2009

The effect of feeding high-protein distillers dried grains on milk production of Holstein cows

K. J. Hubbard
University of Nebraska-Lincoln

Paul J. Kononoff
University of Nebraska-Lincoln, pkononoff2@unl.edu

A. M. Gehman
University of Nebraska-Lincoln, agehman2@unl.edu

J. M. Kelzer
University of Nebraska-Lincoln

K. Karges
Dakota Gold Research Association

See next page for additional authors

J. Dairy Sci. 92:2911–2914
doi:10.3168/jds.2008-1955

Short communication: The effect of feeding high-protein distillers dried grains on milk production of Holstein cows[1]

K. J. Hubbard,*[2] P. J. Kononoff,*[3] A. M. Gehman,* J. M. Kelzer,* K. Karges,† and M. L. Gibson†
*Department of Animal Science, University of Nebraska-Lincoln, Lincoln 68583-0908
†Dakota Gold Research Association, Sioux Falls, SD 57104-4506

ABSTRACT

The objectives of this study were to evaluate the effects of feeding high-protein distillers dried grains (HPDDG) on rumen degradability, dry matter intake, milk production, and milk composition. Sixteen lactating Holstein cows (12 multiparous and 4 primiparous) averaging 80 ± 14 d in milk were randomly assigned to 1 of 2 dietary treatments in a 2 × 2 crossover design. A portion of forage and all soy-based protein in the control diet were replaced by HPDDG (20% dry matter). Milk production and dry matter intake were recorded daily and averaged for d 19 to 21 of each 21-d period. Milk samples were collected on d 20 to 21 of each period. Milk yield increased with the inclusion of HPDDG (33.4 vs. 31.6 ± 2.13 kg/d), and 3.5% FCM was higher for the ration containing HPDDG (36.3 vs. 33.1 ± 2.24 kg/d). Percentage protein was not affected by treatment (average 3.04 ± 0.08%), but protein yield increased with inclusion of HPDDG (0.95 to 1.00 ± 0.05 kg/d). Milk fat concentration was not different between treatments (average 3.95 ± 0.20%), but fat yield increased for the ration containing HPDDG (1.35 vs. 1.21 ± 0.09 kg/d). Dry matter intake was not affected and averaged 21.9 ± 0.80 kg across treatments. Because of greater milk production, feed conversion was improved by the inclusion of HPDDG (1.47 to 1.73 ± 0.09). Milk urea N was greater for the HPDDG ration than the control (14.5 vs. 12.8 ± 0.67 mg/dL). This research suggests that HPDDG may effectively replace soy-based protein in lactating dairy cow diets.
Key words: corn milling (co)product, high-protein distillers grains, milk production

Recent growth in the corn-ethanol industry in the United States has resulted in an accompanying change in the livestock feed industry with increased supplies of feed (co)products such as distillers grains with solubles. In 2007, bio-refineries in the United States produced an estimated 14.6 million metric tonnes of distillers grains, 2.6 million metric tonnes more than the year before (RFA, 2008). In the traditional dry-milling process, whole corn is ground and fermented to produce ethanol. Resulting from this process is the corn-ethanol (co) product—wet distillers grains plus solubles. Previous research has indicated that these (co)products are suitable feed sources for dairy cattle as they contain high levels of protein, digestible fiber, and fat (Schingoethe et al., 1999; Kleinschmit et al., 2006). A recently developed process that aims to improve corn-ethanol yield differs from the traditional dry-milling process because the bran and germ are removed from the corn kernel before fermentation. The remaining endosperm and gluten are ground and used as an energy substrate for yeast fermentation and subsequent ethanol production. Given that the bran and germ, which are high in both fiber and fat, are removed before fermentation, the resulting residue is high-protein dried distillers grains (**HPDDG**), which may be higher in protein than traditional distillers grains plus solubles.

The current NRC publication outlining the nutrient requirements of dairy cattle (NRC, 2001) describes the fate of dietary protein. In that publication, feed protein is characterized as RDP and RUP. Understanding the proportion of protein that is not degraded in the rumen is important because it is a direct source of protein and ultimately AA for the animal. Consequently, RUP represents an important contribution to the total pool of MP. Although the degradability of distillers dried grains plus solubles (**DDGS**) was determined previously (Erasmus et al., 1994; Kononoff et al., 2007), changes in the corn-ethanol process and perhaps also rumen degradability warrant continued research. In this study, the chemical composition and rumen degradability of HPDDG was determined and then HPDDG was fed to lactating dairy cows. The objective of this experiment

