Interaction of Urea with Frequency and Amount of Distillers Grains Supplementation on Growing Steer Rumen Digestion Parameters

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Summary with Implications

Ruminally cannulated steers were used in 8 × 6 row-column design with 8 animals and 6 periods. Treatment design was a 2 × 2 × 2 factorial, with factors including amount of supplementation, frequency of supplementation, and inclusion of urea. Hay dry matter intake was reduced by increased amount of supplementation and by decreased frequency of supplementation. Total VFA concentration did not differ among treatments. Rumen ammonia-N concentration was impacted by an interaction of amount of supplementation and inclusion of urea but there was no effect of supplementation frequency. In situ NDF disappearance did not differ between daily and alternate day supplemented animals. These results suggest there is no difference in rumen digestion parameters between daily and alternate day supplementation, and the inclusion of urea to a DDG supplement does not improve digestion parameters of a forage based diet.

Introduction

Reducing the frequency of supplementation has been one method utilized by cattle producers to reduce labor and costs on a backgrounding operation. However, infrequent supplementation of certain supplements, such as dried distillers grains, has been observed to cause a decrease in animal performance (*2003 Nebraska Beef Cattle Report*, pp 8–10). One hypothesis for this response is that there is a lag in the N recycling mechanism when dried distillers grains (DDG) is fed infrequently. In low-quality forage-based diets, rumen degradable protein (RDP) is often the limiting nutrient. Due to the ability of the ruminant to recycle excess nitrogen, even in the case of DDG supplementation RDP is often sufficient for rumen digestion, as the inclusion of RDP has not improved performance in daily DDG supplemented cattle (*2004 Nebraska Beef Cattle Report*, pp 20–21). Yet, this mechanism could be impacted by infrequent supplementation, resulting in a lag between the supply of N to the rumen and the demand of N required to optimize rumen fermentation. It was hypothesized the inclusion of urea, an RDP source, to a DDGS supplement would immediately contribute to rumen available nitrogen if the animals' nitrogen recycling system could not match rumen microbial demands due to infrequent supplementation. The objective of the study was to determine the interaction of the inclusion of urea with a dried distillers grains supplement fed at either a low or high amount, and supplemented either daily or on alternative days, on growing steer rumen digestion parameters.

Procedure

Eight ruminally cannulated crossbred steers (682 lb, SD = 55) were used in an 8 × 6 row-column design with 8 steers and 6 periods to determine effects of inclusion of urea with the frequency and amount of distillers grain supplementation on rumen digestion parameters. Treatment design was a 2 × 2 × 2 factorial, with factors including amount of supplementation, frequency of supplementation, and inclusion of urea. Steers received supplement at 2.8% **(LO)** or 5.6% **(HI)** of BW per week (0.4 and 0.8% of BW per day, respectively). Supplement amount was split into feedings, either every day **(D)** or every other day **(ALT)**. Urea was included at 0% **(-U)** or 1.3% **(+U)** of the supplement's dry matter. Supplement was fed at 0700 h immediately followed by hay. Brome grass hay (11.5% CP) was fed to attain ad libitum intake. To ensure hay intake was not limited, hay orts were removed and weighed daily. Adjustments to the amount of hay offered were made depending on refusal amount. Periods were 14 d, with 7 d for adaptation and 7 d for collections. Steers on the ALT treatment received supplement for a total of 7 d during the period (d 2, 4, 6, 8, 10, 12, 14). Hay orts during the collection period were subsampled and dried in a forced air oven at 60°C for 48 h to measure dry matter intake **(DMI)**. All animals consumed all supplement offered within 6 h so no supplement orts were collected. The same hay that was fed during the trial was also utilized for in situ incubations. Three in situ bags per time point were placed in a mesh laundry bag with a weight. Bags were inserted in the rumen through cannula at 0700 h then incubated for 4, 8, 12, 24 and 96 h. To determine if there were potential differences in rumen fermentation between days steers received supplement and days they did not, animals on the ALT treatment had two sets of in situ incubations; one on the day of feeding (d 10, 11), and a second on the subsequent non-supplemented day (d 11, 12). However, only one 96 h in situ incubation was conducted, removed on d 14. Animals on the D treatment had one set of in situ incubations, the same day the ALT animals had their supplemented day collections (d 10, 11). Rumen fluid was collected at 2, 4, 8, 12, 16, and 24 h post-feeding to analyze rumen ammonia-N and VFA concentration. Similar to in situ incubations, animals on the ALT treatment had two sets of collections, one on supplemented day (d 12) and not supplemented (d 13). Daily supplemented animals had rumen fluid collected on d 12. To best understand the impacts of frequency, two different data sets were analyzed. One set compared D to ALT, in which values for each measurement for ALT treatments were averaged across all collection days. The other set compared alternate fed **(ALT-F)** to alternate not fed **(ALT-NF)**, in which only the ALT treatments were analyzed but values were averaged for the collection days steers received

