The Nutritional Value of Grain Alcohol Fermentation By-Products for Beef Cattle

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This publication was prepared by North Central Regional Committee 88 on Beef Growing-Finishing Systems. Members of the regional committee are:

Iowa **— A. H. Trenkle**
Illinois **— L. L. Berger**
Indiana **— T. W. Perry**
Kansas **— J. G. Riley**
Michigan **— J. Waller**
Minnesota **— S. D. Plegge**
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ARS, USDA **— C. L. Ferrell**
CSRS, USDA **— C. R. Richards**
Administrative Adviser **— R. G. Cragle**

T. W. Perry organized the material presented in this report and prepared the initial draft of the manuscript.

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THE NUTRITIONAL VALUE OF GRAIN ALCOHOL FERMENTATION BY-PRODUCTS FOR BEEF CATTLE

Distillers of grain alcohol are faced with the problem of disposing of the "spent" stillage that remains after the fermentation and distillation processes have been completed. Although the wet stillage contains a relatively low proportion of solids (5 to 10 percent dry matter), it retains some nutritional value. Distillers may dispose of this material in several ways:

1. Dehydrate it to produce distillers' dried grains with solubles;
2. Separate the liquid from the solids by centrifuging or straining the stillage and then dehydrating both fractions to produce distillers' dried solubles and distillers' dried grains;
3. Centrifuge or strain the stillage to remove some of the water, resulting in a product known as wet distillers' grains;
4. Supply it without modification to livestock producers as "distillers' slop";
5. Deposit it in a landfill or spread it on fields.

It has long been common practice to use distillers' dried solubles in poultry feeds and distillers' dried grains as a source of protein, energy, and bulk in dairy cattle grain mixes. Distillers' dried grains with solubles have also been used in dairy cattle formulations.

When energy was relatively inexpensive, it was practical to remove most of the water from the spent stillage by heating it, producing readily mixable and preservable dried distillery products containing only 10 to 12 percent water. However, the recent increases in energy costs and the possibility that our nation will find it advantageous to produce large quantities of grain alcohol for use as a fuel make it desirable to reexamine how we may best use distillers' by-products.

Several experiment stations in the north central region of the United States have investigated the use of grain alcohol fermentation by-products in beef cattle diets. This bulletin summarizes that research.

CHARACTERISTICS OF FERMENTATION BY-PRODUCTS

In characterizing the nutritive value of distillery by-products for beef cattle, it is helpful to compare the chemical composition of distillers' grains with that of soybean meal (a protein concentrate), shelled corn (an energy concentrate), and corn silage (a forage). It is also useful to compare these analyses with the nutrient requirements of a 550-pound beef steer gaining 2.4 pounds per day (Table 1).

Distillers' grains are a relatively good source of protein, energy, and phosphorous. They have the potential for meeting a major portion of beef cattle requirements for these nutrients. They contain, however, less than the required amounts of calcium and potassium (Table 1).

Table 1. National Research Council Beef Cattle Nutrition Requirements and Average Composition of Distillers' Grains, Shelled Corn, Corn Silage, and Soybean Meal

Item	National Research Council requirement[a]	Feed ingredient			
		Distillers' grains[b]	Shelled corn	Corn silage	Soybean meal
	percentage of dry matter				
Crude protein	12.1	29.5	10.0	8.1	51.5
Total digestible nutrients (TDN)	77.0	84.0	91.0	70.0	81.0
Crude fiber	.....	13.0	2.2	24.4	6.7
Calcium	0.43	0.1	0.02	0.27	0.36
Phosphorus	0.35	0.4	0.35	0.20	0.75
Potassium	0.70	0.1	0.34	1.05	2.21
pH	.....	4.0	.....	3.8	.....

[a] From *Nutrient Requirements of Beef Cattle,* National Research Council, 5th edition, 1976. Requirements are for a 550-pound steer gaining 2.4 pounds per day.
[b] The dry matter content of distillers' wet grains varies but averages 30 percent.

DISTILLERS' GRAINS AS A PROTEIN SOURCE

Research on the use of distillery by-products as a source of supplemental protein for beef cattle is summarized here in two categories. The studies in the first group to be discussed pertain to the use of these by-products as a direct replacement for other sources of supplemental protein. Those in the second group relate to the potential of these by-products for supplying "bypass" protein.

