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Distillers grains as an energy source and effect of drying on protein availability

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Abstract

The use of distillers byproducts as energy sources would expand the market for these byproducts. Drying of these byproducts may produce changes that affect the nutritional value. A series of experiments was conducted to evaluate distillers byproducts as an energy source for finishing cattle and to compare wet vs. dried byproducts. The energy value of wet distillers byproducts was 132 to 174% the value of dry rolled corn for finishing cattle when the byproducts were fed as 40% of the diet dry matter. Distillers dried grains plus solubles were 130% the energy value of corn. Acid detergent insoluble nitrogen level of the dried grains did not affect feeding value. Distillers dried grains plus solubles were equal in protein value to wet byproducts when fed to growing calves. Acid detergent insoluble nitrogen level did not affect protein utilization of dried distillers byproducts.

Keywords: Distillers grains; Protein; Energy; Beef cattle

1. Introduction

Distillers dried grains plus solubles (DDGS) have been commonly used as protein sources for ruminants and non-ruminants. The production of DDGS is increasing as more ethanol is used for fuel. In addition, exports of DDGS to Europe may decrease in the future. Thus it is important to expand the use of distillers grains in domestic markets.

Because drying requires fuel energy, feeding distillers byproducts wet has been studied as a means of reducing this energy and economic cost. Perishability of the byproducts and transportation costs are important considerations when feeding wet byproducts.

Finally, the effects of drying on the nutritional value of DDGS continues to be debated (Van Soest and Sniffen, 1984; Britton et al., 1986; Chase, 1987; Klopfenstein, 1987; Van Soest, 1989; Weiss et al., 1989). Undoubtedly, severely damaged DDGS

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have lower feeding values (Klopfenstein, 1991) but these types of damage do not routinely occur. Criticism of heat damage in DDG continues but may be unwarranted.

We have conducted a series of experiments to study (1) the feeding of distillers byproducts as an energy source to feedlot cattle and (2) the effects of drying on the feeding value of distillers byproducts.

2. Experiments involving wet byproducts

Because of the high moisture content, transportation of wet byproducts is expensive and the byproducts will mold readily. Therefore, it is necessary to feed wet byproducts where a large concentration of cattle exists, such as beef feedlots. Feeding distillers byproducts as both a protein and energy source in feedlot diets would enable the byproducts to be used rapidly.

Distillers byproducts (wet grains and thin stillage) were produced at the University of Nebraska's farm-scale alcohol plant and transported, every other day, to the beef feedlot. Fermented corn mash was screened and pressed, separating the solids (wet grains) from the liquid. The liquid fraction was distilled, removing the alcohol and forming the byproduct thin stillage. For each distillation, the byproducts were weighed, sampled, and measured for DM content. The ratio of wet distillers grains:thin stillage production (DM basis) was computed monthly and diets were altered accordingly. Samples were composited weekly and analyzed for CP. Trial composites were analyzed for DM, CP, starch, NDF, fat, ash and ethanol.

In general, fermentation and distillation removed the corn starch, which concentrated the remaining nutrients threefold (Table 1). Crude protein content of thin stillage produced in our plant (190 g kg^{-1}) was lower than typical values (260 to 290 g kg^{-1}). The wet distillers byproducts (WDB) may not be typical of dry distillers grains and solubles produced from commercial dry milling plants. The WDB used in these trials contained more starch and ethanol and less protein than literature values reported for dry distillers grains plus solubles. In addition, the increased starch content of WDB suggests less starch was converted to alcohol than would be expected in normal commercial

Table 1
Corn and wet distillers byproduct composition, g kg^{-1} of DM [a]

Nutrient	Corn	Wet grains	Thin stillage	WG:TS [b]
Starch	703	90	220	139
Crude protein	101	250	168	219
NDF	109	394	117	291
Fat	38	137	81	116
Ash	14	14	59	31
Ethanol		107	122	113
Dry matter [c]	868	314	50	215

[a] Average of yearling and calf trials. [b] WG: TS = 1.68 wet grains: 1 thin stillage (production ratio), DM basis.
[c] Includes ethanol.

operations. The mean production ratio (DM basis) of wet distillers byproducts (wet grains:thin stillage) during the yearling trials was 1.65:1 and 1.70:1 during the calf trials, compared to the mean feeding ratio of 1.67:1 and 1.81:1 for the yearling and calf trials, respectively. Dry matter content (includes ethanol) of the byproducts was 314 g kg^{-1} (wet grains) and 50 g kg^{-1} (thin stillage) and was variable (wet grains mean coefficient of variation (CV) = 9.5%; thin stillage mean CV = 21.2%).

