Urea Inclusion in Distillers Dried Grains Supplements

L. A. Stalker
West Central Research and Extension Center, University of Nebraska, North Platte, stalkera@byui.edu

D. C. Adams
West Central Research and Extension Center, University of Nebraska, North Platte, dadams1@unl.edu

T. J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

The Professional Animal Scientist 23 (2007):390–394

Urea Inclusion in Distillers Dried Grains Supplements[1]

L. A. Stalker,*[2] D. C. Adams,* and T. J. Klopfenstein†
*West Central Research and Extension Center, University of Nebraska, North Platte 69101; and
†Department of Animal Science, University of Nebraska, Lincoln 68583

ABSTRACT

Two experiments evaluated the inclusion of urea in distillers dried grains supplements. In Exp. 1, 60 Angus heifers (278 ± 16 kg) were individually fed diets consisting of 58% ground corn cobs, 12% sorghum silage, and 30% distillers dried grains (DM basis) in Calan electronic gates. Urea replaced distillers dried grains at 0, 0.4, 0.8, 1.2, or 1.6% of diet DM. In Exp. 2, 48 crossbred heifers were fed meadow hay ad libitum and 1.4 kg (DM) distillers dried grains to which was added either 0 or 45 g urea/heifer daily. In both experiments, no response in animal weight gain or feed efficiency was observed when urea was added to the diet. Based on retrospective NRC (1996) model analysis of diets, metabolizable protein was in excess of requirements. Lack of response in animal performance may indicate lack of rumen degradable protein deficiency or sufficient N recycling to correct a rumen degradable protein deficiency. These studies indicate adding urea to distillers dried grains is not necessary when fed as a supplement in forage-based diets.

Key words: supplementation, nitrogen recycling, cattle, distillers grains, forage

[1]Published with the approval of the director as Journal Series No. 14695, Nebraska Agricultural Research Division.

[2]Corresponding author: astalker3@unl.edu

INTRODUCTION

Distillers dried grains (**DDG**) are a source of energy, phosphorus, and RUP (Stock et al., 2000), making it a desirable supplement for growing cattle consuming forage-based diets (Klopfenstein, 1996; McDowell, 1996; Caton and Dhuyvetter, 1997). Traditionally, DDG are included in beef cattle diets at levels sufficient to meet the animal's protein requirement. However, production of DDG is increasing and at times there is financial incentive to include DDG at levels that exceed the animal's protein requirement to increase dietary energy content.

Balancing diets of growing beef cattle for metabolizable protein (**MP**) can be beneficial (Patterson et al., 2003). Because DDG contain approximately 65% RUP (% of CP), forage-based diets that contain more than about 15% DDG (DM basis) are commonly deficient in RDP but contain excess MP according to the NRC (1996) model. The NRC (1996) model output is dependent upon input values that may not be accurately known for low quality forage-based diets (i.e., microbial CP production), and the degree of RDP deficiency (if any) is difficult to ascertain. Additionally, cattle convert excess MP to urea, which is potentially recycled to the rumen and can serve as a source of RDP (Huntington and Archibeque, 2000). Recycling of excess MP supplied by DDG could help alleviate a potential RDP deficiency, but the NRC (1996) model does not account for net N recycling. Many factors influence urea recycling, and the amount of urea recycled to the rumen when DDG are included in forage-based diets is not known. Therefore, the degree of RDP deficiency is not known. The objective of these experiments was to determine if supplemental RDP is required in forage-based diets in which DDG are fed at levels in excess of the MP requirement. Some degree of N recycling was expected but recycled N may not be sufficient to meet the RDP requirement and therefore some level of supplemental RDP may be necessary.