Use as a Direct Replacement for Other Protein Sources

Because of the relatively high protein content of distillers' grains, researchers at several experiment stations have studied the use of these products to directly replace other protein sources (Table 2). University of Nebraska researchers studied the value of wet distillers' grains as a source of supplemental protein for beef cattle. In two cattle trials and one lamb trial (De Haan et al., 1982; Stock and Klopfenstein, 1982), use of wet distillers' grains as a portion of the supplemental protein resulted in improved rates of gain and feed efficiency.

In one steer trial (Table 2, no.1), crossbred steers averaging 495 pounds initially were fed a diet consisting of equal portions of corn silage and corn cobs supplemented with urea, soybean meal, corn gluten meal, wet distillers' grains, or wet distillers' solubles. The diets supplemented with soybean meal, corn gluten meal, wet distillers' grains, and wet distillers' solubles contained 11.5 percent crude protein, with urea providing one-half of the supplemental crude protein equivalents. Daily gains were fastest (1.75 pounds per day) for steers fed diets supplemented with wet distillers' grains, slowest (1.09 pounds per day) for steers fed urea-supplemented diets, and intermediate for steers fed wet distillers' solubles (1.26 pounds per day), soybean meal (1.40 pounds per day), and corn gluten meal (1.49 pounds per day) during the 106-day trial. The diet supplemented with wet distillers' grains resulted in the most efficient gains (7.06 pounds of feed per pound gained), whereas the urea treatment produced the least efficient gains (11.12 pounds of feed per pound gained). Feed efficiencies for cattle fed the other protein supplements fell between these values.

In a second trial (Table 2, no. 2), steers averaging 489 pounds initially were fed for 112 days a basal diet consisting of 56 percent corn silage and 28 percent corn cobs (on a dry matter basis) formulated to contain 11.5 percent protein and 61 percent total digestible nutrients. Supplemental nitrogen sources in the various trials were: (*a*) 50, 75, and 100 percent soybean meal, (*b*) 30, 40, and 50 percent wet distillers' grains, and (*c*) 30, 40, and 50 percent ensiled wet distillers' grains. Urea furnished the remaining supplemental nitrogen. Differences in gain among steers fed wet distillers' grains, ensiled wet distillers' grains, or soybean meal were small (their gains were 1.21, 1.15, and 1.27 pounds per day, respectively), but steers fed soybean meal, wet distillers' grains, or ensiled wet distillers' grains gained faster than those whose supplemental protein came exclusively from urea (0.92 pounds per day). Steers fed wet distillers' grains had the best feed efficiency (9.64 pounds of feed per pound gained), whereas those receiving the urea supplement had the poorest (13.58 pounds of feed per pound gained).

In a 63-day trial, lambs whose diets were supplemented with ensiled wet distillers' grains gained most rapidly (0.25 pounds per day), followed by those supplemented with wet distillers' grains (0.21 pounds per day), distillers' dried grains (0.18 pounds per day), soybean meal (0.16 pounds per day), and urea alone (0.12 pounds per day).

Researchers at the University of Missouri (Hunt et al., 1982; Paterson et al., 1981a,b) fed corn stillage containing 90 to 95 percent water to supply half the supplemental protein for 790-pound steers fed a diet of 76.6 percent whole shelled corn, 17.0 percent corn silage (dry matter basis), and minerals (Table 2, no. 3). Cattle fed stillage gained 2.99 pounds per day over a 76-day trial, whereas those in which soybean meal supplied half the supplemental protein gained 2.94 pounds per day; those in which urea supplied all of the supplemental protein equivalents gained 2.79 pounds per day. The feed-to-gain ratio was almost identical (6.3 pounds of feed per pound of gain) among the treatments. In two lamb growth trials, stillage was superior to soybean meal (0.32 pounds versus 0.18 pounds per day) in one trial but inferior to soybean meal (0.41 versus 0.51 pounds per day) in the other.

Purdue University researchers conducted two experiments using distillery by-products as a supplemental protein source (Risk, 1981; Risk et al., 1981; Risk et al., 1982a,b). In a 135-day trial (Table 2, no. 4), steers weighing 678 pounds initially were fed a high-concentrate diet (5.2 pounds of corn silage dry matter with ad libitum shelled corn) plus either soybean meal (1.76 pounds per day) or wet distillers' grains (2.34 pounds per day). The cattle fed soybean meal gained faster than those fed wet distillers' grains (2.87 versus 2.47 pounds per day). However, the cattle whose diets were supplemented with soybean meal consumed more dry matter (16.0 versus 15.0 pounds per day) than those supplemented with wet distillers' grains, and therefore the feed efficiency was better for

the cattle fed wet distillers' grains. In a second trial, heifers averaging 534 pounds initially were fed diets similar to those used in the Purdue steer study (Table 2, no. 5). Heifers fed wet distillers' grains and soybean meal supplements gained 2.81 and 2.84 pounds per day, respectively, and had similar feed efficiencies.