Received December 8, 2008.
Accepted January 27, 2009.
[1]A contribution of the University of Nebraska Agricultural Research Division. Research is in part supported by funds provided through the Hatch Act. Mention of a trade name, proprietary products or company name is for presentation clarity and does not imply endorsement by the authors of the University of Nebraska.
[2]Written for thesis submission to University of Nebraska-Lincoln Undergraduate Honors Program.
[3]Corresponding author: pkononoff2@unl.edu

Table 1. Chemical composition of high-protein distillers dried grains (HPDDG) and corn silage, brome hay, and alfalfa haylage used in the study

Item	HPDDG		Corn silage		Brome hay		Alfalfa haylage	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
DM, %	91.4	1.07	35.2	3.25	91.4	0.64	35.0	0.66
CP, %	46.1	0.55	8.90	0.71	9.3	0.42	21.2	0.14
Soluble CP, % of CP	10.7	1.53	68.0	2.83	31.0	2.83	65.5	2.12
NDF, %	26.4	1.91	38.0	2.90	68.7	0.85	40.7	0.78
ADF, %	15.6	1.72	22.5	2.33	42.9	2.05	34.5	0.84
Ether extract, %	4.63	0.12	3.30	0.28	2.15	0.35	4.5	0.71
Ca, %	0.02	0.01	0.27	0.04	0.29	0.01	1.12	0.06
Mg, %	0.09	0.00	0.17	0.01	0.10	0.00	0.21	0.06
P, %	0.37	0.02	0.30	0.04	0.29	0.01	0.26	0.01
K, %	0.37	0.04	1.13	0.15	2.15	0.06	2.82	0.00

was to evaluate the effects of feeding HPDDG on milk production, milk composition, and DMI.

Ruminal degradability of HPDDG (Poet Biorefinery, Coon Rapids, IA) was estimated using the in situ bag technique (Kononoff et al., 2007). Two British breed crossbred steers fitted with flexible ruminal cannulas were housed individually and fed a mixed diet of hay and concentrate twice daily (2.1% of BW) with free access to water. Approximately 1.0-g samples of HPDDG were weighed to the nearest 0.1 mg, placed in preweighed 3.5- × 5-cm Dacron bags (Ankom Inc., Fairport, NY) with a pore size of 50 μm and heat-sealed (Vanzant et al., 1998) before being placed in the rumen at staggered intervals inside a weighted large-mesh bag. Each steer received 8 bags incubated for 16 h and 12 bags incubated for 24 and 48 h. Following removal from the rumen, all bags were machine-washed using 5 cycles with 1 min of agitation followed by a 2-min spin. Each bag was then individually rinsed with distilled water to remove all visible external residue from the seams before being dried in an oven for 48 h at 55°C. Individual dry weight was taken for each bag and again after a 4-h air equilibrium period. Percentage ruminal degradability for each bag was calculated by subtracting the bag weight from the end dry weight and then dividing by original sample weight corrected for DM. The proportion of CP remaining at each time point was assumed to be RUP.

Sixteen lactating Holstein cows (12 multiparous and 4 primiparous) averaging 80 ± 14 DIM and weighing 623 ± 94 kg were used to study the effect of feeding HPDDG on milk production. Cows were randomly assigned to 1 of 2 dietary treatments in a 2 × 2 crossover design. Control and treatment diets were balanced to be similar in CP with a portion of forage and all soy-based protein being replaced with HPDDG (20% DM) in the treatment ration. Cattle were housed in individual tie-stalls and fed ad libitum to allow for approximately 10% refusal over four 21-d periods. Milk production and DMI were recorded daily and averaged for d 18 to 21. Milk samples were collected from 6 consecutive milkings on d 19, 20, and 21, preserved in 2-bromo-2-nitropane-1,3-diol, and analyzed for fat and true protein using a B2000 Infrared Analyzer (Bentley Instruments, Chaska, MN) by Heart of America DHIA (Manhattan,

Table 2. Ingredient composition and chemical analysis for control and treatment diets

Item	Ration	
	Control	Treatment
Ingredients, % of DM		
Corn silage	31.4	28.2
Alfalfa haylage	15.6	14.1
Corn grain	13.7	13.7
Brome hay	12.3	12.3
Soybean meal	9.7	—
Soybean hulls	9.0	9.0
Soy pass[1]	5.6	—
Limestone	1.23	1.43
Sodium bicarbonate	0.72	0.72
Salt	0.06	0.06
Vitamin ADE[2]	0.12	0.12
Trace mineral[3]	0.04	0.04
Magnesium oxide	0.18	0.18
Sel-plex 1000[4]	0.02	0.02
Vitamin E	0.02	0.02
HPDDG[5]	—	20.0
Chemical composition		
CP, % of DM	17.5	17.7
NDF, % of DM	37.3	36.7
NFC, % of DM	36	34.9
Ether extract, % of DM	3.2	5.7
NE_L,[6] Mcal/kg	1.56	1.65