MATERIALS AND METHODS

Experiment 1

This experiment was conducted at the University of Nebraska-Lincoln, Agriculture Research and Development Center near Mead, NE. Animal use and management were in accordance with University of Nebraska Institutional Animal Care and Use Committee guidelines. Sixty yearling, Angus heifers (BW 278 ± 16 kg) were stratified by BW and then assigned randomly to 1 of 5 treatments. Treatments were designed to correct 0, 33, 67, 100, and 133% of the NRC (1996) predicted RDP deficiency of the base diet using default model values for RUP digestibility and book value DDG TDN content. This was accom-

Table 1. Ingredient composition of supplements (% of DM) used in Exp. 1 and 2 in which 0, 33, 67, 100, or 133% of the NRC-predicted RDP deficiency was met with supplemental urea

	Exp. 1[1]					Exp. 2[2]	
Ingredient	**0**	**33**	**67**	**100**	**133**	**0**	**100**
Distillers dried grain	95.59	94.26	92.92	91.59	90.26	94.28	91.78
Molasses	—	—	—	—	—	2.90	2.90
Urea	—	1.33	2.67	4.00	5.33	—	2.50
Limestone	3.16	3.16	3.16	3.16	3.16	1.60	1.60
Salt	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Trace mineral premix[3]	0.17	0.17	0.17	0.17	0.17	0.16	0.16
Melengesterol acetate	0.05	0.05	0.05	0.05	0.05	—	—
Vitamin premix[4]	0.03	0.03	0.03	0.03	0.03	0.06	0.06

[1]Supplement comprised 30% of the diet.

[2]Supplement comprised approximately 25% of the diet.

[3]Contained (g/kg of premix): 130 Ca; 10 Co; 15 Cu; 2 I; 100 Fe; 80 Mn; and 120 Zn.

[4]Contained (per kilogram of premix) 29.9 million IU of vitamin A, 6.0 million IU of vitamin D, and 7,000 IU of vitamin E.

plished by including urea at 0, 0.4, 0.8, 1.2, or 1.6% of diet DM. Heifers were individually fed with Calan electronic gates (American Calan, Northwood, NH) for ad libitum consumption of a diet consisting of 58% ground corn cobs and 12% sorghum silage. The remaining 30% of the diet was the appropriate DDG-based supplement described in Table 1.

Heifers were limit-fed a common diet at 1.75% BW for 5 d at the beginning and for 5 d at the end of the 84-d experiment. Heifer BW was recorded on each of the last 3 d of both limit-feeding periods. Heifers were allowed ad libitum intake of water during the experiment including the limit-feeding periods. Beginning on d 46 of the experiment, approximately 50 mL of urine was spot-collected from each heifer for 5 consecutive days prior to morning feeding. Urine samples were immediately frozen and stored at –20°C until analysis, whereupon they were composited by animal and analyzed for creatinine and purine derivative concentrations by high performance liquid chromatography (Waters Breeze System, Waters Corp., Milford, MA) according to the procedure of Shingfield and Offer (1999). The ratio of allantoin to creatinine was used to make relative comparisons among treatments of microbial CP production (Shingfield, 2000).

Feedstuffs used in the experiment were analyzed for DM, OM (AOAC, 1990), N (Leco Corp., Henderson, NV), in-situ RUP content (Klopfenstein et al., 2001), and IVDMD using a modified Tilley and Terry (1963) procedure with the addition of 1 g of urea to the buffer (Weiss, 1994; Table 2).

Level 1 of the NRC (1996) model software was used to perform a retrospective analysis to quantify RDP deficiency and amount of excess MP available to be recycled. To accurately estimate MP supply, both the TDN content and RUP digestibility of the diet were considered. Total digestible nutrient composition of sorghum silage and corn cobs were calculated from IVDMD values. The TDN value of DDG is superior to corn in forage-based diets (Loy et al., 2003), but this is due in large part to lipid content. Neither the lipid (Jenkins, 1993) nor RUP content of DDG is a source of fermentable energy in the rumen; therefore, they were not allowed to inflate the dietary TDN concentration when calculating microbial CP production. Distillers dried grains has about 63% as much carbohydrate as corn (NRC, 1996). If corn is 90% TDN, then the ruminally effective TDN of DDG is about 57%. Therefore, we used a TDN value of 57% for DDG in our retrospective analysis and used the NE adjuster to correctly model animal BW gain. The NRC (1996) model assumes a RUP digestibility of 80% regardless of source. Recent research has demonstrated RUP in forage to be less digestible than 80% (NRC, 2001). The RUP digestibility values used in this evaluation were 52% for corn cobs, 36% for sorghum silage, and 90% for DDG (MacDonald et al., 2005).