Table 1. Hay intake of steers fed distillers grains supplement either daily (D) or alternate days (ALT), at a high (HI) or low (LO) amount, and with (+U) or without (-U) the inclusion of urea during digestion trial

	Treatment									
	Freq[1]		Amt[2]		Urea[3]			*P*-value		
	D	ALT	LO	HI	-U	+U	SEM	Freq	Amt	Urea
Hay DMI, lb/d	13.95	12.91	14.52	12.34	13.17	13.68	1.28	<0.01	<0.01	0.21

[1] D = daily, ALT = every other day

[2] LO = 0.4% of body weight, HI = 0.8% of body weight

[3] +U = inclusion of urea at 1.3% of supplement DM, -U = no inclusion of urea

Table 2. In Situ NDF Disappearance for steers fed distillers grains supplement either daily (D) or alternate days (ALT), and at a high (HI) or low (LO) amount

	Treatment							
	D		Alt			*P*-Value		
	Hi	LO	Hi	Lo	SEM	Freq[1]	Amt[2]	Interaction
Washout Fraction	0.25	-0.05	-0.08	0.12	0.12	0.82	0.90	0.51
Potentially Digestible Fraction, %	49.6	51.5	49.1	50.2	0.90	0.12	0.36	0.66
Rate, %/h	4.19[b]	5.22[a]	4.19[b]	4.23[b]	0.24	0.06	0.03	0.05

[a,b] Within a row, common superscripts indicate no significant difference between means, $P > 0.05$

[1] D = daily, ALT = every other day

[2] LO = 0.4% of body weight, HI = 0.8% of body weight

Table 3. In Situ NDF Disappearance for steers fed distillers grains supplement on alternative days comparing day fed (ALT-F) to day not fed (ALT-NF), and at a high (HI) or low amount (LO)

	Treatment							
	ALT-F		ALT-NF			P-Value		
	Hi	Lo	Hi	Lo	SEM	Day Fed[1]	Amt[2]	Interaction
Washout Fraction	-0.5	-0.2	0.4	0.5	0.7	0.44	0.63	0.91
Potentially Digestible Fraction, %	51.2	49.4	51.8	51.0	1.2	0.31	0.34	0.62
Rate of NDF Digestibility, %/h	3.76[b]	4.72[a]	4.63[b]	3.75[b]	0.43	0.89	0.92	<0.01

[a,b] Within a row, common superscripts indicate no significant difference between means, P > 0.05

[1] ALT-F = fed, ALT-NF = not fed

[2] LO = 0.4% of body weight, HI = 0.8% of body weight

supplement, and the collection days they did not. The model for the D vs ALT data set included amount of supplementation, frequency of supplementation, inclusion of urea, and all factorial interactions. The ALT-F vs ALT-NF model included amount of supplementation, feeding of supplementation, inclusion of urea, and all factorial interactions. Time post feeding was also included in both models for those variables analyzed as repeated measures. Interactions that were not significant ($P < 0.05$) were removed from the models. Rumen ammonia-N and VFA data were analyzed using repeated measures over time. For DMI, rumination, and in situ NDF disappearance rate, data were analyzed using the MIXED Procedure of SAS (SAS Inst. Inc., Cary, NC). To determine the in situ degradation ratio, the NCIN Procedure of SAS with the Marquardt degradation model was used.

Results

Hay intake was impacted by both amount and frequency of supplementation ($P < 0.01$; Table 1). High amount of supplement reduced hay DMI by 2.19 lb/d compared to LO, and ALT reduced hay DMI by 1.03 lb/d compared to D. Urea inclusion had no significant effect on hay DMI ($P = 0.21$).