Two finishing trials were conducted, beginning in May 1990 and 1991, using 80 crossbred yearling steers per trial (Year 1, body weight = 316 kg; Year 2, body weight = 340 kg). Steers were randomly allotted to eight pens (two pens per treatment per trial). Treatments consisted of a control and 52, 126, and 400 g kg^{-1} (of diet DM) WDB. The proportion of wet distillers grains:thin stillage was constant among WDB levels and based on the ratio of byproduct production. All diets contained 50 g kg^{-1} corn silage and 50 g kg^{-1} alfalfa hay. The control diet contained 790 g kg^{-1} dry rolled corn, 50 g kg^{-1} molasses, and 60 g kg^{-1} supplement. Supplemental protein for the control diet was a 50:50 combination (CP basis) of soybean meal and urea. The low level (52 g kg^{-1}) of WDB replaced the same amount of CP as supplied by soybean meal in the control diet. The medium level (126 g kg^{-1}) of WDB replaced the same amount of CP as supplied by soybean meal and urea in the control diet. The high level (400 g kg^{-1}) of WDB replaced all of the soybean meal and urea CP, and a portion of the corn. Thus, 400 g kg^{-1} WDB was used as both a source of CP and energy. Diets were balanced for 12% CP (400 g kg^{-1} WDB diet contained 155 g kg^{-1} CP), 7 g kg^{-1} calcium, 3.5 g kg^{-1} phosphorus, and 7 g kg^{-1} potassium and contained 25 g ton^{-1} monensin and 10 g ton^{-1} tylosin (DM basis). Steers were adapted to the final diets in 21 days using four step-up diets containing 450 (3 days), 350 (4 days), 250 (7 days), and 150 g kg^{-1} roughage (7 days; DM basis). Roughage was a mixture of corn silage and alfalfa hay with corn silage assigned a value of 500 g kg^{-1} roughage. Wet distillers grains were mixed in all diets; however, because of the high moisture content of thin stillage (955 g kg^{-1} moisture), thin stillage was mixed in diets containing 52 and 126 g kg^{-1} byproducts and offered as the source of drinking water at the 40% byproduct level. When steers had consumed their allotted thin stillage, water was available ad libitum. Cattle were implanted with estradiol, fed once daily, and housed in an open-front confinement barn.

Two finishing trials were conducted, beginning in November of 1990 and 1991, using 80 crossbred steer calves per trial (Year 1, body weight = 274 kg; Year 2, body weight = 279 kg). Experimental treatments and procedures for the calves were the same as for the yearlings with the following exception; the calf control supplement contained soybean meal as the only supplemental protein source (no urea). The trial was initiated approximately 30 days after arrival at the feedlot, at which time the calves were implanted with Compudose. Calves were fed for 194 and 181 days in 1990 and 1991, respectively. Adaptation to the final diets, feeding, initial weighing procedures, and carcass measurements were performed as in the yearling trials.

Both yearlings and calves responded similarly (Table 2) to WDB. No interactions ($P > 0.1$) between years in cattle performance were detected among WDB levels, therefore, data were pooled across years within yearling and calf trials. As level of WDB increased, cattle consumed less DM (linear, $P < 0.01$), gained faster (linear, $P < 0.1$)

Table 2
Effect of wet distillers byproduct level on finishing performance of yearlings and calves

Item	Byproduct level, g kg^{-1} of diet DM [a]			
	0	52	126	400
Daily feed (kg)				
Yearlings [b]	11.5	11.2	10.9	9.7
Calves [b]	8.4	8.7	8.4	7.9
Daily gain (kg)				
Yearlings [c]	1.64	1.71	1.75	1.75
Calves [b]	1.30	1.39	1.40	1.46
Feed/gain [d]				
Yearlings [e]	6.94	6.62	6.33	5.78
Calves [b]	6.45	6.33	6.10	5.65

[a] Wet grains: thin stillage (fed ratio), yearlings = 1.67:1;calves = 1.81:1, DM basis. [b] Byproduct level, linear ($P < 0.01$). [c] Byproduct level, linear ($P < 0.10$); quadratic ($P < 0.10$). [d] Accounts for ethanol consumption.[e] Byproduct level, linear ($P < 0.01$); quadratic ($P < 0.10$).

and were more efficient (linear, $P < 0.01$) than with the control cattle. Fat thickness at slaughter did not differ among treatments and averaged 1.3 cm for yearlings and 1.4 cm for calves. Liver abscess score was not statistically different among treatments; however, there were three severely abscessed livers from cattle fed the control compared to 0 for cattle fed 40% WDB. Quality grade of yearlings did not differ among treatments (average = 70% choice), while calves fed WDB graded higher (linear, $P < 0.01$) than the control calves (0% WDB = 68% choice, 40% WDB = 93% choice).