Data were analyzed using the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC) as a completely randomized design using animal as the experimental unit. Orthogonal polynomials were used to evaluate the response to level of supplemental RDP.

Experiment 2

This experiment was conducted at the University of Nebraska-Lincoln, Gudmundsen Sandhills Laboratory near Whitman, NE. Animal use and management were in accordance with University of Nebraska Institutional Animal Care and Use Committee guidelines. Forty-eight yearling, crossbred heifers (BW 205 ± 20 kg) were stratified by BW and assigned randomly to 1 of 8 pens. Pens were then assigned randomly to 1 of 2 supplement treatments, resulting in 4 pens per treatment. Heifers were fed for ad libitum consumption of grass hay (Table 2) and supplemented with either 1.4 kg DDG/heifer daily (DM basis) or 1.4 kg DDG plus 45 g of urea/d per heifer (Table 1). This was the amount of urea required to meet the NRC (1996) predicted RDP requirement. Heifers were weighed on 2 consecutive days at the beginning and end of the 84-d trial without limiting intake. Beginning on d 55 of the experiment, approximately 50 mL of urine was spot-collected from each heifer for 3 consecutive days

Table 2. Chemical composition (± SD) of feedstuffs

	Exp. 1[1]			Exp. 2	
Item	SS	CC	DDG	Hay	DDG
DM, %	34.6 ± <0.1	88.8 ± <0.1	90.5 ± <0.1	91.3 ± <0.1	91.1 ± <0.1
OM, %	93.1 ± <0.1	98.1 ± <0.1	97.7 ± <0.1	90.5 ± <0.1	95.8 ± <0.1
IVDMD, %	68.1 ± <0.1	51.5 ± <0.1	—	58.1 ± <0.1	—
TDN,[2] %	61.0	48.0	57.0	54.0	57.0
CP, % DM	9.4 ± 0.2	4.6 ± 0.3	31.5 ± 0.2	7.4 ± <0.1	31.1 ± 0.7
RUP,[3] % CP	20.0	91.0	56.0	19.5	56.0
RUP digestibility,[4] %	36.0	52.0	90.0	21.0	90.0

[1]SS = sorghum silage, CC = corn cobs, DDG = distillers dried grains.

[2]TDN of sorghum silage, corn cobs, and hay calculated from IVDMD and ruminally effective TDN of distillers dried grains relative to corn.

[3]Estimated in situ according to Klopfenstein et al., 2001 except in hay (NRC, 1996).

[4]RUP digestibility from MacDonald et al. (2005) and Haugen et al. (2006).

prior to morning feeding. Urine samples were composited by animal and analyzed as described in Exp. 1.

Retrospective analysis of MP supply and RDP deficiency was conducted using Level 1 of the NRC (1996) model as explained for Exp. 1. The RUP value of the hay was 19.5% of CP and digestibility of RUP was 21% (Haugen et al., 2006; Table 2).

Data were analyzed using the MIXED procedures of SAS (SAS Inst. Inc., Cary, NC) as a completely randomized design. The model included the effect of treatment and pen was used as the experimental unit.