Kansas State University researchers used sorghum grain stillage in feeding trials (Soderlund et al., 1981). Feeding decanted stillage (89.5 percent water) as a source of supplemental protein in finishing rations for cattle resulted in slower daily gains and required a greater amount of feed per pound of gain than diets supplemented with soybean meal or urea (Table 3). In one trial, steers weighing 795 pounds initially were fed a diet of 82 percent milo and 14 percent corn silage (dry matter basis) fortified with minerals. Soy-

Table 2. Results of Nebraska, Missouri, and Indiana Studies on the Use of Distillers' Grains in Beef Cattle Diets

Supplemental nitrogen source	Daily intake of test protein (pounds)	Initial weight of cattle (pounds)	Daily feed intake* (pounds)	Daily gain (pounds)	Feed efficiency (pounds of feed per pound gained)	Length of trial (days)	Protein efficiency ratio
1. Nebraska							
Urea	0.29	495	12.1	1.09[a]	11.12[a]	106	
½ soybean meal:½ urea	0.68:0.18		12.4	1.40[b]	8.85[b]		1.07[a]
½ corn gluten meal:½ urea	0.50:0.18		12.2	1.49[b]	8.21[b,c]		1.31[a]
½ wet distillers' grains:½ urea	1.10:0.18		12.4	1.75[c]	7.06[c]		2.19[b]
½ wet distillers' solids:½ urea	1.03:0.17		11.7	1.26[b]	9.30[b]		0.48[a]
2. Nebraska							
Urea	0.20	489	12.3	0.92[a]	13.58[a]	112	
Soybean meal:urea	0.62:0.10		12.4	1.27[b]	10.12[b]		0.86
Wet distiller's grains:urea	0.59:0.15		12.5	1.21[b]	9.64[b]		2.13
Ensiled wet distiller's grains:urea	0.58:0.15		12.2	1.15[b]	11.28[b]		1.40
3. Missouri							
Urea	0.12	790	17.7	2.79	6.35	76	
Soybean meal	0.38		18.8	2.94	6.38		
Whole stillage	0.64		18.9	2.99	6.32		
4. Purdue							
Soybean meal	1.76	678	16.0	2.87	5.60	135	
Wet distillers' grains	2.34		15.0	2.47	6.07		
½ wet distillers' grains	1.04		16.1	2.75	5.85		
5. Purdue							
Soybean meal	1.8	534	15.6	2.84	5.50	133	
Wet distillers' grains	1.8		15.8	2.81	5.60		

* Intake on a dry matter basis.
[a,b,c] Numbers within the same data set in any one column are significantly different ($P<0.05$) if their superscripts are different.

Table 3. Results of Kansas Study on the Use of Distillers' Grains in Beef Cattle Diets

Dietary content of wet distillers' grains (percent)	Amount of wet distillers' grains per day (pounds)	Initial weight of cattle (pounds)	Daily feed intake* (pounds)	Daily gain (pounds)	Feed efficiency (pounds of feed per pound gained)	Length of trial (days)
0	0.0	795	24.2	3.27	7.44	86
0	0.0		24.3	3.16	7.68	
33	22.8		24.1	2.99	8.10	
15	8.7		24.3	3.07	8.00	

* Intake on a dry matter basis.

bean meal, urea, stillage, or stillage plus urea were used as sources of supplemental protein. The daily weight gain was highest for cattle whose diets were supplemented with soybean meal (3.27 pounds) followed by those fed diets supplemented by urea only (3.16 pounds), stillage plus urea (3.07 pounds), and stillage alone (2.99 pounds). Cattle fed soybean meal had the best feed efficiency (7.44 pounds of feed per pound of gain), and those fed stillage had the poorest (8.10 pounds of feed per pound of gain).

Based on the research summarized here, it appears that wet distillers' corn grains alone or in combination with urea are equal in value to soybean meal or corn gluten meal in satisfying the total supplemental protein requirements for growing and finishing beef cattle. The results for sorghum stillage, on the other hand, indicate that as a protein source it is inferior to soybean meal.