Dry matter intake values would not account for ethanol intake since ethanol is volatized upon drying. Accounting for ethanol intake, yearlings were 5%, 9%, and 17% more efficient while calves were 2%, 5%, and 12% more efficient than the controls when fed 52, 126, and 400 g kg^{-1} wet distillers byproducts, respectively. Calves were expected to benefit more from high levels of metabolizable protein than yearlings due to differences in composition of gain (more lean growth). However, metabolizable protein intake was above the calculated requirement for all treatments so no response was obtained.

Improvements in yearling and calf performance at each level of wet distillers byproducts can be attributed to increased energy utilization. The NE_g of each diet was calculated, based on performance, according to the equations by Lofgreen and Garrett (Table 3). The NE_g content of wet distillers byproducts was calculated by substitution. Wet distillers byproducts contributed 94%, 76%, and 51% more energy than corn when fed to yearlings and 26%, 35%, and 34% more energy than corn when fed to calves at 52, 126, and 400 g kg^{-1} of the diet DM, respectively. Compared with corn, WDB contained an average of 1.74 times the energy for gain of yearlings and 1.32 times the energy for gain of calves when included up to 400 g kg^{-1} of the diet (Table 3).

A combination of factors likely contributed to the high energy value of wet distillers byproducts. First, the byproducts contained over three times more fat (corn oil) than corn (Table 1). Although fat theoretically contains 3.5 times more metabolizable energy than corn grain and ethanol contains 1.7 times more gross energy than starch, nutrient

Table 3
Net energy content of diets and wet distillers byproducts in yearling and calf trials, Mcal kg^{-1} of DM [a]

NE_g	Byproduct level (g kg^{-1} of diet DM) [a]			
	0	52	126	400 [b]
Diet (Mcal kg^{-1}) [a]				
Yearlings	1.37	1.46	1.52	1.69
Calves	1.39	1.42	1.48	1.61
Wet distillers (Mcal kg^{-1}) [b]				
Yearlings		2.98	2.71	2.33
Calves		1.96	2.10	2.07
Relative to corn (%)				
Yearlings		194	176	151
Calves		126	135	134

[a] Based on cattle performance. [b] Calculated by substitution.

content could only account for WDB containing 18% more energy than corn. Secondly, cattle fed WDB consumed less starch and more corn fiber, which is highly digestible, than the control cattle. This may have reduced digestive problems (acidosis). The greater potential for yearlings to experience acidosis may have contributed to the different energy values, relative to corn, of WDB between yearlings (average relative value = 174%) and calves (average relative value = 132%). Relieving subacute acidosis is typically associated with an increase in intake, however, because cattle eat to a constant energy level and the WDB contained more energy than corn, DMI was not increased (Tables 2 and 3). Thirdly, the use of bypass protein as an energy source may have reduced metabolic losses associated with microbial fermentation.

3. Experiments involving wet vs. dry byproducts

Two experiments were conducted to compare wet distillers byproducts to DDGS as protein and energy sources. Wet byproducts were produced as described previously. Eleven batches of dried byproducts were obtained from commercial distilleries. Three composites were prepared on the basis of acid detergent insoluble nitrogen (ADIN; low, medium, high).

For energy evaluation, 160 yearling steers (389 kg) were fed diets of 50 g kg^{-1} corn silage, 50 g kg^{-1} alfalfa hay, 50 g kg^{-1} molasses, 60 g kg^{-1} supplement and 790 g kg^{-1} dry rolled corn. Distillers byproducts replaced supplemental protein and corn to supply 400 g kg^{-1} of the diet dry matter. For the wet byproduct, the thin stillage was consumed as the drinking water. This experiment was conducted similarly to those discussed previously.