RESULTS AND DISCUSSION

In Exp. 1, heifer ADG did not differ among treatments. Similarly, total DMI and feed efficiency did not differ (Table 3). We hypothesized heifers consuming the 0, 33, and possibly the 67% diets would exhibit reduced ADG compared with the 100 and 133% diets because of a dietary RDP deficiency. This was not the case, however, as no differences in performance were observed. One explanation for this lack of difference is sufficient endogenously produced urea being recycled to the rumen to meet RDP requirements in all treatments. The NRC (1996) model sets the RDP requirement equal to microbial CP production. In this experiment we measured the allantoin to creatinine ratio in the urine to make relative comparisons of microbial CP production among treatments (Shingfield, 2000). Allantoin to creatinine ratio did not increase and actually tended to linearly decrease ($P = 0.07$) as supplemental RDP increased. The relationships among treatments for allantoin to creatinine ratios observed in this study agree with the performance data and suggest microbial CP

Table 3. Performance and allantoin to creatinine ratios in urine of heifers fed diets in which 0, 33, 67, 100, or 133% of the NRC-predicted RDP requirement was met with supplemental urea (Exp. 1)

	Treatment						Contrasts[2]			
Item	0	33	67	100	133	SEM[1]	L	Qd	C	Qt
Initial BW, kg	278.7	277.3	279.3	279.9	279.0	5.0	0.84	0.98	0.74	0.90
Final BW, kg	319.0	316.4	314.7	318.5	318.4	6.7	0.97	0.67	0.82	0.80
ADG, kg/d	0.48	0.47	0.42	0.46	0.47	0.03	0.79	0.29	0.96	0.42
DMI, % BW	1.78	1.80	1.80	1.80	1.78	0.01	0.98	0.04	0.73	0.75
G:F, kg:kg	0.093	0.090	0.081	0.088	0.090	0.006	0.69	0.23	0.96	0.35
Allantoin to creatinine ratio	0.99	0.95	0.93	0.93	0.90	0.04	0.07	0.81	0.52	0.82

[1]Pooled SE of treatment means, n = 12 heifers/treatment.

[2]Observed significance level for orthogonal contrasts: L = linear, Qd = quadratic, C = cubic, Qt = quartic.

production was not reduced in the RDP deficient diets.

A second explanation for a lack of difference among treatments is the inexistence of a RDP deficiency even in the control diet, which did not contain exogenous urea. However, based on a retrospective analysis this does not appear to be the case. In an effort to precisely quantify RDP balance we performed a retrospective analysis using level 1 of the NRC (1996) model software and used actual animal performance, intake, and nutrient analyses as inputs. Variables used as inputs as well as outputs generated from the model are reported in Table 5. According to this retrospective analysis, heifers not fed supplemental urea were 108 g/d deficient in RDP but were fed an excess 143 g/d of MP in Exp. 1. The NRC (1996) model software assumes the RDP requirement is met when calculating MP balance. When the MP balance was corrected to account for MP not supplied by the RDP deficiency (74 g/d), there was not sufficient excess MP to correct the RDP deficiency. The efficiency of conversion of MP to net protein (**NP**) is assumed by the NRC (1996) model to be about 50%. Metabolizable protein not converted to NP should be available to be recycled to the rumen and could explain the results of this study. The MP requirement for gain was 147 g/d. If 50% was converted to NP, then 73 g/d should have been available for recycling. This 73 g/d plus the excess MP of 74 g/d (147 g/d) is greater than the RDP deficiency (108 g/d).

In Exp. 2, heifer ADG did not differ ($P = 0.17$) between treatments. Likewise, total DMI ($P = 0.85$) and feed efficiency ($P = 0.34$) were not different (Table 4). Allantoin to creatinine ratio ($P = 0.65$) was also similar between treatments. Retrospective analysis of Exp. 2 using observed animal performance, intake, and feedstuff analysis indicated the calves were not RDP deficient (Table 5). Therefore, one would not expect a response to added urea (RDP). The control diet was designed to be RDP deficient; however, 3 factors changed from the perspective analysis to the retrospective analyses. The CP content of the hay and therefore RDP content was higher than estimated, and the RDP content of the DDG was higher than estimated when planning the study. Additionally, the TDN value for DDG was lowered from 90 to 57% in the retrospective analysis to account for the energy components of DDG that are not available to be fermented in the rumen. If 90% TDN is used for DDG in the retrospective analysis, a RDP deficiency of 29 g/d is predicted.