Use as a Source of Rumen Bypass Protein

As early as 1969, evidence began to accumulate that certain sources or combinations of natural protein were used more efficiently than others by beef cattle. Horn and Beeson (1969) reported that adding 5 percent corn distillers' dried grains with solubles to high-urea diets improved nitrogen retention by beef steers. Levels of ruminal ammonia, blood urea levels, and plasma free amino acids were not affected, nor was there any shift in the level of total rumen volatile fatty acids as a result of feeding distillers' dried grains with solubles.

Hatch et al. (1972) summarized three steer metabolism trials at Purdue University in which 2.5 percent (dry matter basis) corn distillers' solubles were incorporated into a liquid supplement. Nitrogen retention increased ($P<0.10$) and rumen ammonia and plasma urea concentrations decreased when corn distillers' solubles replaced urea in the liquid supplement. In accompanying feedlot studies, the rate of gain was improved (2.44 versus 2.75 pounds per day, $P<0.05$) when 2.5 percent distillers' solubles were incorporated into a 64 percent high-urea liquid supplement.

Chen et al. (1977) summarized nine Purdue University metabolism trials designed to evaluate the products of several methods for processing distillers' by-products: (*a*) screened-process distillers' solubles, (*b*) screened-process distillers' grains, (*c*) screened-process distillers' grains with solubles, (*d*) centrifuged-process distillers' solubles, and (*e*) centrifuged-process distillers' grains with solubles. Their data suggest that most of those constituents of distillery by-products that enhance nitrogen use by ruminants exist in the screened-process distillers' solubles and centrifuged-process distillers' grains with solubles.

Researchers at the University of Nebraska have investigated the value of distillers' by-products as protein supplements (Klopfenstein et al., 1978). In a cattle growth trial, calves fed diets containing distillers' dried grains plus urea gained nearly as rapidly and efficiently as those fed diets with soybean meal, and they gained more rapidly and efficiently than those fed diets supplemented with urea alone. These researchers introduced the term "efficiency of protein utilization" and defined it as the increase in weight gain per day (over that of control animals fed diets supplemented with urea only) divided by the added natural protein intake. Distillers' dried grains plus urea produced an efficiency ratio of 1.33 compared to 0.89 for soybean meal, indicating that protein from distillers' dried grains was 50 percent more efficient, when fed in combination with urea, than was the protein supplied by soybean meal.

Metabolism trials with lambs indicated that when distillers' dried grains were fed in combination with urea, ruminal ammonia levels were as high as those for lambs fed soybean meal. However, when urea was removed, rumen ammonia decreased rapidly during a 6-hour post-feeding period.

A cattle growth study was conducted with calves to compare various sources of supplemental protein (urea, urea plus soybean meal, corn distillers' dried grains plus urea, corn distillers' dried grains with solubles plus urea, distillers' dried grains plus soybean meal and urea, and distillers' dried grains with solubles plus soybean meal and urea). The performance of all cattle fed natural protein supplements was superior to that of the cattle fed urea. The greatest and most efficient daily gains were achieved by calves consuming diets supplemented with distillers' dried grains (from 160 to 200 percent of the gains with soybean meal) and those whose diets were supplemented with distillers' dried grains with solubles (from 101 to 180 percent of the gains with soybean meal). In another summary, Klopfenstein and Abrams (1981) suggested that distillers' dried grains have 173 percent of the protein value of soybean meal.

Waller et al. (1980a,b) summarized results of studies at Michigan State University in which the "bypass" protein characteristics of distillers' feeds were evaluated. In the first paper, steers fed diets supplemented with milo distillers' dried grains, milo distillers' dried grains with urea, or milo distillers' dried grains with solubles plus urea gained faster ($P<0.05$) than steers whose diets were supplemented only with urea. Distillers' dried grains from either milo or corn produced a greater complementary effect when fed with urea than did corn or milo distillers' dried grains with solubles plus urea. Drying of milo distillers' solubles

Table 4. Results of Illinois Study on the Use of Distillers' Grains in Beef Cattle Diets

Dietary supplement	Amount of wet distillers' grains per day (pounds)	Initial weight of cattle (pounds)	Daily feed intake* (pounds)	Daily gain (pounds)	Feed efficiency (pounds of feed per pound gained)	Length of trial (days)
Wet distillers' grains	4.0	595	15.0	2.59[a]	5.84	77
Soybean meal	0.0		15.3	2.33[b]	6.53	

* Intake on a dry matter basis.
[a,b] These values are significantly different ($P<0.05$).

in the production of distillers' dried grains with solubles appeared to increase the animals' use of the solubles fraction. In the second paper, the authors recommended: (*a*) that distillers' dried grains should be used in the growing phase when protein requirements are high, (*b*) that distillers' dried grains should not be used in competition with soybean meal when its degradation characteristics are not optimized, and (*c*) that condensed distillers' solubles should be included in diets as a source of soluble nitrogen to replace urea.