For in situ NDF disappearance, there were no significant three-way interactions for D vs ALT treatments or ALT-F vs ALT-NF treatments ($P > 0.05$). There were also no significant differences in the washout fraction, or the potentially digestible fraction in either data set (Table 2). For the D vs ALT comparison, there was an interaction of frequency × amount ($P = 0.05$) for rate of NDF disappearance. Treatment D LO had a faster rate of NDF disappearance than D HI, ALT HI, and ALT LO (Table 2). For the ALT-F vs ALT-NF comparison, there was an interaction of feeding amount ($P < 0.01$; Table 3). Rate of NDF disappearance was greater for ALT-F LO and ALT-NF HIGH than ALT-F HI and ALT-NF LO ($P < 0.01$). If RDP was limiting for forage digestion, one would expect an improvement in NDF digestibility for treatments with urea. However, that was not observed in this data.

In the D vs ALT data set for rumen ammonia-N concentration, there was a significant interaction of amount × urea ($P < 0.01$; Table 4). Treatment HI +U had the greatest

Table 4. Ruminal Ammonia-N concentration for steers fed distillers grains supplement either daily (D) or alternate days (ALT), at a high (HI) or low (LO) amount, and with (+U) or without (-U) the inclusion of urea

	Treatment							
	Hi		Lo			*P*-Value		
	+U	-U	+U	-U	SEM	Amt[1]	Urea[2]	Interaction
Ammonia-N, mg/dL	8.05[a]	5.00[b]	5.01[b]	3.60[c]	0.325	<0.01	<0.01	<0.01

[a,b] Within a row, common superscripts indicate no significant difference between means, $P > 0.05$

Time interaction ($P < 0.01$), data not shown

[1] LO = 0.4% of body weight, HI = 0.8% of body weight

[2]+U = inclusion of urea at 1.3% of supplement DM, -U = no inclusion of urea

Table 5. Ruminal Ammonia-N concentration for steers fed distillers grains supplement on alternative days comparing day fed (ALT-F) to day not fed (ALT-NF), at a high (HI) or low amount (LO), and with (+U) or without (-U) the inclusion of urea

	Treatment												
	ALT-F				ALT-NF								
	Hi		Lo		Hi		Lo			P-Value			
	+U	-U	+U	-U	+U	-U	+U	-U	SEM	Day Fed	Amt	Urea	Day Fed × Urea
Ammonia-N, mg/dL	10.56[a]	4.89[c]	5.63[b]	3.58[c]	5.13[b,c]	4.49[b,c]	4.17[c]	3.78[c]	0.489	<0.01	<0.01	<0.01	<0.01

[a,b] Within a row, common superscripts indicate no significant difference between means, P > 0.05

[1] ALT-F = fed, ALT-NF = not fed

[2] LO = 0.4% of body weight, HI = 0.8% of body weight

[3] +U = inclusion of urea at 1.3% of supplement DM, -U = no inclusion of urea

Table 6. Ruminal VFA concentration for steers fed distillers grains supplement either daily (D) or alternate days (ALT), at a high (HI) or low (LO) amount, and with (+U) or without (-U) the inclusion of urea

	Treatment												
	D				Alt					P-Value			
	Hi		Lo		Hi		Lo						3-way
	+U	-U	+U	-U	+U	-U	+U	-U	SEM	Freq[1]	Amt[2]	Urea[3]	Interaction
Acetate, %	64.2	64.7	65.7	66.9	67.5	65.3	69.2	68.1	0.09	<0.01	<0.01	0.52	0.89
Butyrate, %	11.1	11.0	9.73	10.0	8.98	9.87	8.80	9.34	0.04	<0.01	0.02	0.46	0.94
Propionate, %	22.4	21.2	21.2	20.1	21.4	21.8	20.2	20.1	0.05	0.28	<0.01	0.22	0.58
A:P ratio[1]	2.94	3.12	3.19	3.37	3.24	3.07	3.51	3.47	0.10	0.02	<0.01	0.64	0.65

Freq × Urea interaction ($P < 0.05$). Urea did not affect A:P for D, but tended to reduce A:P for ALT $P < 0.08$