Few studies examine the value of using protein sources high in RUP to meet RDP requirements. This is likely because RDP sources, such as urea, tend to be less expensive than RUP sources (DelCurto et al., 2000). However, evidence of excess RUP satisfying RDP deficiencies exist (Huntington and Archibeque, 2000). Bohnert et al. (2002) fed an 82% RDP supplement at levels sufficient to meet RDP requirements and an equal amount (N basis) of a 60% RUP supplement to cows fed moderate quality (5% CP) hay. Cow BW and BCS change were similar between treatments. In a companion experiment where the same supplements were fed to sheep, NDF digestibility was not decreased but rather was increased when the high RUP supplement was fed (Bohnert et

Table 4. Performance and allantoin to creatinine ratios in urine of heifers fed diets in which 0 or 100% of the NRC-predicted RDP requirement was met with supplemental urea (Exp. 2)

	Treatment			
Item	0	100	SEM	*P*-value
Initial BW, kg	205	204	0.4	0.10
Final BW, kg	263	266	1.9	0.38
ADG, kg	0.69	0.74	0.02	0.17
DMI, kg	6.8	6.7	0.3	0.85
G:F, kg:kg	0.102	0.111	0.005	0.34
Allantoin to creatinine ratio	0.81	0.82	0.03	0.65

Table 5. Diet evaluation using the NRC (1996) model in which 0, 33, 67, 100, or 133% of the predicted RDP requirement was met with supplemental urea

	Exp. 1					Exp. 2	
Item	0	33	67	100	133	0	100
Inputs							
TDN, %	70	70	69	69	69	64	64
CP, %	12.6	13.6	14.6	15.6	16.6	11.8	13.6
NE adjuster, %	100	98	95	101	103	91	96
Outputs							
RDP balance, g/d	–108	–48	13	73	133	31	157
MP[1] balance, g/d	143	139	134	130	125	77	74
Corrected MP balance,[2] g/d	74	108	—	—	—	—	—

[1]MP = metabolizable protein.

[2]The NRC (1996) model software assumes the RDP requirement is met when calculating MP balance; therefore, the corrected MP balance accounts for MP not supplied by the RDP deficiency.

al., 2002). Ferrell et al. (1999) fed wethers supplements containing either RUP (blood meal and feather meal combination) or RDP (urea) at similar CP levels. Diet OM digestibility was greater in supplemented wethers compared with unsupplemented controls but was not different between RUP and RDP supplements. One explanation for these results is recycling of endogenous urea.

IMPLICATIONS

Providing urea to meet the degraded intake protein deficiency did not improve ADG, intake, or feed efficiency in either experiment. These results indicate supplemental degraded intake protein is not necessary when DDG are fed to satisfy CP requirement or given as an energy source in forage-based diets. This means producers can purchase and feed DDG as a commodity regardless of whether the reason for no difference in treatments is a lack of RDP deficiency or sufficient N recycling.

LITERATURE CITED

AOAC. 1990. Official Methods of Analysis. 15th ed. Assoc. Off. Anal. Chem., Arlington, VA.

Bohnert, D. W., C. S. Schauer, and T. DelCurto. 2002. Influence of rumen protein degradability and supplementation frequency on performance and nitrogen use in ruminants consuming low quality forage: Cow performance and efficiency of nitrogen use in wethers. J. Anim. Sci. 80:1629.

Caton, J. S., and D. V. Dhuyvetter. 1997. Influence of energy supplementation on grazing ruminants: Requirements and responses. J. Anim. Sci. 75:533.

DelCurto, T., B. W. Hess, J. E. Huston, and K. C. Olsen. 2000. Optimum supplementation strategies for beef cattle consuming low-quality roughages in the western United States. Proc. Am. Soc. Anim. Sci., 1999. http:/www.asas.org/JAS/symposia/proceedings/0922.pdf Accessed Feb. 12, 2007.

Ferrell, C. L., K. K. Kreikemeier, and H. C. Freetly. 1999. The effect of supplemental energy, nitrogen, and protein on feed intake, digestibility, and nitrogen flux across the gut and liver in sheep fed low-quality forage. J. Anim. Sci. 77:3353.

