68	7.25

Source: Norell

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