The cattle fed the distillers byproducts gained significantly faster than those on the control corn diet (Table 4). Cattle fed the DDGS ate more than the controls while those fed the wet byproducts ate less than the controls. Most importantly, feed efficiency was improved by feeding the distillers byproducts compared to the control. The wet byproducts were significantly higher in nutritive value than the dried. Wet byproducts

Table 4
Energy value of wet vs. dry grains

	Form of distillers grains				
	Control	Wet	Low [a]	Medium [a]	High [a]
Daily feed (kg)	11.0 [bc]	10.6 [b]	11.5 [c]	11.4 [c]	11.8 [c]
Daily gain (kg)	1.46 [b]	1.68 [c]	1.66 [c]	1.68 [c]	1.71 [c]
Feed/gain	7.69 [b]	6.33 [c]	6.94 [d]	6.76 [d]	6.90 [d]
Improvement (%)					
Diet		21.5		11.9 (ave.)	
Distillers vs. corn		53.8		29.8	

[a] Level of ADIN, 97, 175, and 288 g kg^{-1}. [b,c,d] Means in same row with different superscripts differ ($P < 0.05$).

had 54% more energy than corn and dried products 30% more. There was no effect of ADIN level in the DDGS on cattle performance when the DDGS were fed as an energy source.

For protein evaluation, 60 growing calves (204 kg) were individually-fed diets based on sorghum silage (317 g kg^{-1} of diet DM) and corncobs (500 g kg^{-1} of diet DM). The distillers byproducts served as the bypass protein supplements and a urea supplement served as a control. The distillers byproduct supplements were combined with the urea supplement to provide increasing levels of protein from the distillers byproducts (250, 340, 430 and 520 g kg^{-1} of supplemental protein). There were 12 calves on the urea control and 12 calves on each source of distillers byproducts (three per level). The calves were implanted with Compudose at the beginning of the trial and were fed for 56 days. Weights were taken for three consecutive days at the beginning and end of the experiment. The diets were fed at an equal proportion of body weight to all animals and the amount of refusals was minimized. Data were analyzed using the slope-ratio technique.

The urea control cattle gained 0.45 kg day^{-1} (Table 5) and the cattle at the highest protein level gained 0.70 kg day^{-1}. No significant differences were observed in gains of the cattle averaged across protein levels. The protein level was lowest in the wet grains but cattle fed the diet based on wet grains gained more per unit of protein and had

Table 5
Calf gains and protein efficiencies [a]

Supplemental protein	Daily gain [b] (kg)	Protein efficiency [c]	Protein escape [d]	ADIN (g kg^{-1} CP)
Urea	0.45	–	–	–
Wet grains + thin stillage	0.66	2.55	549	–
Low ADIN dried grains + solubles	0.64	2.00	380	97
Medium ADIN dried grains + solubles	0.67	1.79	474	175
High ADIN dried grains + solubles	0.70	2.50	494	288

[a] Intake averaged 23 g kg^{-1} (DM) of body weight. [b] Averaged across levels of supplemental protein. [c] Gain above urea controls divided by protein intake above urea controls (slopes of regression lines). [d] 12 h dacron bag escape values, g kg^{-1} of CP.

numerically higher protein efficiency values than those fed DDGS but overall the differences were small and nonsignificant.

There were no significant differences in the protein efficiency values for the DDGS composites. Numerically the protein efficiency values increased with ADIN level, indicating no heat damage. This supports prior research that suggests ADIN is a poor indicator of protein damage in protein supplements. Distillers byproducts are good sources of bypass protein. Drying appears to have very little effect on the value of the protein for growing calves.

References

Britton, R.A. et al., 1986. Methods of estimating heat damage in protein sources. Proc. 41st. Distillers Feed Conf., Distillers Feed Research Council, Cincinatti, OH, p. 67.

Chase, L.E., 1987. Heat damaged protein — why worry about it? Proc. 42nd Distillers Feed Conf., Distillers Feed Research Council, Cincinatti, OH, p. 87.

Klopfenstein, T.J., 1991. Efficiency of escape protein utilization. Proc. 46th Distillers Feed Conf., Distillers Feed Research Council, Cincinatti, OH, p. 77.

Klopfenstein, T.J., 1987. Heat damage — real or artifact? Proc. 42nd Distillers Feed Conf., Distillers Feed Research Council, Cincinatti, OH, p. 84.

Van Soest, P.J. and Sniffen, C.J., 1984. Nitrogen fractions in NDF and ADF. Proc. 39th Distillers Feed Conf., Distillers Feed Research Council, Cincinatti, OH, p. 72.

Van Soest, P.J., 1989. On the digestibility of bound N in distillers grains: A reanalysis. Proc. Cornell Nutr. Conf., Distillers Feed Research Council, Ft. Mitchell, KY, p. 127.

Weiss, W.P. et al., 1989. Barley distillers grains as a protein supplement for dairy cows. J. Dairy Sci., 72: 980.