[1] D = daily, ALT = every other day

[2] LO = 0.4% of body weight, HI = 0.8% of body weight

[3] +U = inclusion of urea at 1.3% of supplement DM, -U = no inclusion of urea

average ruminal ammonia concentration. There was also a significant amount × urea × time interaction ($P < 0.01$). For all treatments, ruminal ammonia-N concentration was greatest 2 h post-feeding and decreased from 4 h post-feeding to 16 h post-feeding. Ammonia-N concentrations reached their lowest at 16 h post feeding for all treatments. None of these treatments reached a ruminal ammonia-N concentration below 2 mg/dL. Concentrations were then increased at 24 h post-feeding for all treatments. In the ALT-F vs ALT-NF data set, there was a significant interaction of feeding × amount × urea ($P < 0.01$; Table 5). Steers on the HIGH +U treatment on the day they were fed, had the greatest ruminal ammonia-N concentration. A ruminal ammonia-N concentration below 2 mg/dL is the value stated at which fibrolytic bacteria growth is inhibited. Thus, none of the treatments reaching a concentration below this would suggest that ruminal available nitrogen pool was not limiting for fiber digestion.

Ruminal VFA concentrations for the D vs ALT comparison, had no significant three-way interactions ($P \geq 0.58$; Table 6). For both acetate and butyrate, the main effects of frequency and amount were significant ($P \leq 0.02$). However, only the main effect of amount was significant for propionate ($P < 0.01$). Alternate day supplementation animals had greater concentration of acetate compared to D, but lesser concentrations of butyrate. Steers supplemented a HI amount of supplement had increased concentrations of propionate and butyrate but decreased concentration of acetate compared with the LO supplemented steers. This resulted in HI steers having a lower A:P ratio than LO steers ($P < 0.01$). This result would be expected as HI steers con-

Table 7. Ruminal VFA concentration for steers fed distillers grains supplement on alternative days comparing day fed (ALT-F) to day not fed (ALT-NF), at a high (HI) or low amount (LO), and with (+U) or without (-U) the inclusion of urea

	Treatment									P-Value			
	ALT-F				ALT-NF								3-way
	Hi		Lo		Hi		Lo						
	+U	-U	+U	-U	+U	-U	+U	-U	SEM	Freq[1]	Amt[2]	Urea[3]	Interaction
Acetate, %	65.1	62.4	67.1	65.1	70.0	68.1	71.0	71.0	0.08	<0.01	<0.01	0.02	0.59
Butyrate[4], %	10.3	11.7	9.91	10.6	7.62	7.91	8.21	7.71	0.03	<0.01	0.26	<0.01	0.07
Propionate, %	23.2	23.1	21.4	22.1	19.5	20.0	19.0	18.4	0.05	<0.01	<0.01	0.68	0.03
A:P ratio	2.88	2.73	3.18	3.08	3.60	3.46	3.84	3.90	0.10	<0.01	<0.01	0.32	0.41

[1] ALT-F = fed, ALT-NF = not fed

[2] LO = 0.4% of body weight, HI = 0.8% of body weight

[3] +U = inclusion of urea at 1.3% of supplement DM, -U = no inclusion of urea

[4]Freq × Amt interaction (P <0.01). Butyrate concentrations were not affected by amount of supplement on days when supplement was not fed (P > 0.47), but HI supplement resulted in greater butyrate concentration than LO on days when supplement was fed (P < 0.01).

Freq × Urea interaction (P <0.05). Butyrate concentrations were not affected by urea on days when supplement was not fed (P > 0.14), but urea decreased butyrate concentration on the day supplement was fed (P < 0.01).

sumed less forage than LO. In the ALT-F vs ALT-NF data set, a feeding × amount interaction (P < 0.01) and feeding × urea interaction (P < 0.05) were observed (Table 7). Acetate and propionate concentrations were affected by both feeding and amount. On the day not supplemented, steers had increased concentration of acetate, but decreased concentration of propionate and butyrate (P < 0.01). However, on the day steers were supplemented, concentrations of propionate and butyrate increased, but acetate concentration decreased (P < 0.01). HI steers also had greater concentration of propionate compared to the LO steers, but lesser concentration of acetate (P < 0.01). Again, these results would be expected given the hay intake data.

Conclusion

Overall, rumen digestion parameters were not impacted by the inclusion of urea, suggesting that RDP was sufficient for rumen digestion, and there was not a lag in N recycling when supplementing DDG infrequently. The results of these studies suggest that a DDGS supplement can be fed every other day to growing steers on a high forage diet without impacting forage digestion.

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