In University of Illinois studies, Berger (1981) and Berger and Fahey (1982) reported that steers fed wet distillers' grains as a source of supplemental protein gained 0.26 pounds more per day (2.59 versus 2.33 pounds per day) and required 11 percent less feed per pound of gain than those whose diets contained soybean meal (Table 4). Both diets were formulated to contain 73 percent total digestible nutrients (TDN) and 12 percent crude protein.

In two University of Minnesota trials, dried distillers' grains with solubles were tested as a source of supplemental protein (Garrett et al., 1981). Supplementing the feed with distillers' dried grains with solubles plus urea did not improve daily gains or feed efficiency over that obtained when urea alone was used (Table 5, nos. 1 and 2). Lightweight steers (375 pounds initially) but not heavy steers (520 pounds) gained faster than those whose diets were supplemented only with urea when distillers' dried grains with solubles were the sole source of supplemental protein.

Two trials were conducted at Iowa State University in which corn stillage (79 percent water) was added with urea to cattle-growing diets (Trenkle et al., 1981; Rouse and Trenkle, 1980). In a 168-day trial, steers weighing 490 pounds were fed 11 percent protein, 60 percent TDN diets containing 63 percent ground cobs, 12 percent molasses, minerals, and varying quantities of corn (Table 5, no. 3). The diets were supplemented with 15 percent soybean meal, 5.2 percent corn gluten meal, 15.3 percent wet distillers' grains, or urea. The quantities of corn gluten meal and wet distillers' grains were calculated to provide a quantity of bypass protein similar to that which would be provided by soybean meal, assuming a ruminal degradation of 75 percent for soybean meal protein and 56 percent for corn gluten meal and wet distillers' grains protein. Consequently, urea supplied about one-half of the supplemental nitrogen in the diets containing corn gluten meal or wet distillers' grains. The rates of gain were similar for the cattle fed soybean meal, corn gluten meal, and wet distillers' grains (1.96, 1.96, and 1.91 pounds per day, respectively) but superior to the gain of those receiving supplemental nitrogen solely from urea (1.43 pounds per day). Feed efficiency was better for cattle fed corn gluten meal or wet distillers' grains (7.49 and 7.48 pounds of feed per pound of gain, respectively) than for those fed soybean meal or urea only (8.26 and 9.51 pounds of feed per pound of gain, respectively).

In a 56-day heifer finishing trial (using animals with an initial weight of 760 pounds), replacing one-half of the urea and about one-fourth of the corn dry matter with wet distillers' grains resulted in no change in the rate of gain (3.46 pounds per day) or feed efficiency (6.5 pounds of feed per pound of gain).

DISTILLERS' GRAINS AS AN ENERGY SOURCE

Because of their 28 percent protein content, distillers' grains are more frequently considered as a source of supplemental protein than of energy. However, if abundant supplies of wet distillers' grains should become available — as a result, for example, of increased production of fuel alcohol — this by-product could be used as an energy source in livestock feeds. A volume edited by Parsons (1982) reports several studies of the use of distillers' grains as a cattle feed. In a Nebraska trial (Stanley Farlin, personal communication), wet distillers' grains at levels of 0, 21.25, 42.5, and 63.75 percent were fed for 123 days to steers with an initial weight of 772 pounds. Daily gains were highest at the 42.5 percent level (3.03, 3.00, 3.33, and 2.99 pounds per day for the four percentages of wet distillers' solubles, respectively), but feed efficiency was most favorable in steers fed the highest level of wet distillers' grains (5.58 versus 6.21 pounds of feed per pound of

Table 5. Results of Minnesota and Iowa Studies on the Use of Distillers' Grains in Beef Cattle Diets