Haugen, H. L., S. K. Ivan, J. C. MacDonald, and T. J. Klopfenstein. 2006. Determination of undegradable intake protein digestibility in forages using the mobile nylon bag technique. J. Anim. Sci. 84:886.

Huntington, G. B., and S. L. Archibeque. 2000. Practical aspects of urea and ammonia metabolism in ruminants. Proc. Am. Soc. Anim. Sci., 1999. http://www.asas.org/jas/symposia/proceedings/0939.pdf. Accessed Feb. 12, 2007.

Jenkins, T. C. 1993. Lipid metabolism in the rumen. J. Dairy Sci. 76:3851.

Klopfenstein, T. J. 1996. Need for escape protein by grazing cattle. Anim. Feed Sci. Technol. 60:191.

Klopfenstein, T. J., R. A. Mass, K. W. Creighton, and H. H. Paterson. 2001. Estimating forage protein degradation in the rumen. J. Anim. Sci. 79:E208.

Loy, T. W., T. J. Klopfenstein, G. E. Erickson, and C. N. Macken. 2003. Supplement type and frequency on intake and performance, and energy value of dry distillers grains in a high-forage diet. J. Anim. Sci. 81(Suppl. 2):107. (Abstr.)

MacDonald, J. C., T. J. Klopfenstein, and G. E. Erickson. 2005. Variation in digestibility of undegradable intake protein among feedstuffs. J. Anim. Sci. 83(Suppl. 1):47. (Abstr.)

McDowell, L. R. 1996. Feeding minerals to cattle on pasture. Anim. Feed Sci. Technol. 60:247.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th ed. Natl. Acad. Press, Washington, DC.

NRC. 2001. Nutrient Requirements of Dairy Cattle. 7th ed. Natl. Acad. Press, Washington, DC.

Olson, K. C., R. C. Cochran, T. J. Jones, E. S. Vanzant, E. C. Titgemeyer, and D. E. Johnson. Effects of ruminal administration of supplemental degradable intake protein and starch on utilization of low-quality warm-season grass hay by beef steers. 1999. J. Anim. Sci. 77:1016.

Patterson, H. H., D. C. Adams, T. J. Klopfenstein, R. T. Clark, and B. Teichert. 2003. Supplementation to meet metabolizable protein requirements of primiparous beef heifers II: Pregnancy and economics. J. Anim. Sci. 81:563.

Sanson, D. W., D. C. Clanton, and I. G. Rush. 1990. Intake and digestion of low-quality meadow hay by cattle receiving various levels of whole shelled corn. J. Anim. Sci. 68:595.

Stock, R. A., J. M. Lewis, T. J. Klopfenstein, and C. T. Milton. 2000. Review of new information on the use of wet and dry milling feed by-products in feedlot diets. Proc. Am. Soc. Anim. Sci., 1999. http://www.asas.org/JAS/symposia/proceedings/0924.pdf. Accessed Feb. 12, 2007.

Shingfield, K. J. 2000. Estimation of microbial protein supply in ruminant animals based on renal and mammary purine metabolite excretion. A review. J. Anim. Feed Sci. 9:169.

Shingfield, K. J., and N. W. Offer. 1999. Simultaneous determination of purine metabolites, creatinine, and pseudouridine in ruminant urine by reverse-phase high performance liquid chromatography. J. Chromatogr. B Biomed. Sci. Appl. 723:81.

Tilley, J. M. A., and R. A. Terry. 1963. A 2-stage technique for the in vitro digestion of forages. J. Br. Grassl. Soc. 18:104.

Weiss, W. P. 1994. Estimation of digestibility of forages by laboratory methods. p 44 in Forage Quality, Evaluation, and Utilization. G. C. Fahey Jr., M. Collins, D. R. Mertens, and L. E. Moser, ed. Am. Soc. Agron., Crop Sci. Soc. Am., Soil Sci. Soc. Am., Madison, WI.