Effect of Phase Feeding Protein on Cattle Performance and Nitrogen Mass Balance in Open Feedlots

Stephanie A. Quinn
University of Nebraska-Lincoln

Galen E. Erickson
University of Nebraska-Lincoln, gerickson4@unl.edu

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

Richard R. Stowell
University of Nebraska-Lincoln, rstowell2@unl.edu

Dawn M. Sherwood
University of Nebraska-Lincoln

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Summary

Two experiments using calves fed 176 days from November to May (WINTER) and yearlings fed 117 days from May to September (SUMMER) were conducted to compare conventional CP levels to phase-fed diets balanced for degradable intake protein and undegradable intake protein on performance and N volatilization. Phase fed diets were formulated to balance degradable intake protein and metabolizable protein. Phase feeding resulted in greater ADG and better F:G in WINTER and similar performance in SUMMER than traditional feeding methods. Nitrogen excretion was significantly reduced in both WINTER and SUMMER which translated into significantly less N volatilization without impacting N removed in manure.

Introduction

Overfeeding nutrients increases the excretion and subsequent loss of those nutrients *(1998 Nebraska Beef Report,* pp. 78-80; 2000 Nebraska Beef Report, pp. 65-67). Nutrition and management practices can influence the quantity, form, and route (feces, urine) of nutrient excretion by the animal (*2002 Nebraska Beef Report,* pp.54-57; *2003 Nebraska Beef Report,* pp. 54-58). As nutrient requirements change with the physiological state of an animal, it may be possible to decrease NH_3 emissions and nutrient excretion by decreasing CP concentrations of beef cattle finishing diets as time on feed increases without adversely affecting performance. The objective of these experiments was to compare the effects of a phase feeding system balanced for degradable intake protein (DIP) and undegradable intake protein (UIP) to a constant, conventional CP level on animal performance and nitrogen mass balance in feedlot cattle.

Procedure

Two experiments were conducted using 96 steer calves (647 ± 0.59 lb BW) fed 176 days from November to May (WINTER) and 96 yearling steers (823 ± 0.26 lb BW) fed 117 days from May to September (SUMMER). Steers were weighed initially on two consecutive days after being limit fed (2% BW) for 5 days to minimize gut fill differences. Steers were stratified by BW and assigned randomly to treatment (eight steers/pen, six pens/treatment)

Two diets were fed (Table 1). One was a "typical" feedlot diet with dry-rolled corn and contained 12.7% and 14.2% CP for WINTER and SUMMER, respectively. Cattle assigned to the PHASE treatment were intensively managed for protein requirements across the feeding period. A basal diet identical to CONTROL was fed. The dry supplement was incorporated at 5% of the diet (DM basis) and altered every 14 days. PHASE was formulated with the 1996 NRC computer model to balance DIP and MP. Formulations were conducted to meet changing animal requirements across the feeding period for every 50 lb of gain. Adjustments were made to the 1996 NRC calculations to balance DIP and MP with the following hypothesis: excess MP, from excess UIP from DRC corn, will encourage blood urea N recycling to a DIP deficient rumen.

For formulations, the DIP and MP supply and requirements from 1996 NRC computer model were used to predict DIP and MP balances. For example, 341 kg initial BW and 591 kg final BW were entered into the computer model along with historical gain and DMI. The first step was to formulate the diet without urea. The resulting MP and DIP requirements, supplies and balances were used for the second step of formulation. The 1996 NRC predictions for MP supply assume that DIP requirements are met. However, this is not always true. Therefore, if DIP was in negative balance but MP was in positive balance, we modified MP supply to determine the amount of MP that would be necessary to bring DIP to a positive balance. For example, if the MP balance

Table 1. Composition of diet (% DM) fed to steers during WINTER[a] and SUMMER[b] trials

	Treatment					
	Winter			Summer		
Item[c]	Control	Phase 1[d]	Phase 11[d]	Control	Phase 1[d]	Phase 9[d]
DRC[e]	74	74	74	83	83	83
WCGF[f]	8	8	8	—	—	—
Alfalfa Hay	7	7	7	7	7	7
Molasses	5	5	5	5	5	5
Supplement	6	6	6	5	5	5
Urea	0	0.25	0	1.17	0.78	0.33
Soypass	4	2.47	0	0	0	0
Composition						
CP	12.3	13.5	11.5	14.2	12.8	11.3
DIP[g]	-45	2	-96	77	80	253
MP[h]	32	0	101	42	-27	-125

[a]WINTER calves fed from November to May.
[b]SUMMER yearlings fed from May to September.
[c]% of DM.
[d] Each diet phase is 14 days; Phase 1 is first finisher diet, Phase 11 is last diet fed for WINTER, Phase 9 is last diet fed for SUMMER.
[e]Dry-rolled corn.
[f]Wet corn gluten feed.
[g,h]Values from 1996 Beef NRC Level 1 model; inputs were expected feedlot performance of 3.50 ADG and 21 lb/day DMI.