[1]LignoTech (Overland Park, KS).
[2]Formulated to contain 222,000,000 IU/kg of vitamin A, 555,000 IU/kg of vitamin D, and 6,600 IU/kg of vitamin E.
[3]Formulated to contain 13.9% Ca, 0.03% P, 0.42% Mg, 0.20% K, 4.17% S, 0.08% Na, 0.03% Cl, 455 mg/kg of Fe, 60,020 mg/kg of Zn, 17,374 mg/kg of Cu, 43,470 mg/kg of Mn, 287 mg/kg of Se, 527 mg/kg of Co, 870 mg/kg I.
[4]Alltech, Inc. (Nicholasville, KY).
[5]High-protein dried distillers grains (Poet Biorefinery, Coon Rapids, IA).
[6]As predicted by NRC (2001).

Table 3. The effects of feeding a control and diet containing high-protein dried distillers grains (HPDDG) on milk yield and composition

	Ration[1]			
Item	Control	Treatment	SEM[2]	P-value
Milk yield, kg/d	31.6	33.4	2.13	0.05
DMI, kg/d	22.6	21.2	0.80	0.12
3.5% FCM,[3] kg/d	33.2	36.3	2.24	0.03
Fat, %	3.85	4.07	0.20	0.22
Fat yield, kg/d	1.21	1.35	0.09	0.05
Protein, %	3.05	3.02	0.08	0.46
Protein yield, kg/d	0.95	1.00	0.05	0.05
MUN, mg/dL	12.8	14.5	0.67	<0.01
BW, kg	626.7	621.5	18.4	0.20
BCS	3.22	3.26	0.09	0.46
FC[4]	1.47	1.73	0.09	0.01

[1]Control = 0% HPDDG; treatment = 20% HPDDG (DM basis).

[2]Standard error of treatment means.

[3]3.5% FCM = 0.432 × milk (kg/d) + 16.23 × fat (kg/d) (Tyrrell and Reid, 1965).

[4]Feed conversion = 3.5% FCM/DMI.

KS). Cows were weighed at the start of the trial and on d 20 to 21 of each period. Body condition score (1–5 scale) was also recorded (Wildman et al., 1982) to the quarter point at the start and end of each period by a single trained individual. All experimental animals in the study were cared for following the guidelines stipulated by the University of Nebraska Animal Care and Use Committee.

Feed samples were collected on d 20 and 21 of each period, and subsamples were analyzed by Dairy One Laboratory (Ithaca, NY). The analyses included DM (AOAC, 2000; method 930.15), CP (AOAC, 2000; method 990.06), soluble protein (Roe and Sniffen, 1990), NDF (Van Soest et al., 1991), ether extract (AOAC, 2000; method 2003.05), and minerals (Ca, P, Mg, and K; Sirois et al., 1994). Neutral detergent fiber was analyzed using the Ankom A200 filter bag technique, with 12 mL of α-amylase and 20 g of sodium sulfite. Starch was determined using a YSI 2700 Select Biochemistry Analyzer (Application Note 322; YSI Inc., Yellow Springs, OH).

Milk production data were analyzed using the MIXED procedure of SAS (2004, version 9.1; SAS Institute, Inc., Cary, NC) as a 2-period crossover design with fixed effects for treatment, period, parity, and the interaction between treatment and parity, and cow within period as the random effect. Significance for all models was declared at $P \leq 0.05$, and trends were discussed at $P \leq 0.10$. The PDIFF option was used to test treatment differences among LSMEANS, and all means presented are least squares means.

Table 1 lists the chemical composition of HPDDG and other feedstuffs used in the rations. As expected, CP content was higher (44.1%) and NDF was lower (25.6%) than the traditional DDGS listed in the NRC (2001) publication (CP = 29.7% and NDF = 38.8%). The higher CP and lower NDF were expected because the bran and germ were removed from the corn kernel before fermentation. Estimates of RUP determined in situ were 62.0 ± 8.76, 56.1 ± 5.34, and 30.9 ± 5.93% CP for 16, 24, and 48 h, respectively. Compared with the current study, Kononoff et al. (2007) incubated a sample of DDGS for 16 h and observed a lower proportion of RUP (43.0% CP).