Supplemental nitrogen source	Daily intake of test protein (pounds)	Initial weight of cattle (pounds)	Daily feed intake* (pounds)	Daily gain (pounds)	Feed efficiency (pounds of feed per pound gained)	Length of trial (days)
1. Minnesota						
Control	0.15	375	11.8	1.69	6.98	140
All urea	0.45		11.7	2.02	5.79	
½ urea:½ alfalfa	0.31:0.31		12.7	2.29	5.55	
½ urea:½ soybean meal	0.24:0.24		11.0	2.09	5.26	
½ urea:½ distillers' dried grains with solubles	0.24:0.24		11.5	2.03	5.66	
Alfalfa	0.77		12.8	2.41	5.31	
Soybean meal	0.46		12.9	2.20	5.87	
Distillers' dried grains with solubles	0.69		12.1	2.18	5.55	
2. Minnesota						
Control	0.16	520	13.2	2.00	6.60	108
Urea	0.55		14.7	2.73	5.38	
½ urea:½ alfalfa	0.37:0.37		15.9	2.92	5.44	
½ urea:½ soybean meal	0.30:0.30		14.7	2.72	5.39	
½ urea:½ distillers' dried grains with solubles	0.30:0.30		14.4	2.63	5.48	
Alfalfa	0.88		15.1	2.93	5.15	
Soybean meal	0.50		14.7	2.74	5.36	
Distillers' dried grains with solubles	0.77		14.0	2.62	5.34	
3. Iowa						
Soybean meal	2.43	490	16.2[a]	1.96[a]	8.26[a]	168
Corn gluten meal	0.73		14.7[b]	1.96[a]	7.49[b]	
Stillage	2.18		14.2[b,c]	1.91[a]	7.48[b]	
Urea	0.31		13.5[c]	1.43[b]	9.51[c]	

* Intake on a dry matter basis.
[a,b,c] Numbers within the same data set in any one column are significantly different ($P<0.05$) if their superscripts are different.

Table 6. Results of Illinois, Indiana, and Kansas Studies on the Use of Distillers' Grains in Beef Cattle Diets

Dietary content of wet distillers' grains	Amount of wet distillers' grains per day (pounds)	Initial weight of cattle (pounds)	Daily feed intake* (pounds)	Daily gain (pounds)	Feed efficiency (pounds of feed per pound gained)	Length of trial (days)
1. Illinois						
None	0.0	682	15.4	2.38	6.50	108
25 percent	4.1		16.4	2.53	6.45	
50 percent	7.7		15.5	2.64	5.86	
2. Purdue						
No distiller's grains	0.0	536	15.6	2.84[a]	5.50	133
All corn and soybean meal replaced by wet distillers' grains	5.7		13.1	2.48[b]	5.27	
Intermediate	3.6		14.3	2.74[a]	5.22	
3. Kansas						
None	0.0	650	21.8	2.43[b]	9.15	56
32 percent	11.5		22.7	2.24[b]	10.09	
50 percent	23.5		23.2	2.80[a]	8.32	
68 percent	42.5		21.5	2.54[a,b]	8.48	

* Intake on a dry matter basis.
[a,b] Numbers within the same data set in any one column are significantly different ($P<0.05$) if their superscripts are different.

gain for the 63.75 and 0 percent levels of wet distillers' grains).

In an Illinois study, Berger and Fahey (1982) fed 680-pound steers a finishing diet containing 0, 25, or 50 percent wet distillers' grains (dry matter basis) and obtained gains of 2.38, 2.53, and 2.64 pounds per day, respectively, with an accompanying 10 percent improvement in feed efficiency at the highest concentration of wet distillers' grains (Table 6, no. 1).

In an Iowa study (Rouse and Trenkle, 1981), the daily gain and feed efficiency of heifers were not affected by replacing up to 15 percent of the dry matter in corn rations with wet distillers' grains containing 79 percent water.

Purdue University researchers (Risk et al., 1981) concluded that replacing all of the corn in a steer finishing diet with wet distillers' grains depresses the rate of gain but not feed efficiency (Table 6, no. 2). They suggested that wet distillers' grains could replace up to half of the grain without any effect on rate of gain. Kansas researchers (Soderlund et al., 1981) used sorghum grain stillage containing 7.5 percent dry matter at a rate of 0, 32, 50, and 68 percent of the dry matter content on an as-fed basis in cattle feeding trials and obtained daily gains of 2.43, 2.24, 2.80, and 2.54 pounds per day, respectively (Table 6, no. 3).

Although the studies cited here do not establish the maximum level at which wet distillers' grains can replace corn or milo in cattle growing or finishing diets, it appears that up to one-half of the grain dry matter can be replaced with these distillery by-products.

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