The experimental treatment diets and chemical composition of these diets are listed in Table 2. Milk yield increased from 31.6 to 33.4 ± 2.3 kg/d ($P = 0.05$) with the inclusion of HPDDG (Table 3). This increase is within the range of that reported for similar studies in which a portion of ground corn and soybean meal was replaced by 20% DM DDGS (Nichols et al., 1998; Kleinschmit et al., 2006), indicating its effective use in lactation diets. Milk protein percentage was not affected by treatment, but milk protein yield significantly increased from 0.95 to 1.00 ± 0.05 kg/d when cattle were fed HPDDG. Percentage milk fat was not affected by the addition of HPDDG, but 3.5% FCM significantly increased from 33.2 to 36.3 ± 2.24 kg/d, and milk fat yield rose from 1.21 to 1.35 ± 0.09 kg/d. Daily DMI was not significantly affected and averaged 21.9 ± 0.80 kg across both treatments.

Increased 3.5% FCM coupled with the lack of effect on intake resulted in a significant increase in feed conversion (1.47 vs. 1.73 ± 0.09) when cattle were fed HPDDG. Because total-tract nutrient digestibility was not measured in the current study, it is difficult to account for the positive response in FCM yield and feed conversion when HPDDG was used to replace soy protein sources. However, this may have been due, in part, to differences in energy density. Based on the NRC (2001) model, diets containing HPDDG were more concentrated in energy (1.65 vs. 1.56 Mcal/kg), which is likely a reflection of greater amounts of fat. This may have been because of improved fiber digestibility when fiber from HPDDG partially replaced some forage fiber and improved protein digestibility. This is supported by the observation that MUN increased from 12.8 to 14.5 ± 0.67 in diets containing HPDDG, which might suggest that N in the diet containing HPDDG was more available. In conclusion, the results of this study suggest that HPDDG may effectively replace soy-based protein in commercial dairy rations.

REFERENCES

AOAC. 2000. Official Methods of Analysis. 17th ed. Association of Official Analytical Chemists, Arlington, VA.

Erasmus, L. J., P. M. Botha, and C. W. Cruywagen. 1994. Amino acid profile and intestinal digestibility of dairy cows of rumen-undegradable protein from various feedstuffs. J. Dairy Sci. 77:541–551.

Kleinschmit, D. H., D. J. Schingoethe, K. F. Kalscheur, and A. R. Hipen. 2006. Evaluation of various sources of corn dried distillers grains plus solubles for lactating dairy cattle. J. Dairy Sci. 89:4784–4794.

Kononoff, P. J., S. K. Ivan, and T. J. Klopfenstein. 2007. Estimation of the proportion of feed digested in the small intestine of cattle consuming wet corn gluten feed. J. Dairy Sci. 90:2377–2385.

NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, DC.

Nichols, J. R., D. J. Schingoethe, H. A. Maiga, M. J. Brouk, and M. S. Piepenbrink. 1998. Evaluation of corn distillers grains and ruminally protected lysine and methionine for lactating dairy cows. J. Dairy Sci. 81:482–491.

RFA (Renewable Fuels Association). 2008. http://www.ethanolrfa.org/ Accessed Oct 3, 2008.

Roe, M. B., and C. J. Sniffen. 1990. Techniques for measuring protein fractions in feedstuffs. Pages 81–88 in Proc. Cornell Nutr. Conf., Rochester, NY. Cornell University, Ithaca, NY.

Schingoethe, D. J., M. J. Brouk, and C. P. Birkelo. 1999. Milk production and composition from cows fed wet corn distillers grains. J. Dairy Sci. 82:574–580.

Sirois, P. K., M. J. Reuter, C. M. Laughlin, and P. J. Lockwood. 1994. A method for determining macro and micro elements in forages and feeds by inductively coupled plasma atomic emission spectrometry. Spectroscopist 3:6–9.

Tyrrell, H. F., and J. T. Reid. 1965. Prediction of the energy value of cow's milk. J. Dairy Sci. 48:1215–1233.

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Symposium: Carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583–3597.

Vanzant, E. S., R. C. Cochran, and E. C. Titgemeyer. 1998. Standardization of in situ techniques for ruminant feedstuff evaluation. J. Anim. Sci. 76:2717–2729.

Wildman, E. E., G. M. Jones, P. E. Wagner, H. F. Troutt, and T. N. Lesch. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. J. Dairy Sci. 65:495–501.