Table 2. Performance of steer calves fed during WINTER.

Item	CONTROL	PHASE	SEM	P-value
Initial BW, lb	647	648	0.5	0.38
Final BW, lb	1273	1298	7	0.09
DMI, lb/d	22.0	21.5	0.17	0.20
ADG, lb	3.56	3.62	0.05	0.11
Feed:gain	6.17	5.95	—	—
Hot carcass weight, lb	802	809	5	0.52
Marbling score[a]	566	531	15	0.52
12th rib fat, inches	0.43	0.41	0.01	0.69

[a]Marbling score: 450 = slight^{50}, 500 = small^{00}, and 550 = small^{50}.

Table 3. Performance of steer calves fed during SUMMER.

Item	CONTROL	PHASE	SEM	P-value
Initial BW, lb	823	824	2	0.88
Final BW, lb	1254	1235	11	0.22
DMI, lb/d	22.0	21.5	0.4	0.08
ADG, lb	3.68	3.51	0.09	0.23
Feed:gain	6.28	6.30	—	—
Hot carcass weight, lb	750	743	5	0.40
Marbling score[a]	464	462	9	0.86
12th rib fat, inches	0.43	0.35	0.04	0.08

[a]Marbling score: 450 = slight^{50}, 500 = small^{00}, and 550 = small^{50}.

was +30 but the DIP balance was - 26, then we assumed that 26*(80% true protein)*(80% digestibility) = 16.64g of MP would not be produced. The actual MP supply was then reduced by this amount to result in a MP balance of +13.4. The final step was to add urea to the diet to bring the DIP balance from - 26 up to - 13.4 and thus be in zero balance. In this diet, a dry supplement containing urea was changed every 14 days to match the 1996 NRC computer model predictions for the MP balance of the animals. Therefore, CP levels for PHASE decreased across the feeding period as the animal's requirement for protein concurrently decreased (13.5 to 11.5% CP in WINTER; 12.8 to 11.3% CP in SUMMER).

On day 1, WINTER steers were initially implanted with Synovex-C® (Fort Dodge Animal Health, Overland Park, Kan.) followed by Revalor-S® (Intervet, Inc., Somerville, N.J.) on day 63. SUMMER yearling steers were implanted on day 1 with Synovex-C® (Fort Dodge Animal Health, Overland Park, KS) and reimplanted on day 35 with Revalor-S® (Intervet, Inc., Somerville, N.J.). Carcass data were collected upon completion of experiments at a commercial abattoir. At harvest, HCW were recorded. Final BW was calculated using a common dressing percentage (63%). Following a 24-hour chill, fat thickness at the 12th rib and LM area were collected. Marbling scores were determined by a USDA grader. USDA (1989) Yield Grade was calculated with the following equation: YG = 2.50 + (2.50 × fat thickness, inches) + (0.20 × Kidney, Pelvic and Heart Fat %) + (0.0038 × HCW, lb)- (0.32 × REA, in^2).

Nutrient balance

Nitrogen mass balance was conducted to assess the impact of dietary treatment on N flow in 12 open feedlot pens with a stocking density of 332 ft^2. Animals were fed in the morning. Seven earthen retention ponds collected runoff from the 12 pens. In the case of a runoff event, effluent was collected in the retention ponds, drained through a PVC pipe, sampled, and quantified using an ISCO model 4230 air-bubble flow meter (ISCO, Lincoln, Neb.)

Throughout the feeding period, feed refusals were collected. After cattle were removed from the pens for slaughter, manure was piled on the pen surface. Twenty four subsamples were taken as the wet manure was being loaded out of the pens. Manure was weighed on an as-is basis and hauled to the University of Nebraska compost yard.

Before initiation of the WINTER trial, 16 soil core samples (5.9 inch depth, 1.0 inch diameter soil probe) were taken from each pen and six samples from each retention pond. Core locations were evenly spaced throughout the pen on a grid pattern. Each core represented 165 ft^2. Soil samples were used to correct for manure/soil mixing by cattle activity throughout the experiment and pen cleaning variation. Time between the WINTER and SUMMER trials was 9 days; therefore, cores taken following the WINTER trial were used for the initiation of the SUMMER trial. During this 9-day period following core sampling, runoff was collected and attributed to the SUMMER trial.

Nitrogen intake was calculated using analyzed individual dietary ingredient N content multiplied by DMI, corrected for amount and N content of feed refusals. Net protein and net energy equations established by the NRC (1996) were used to calculate N retention. Nitrogen excreted (urine plus feces) was determined by subtracting N retention from N intake. Manure N was determined by multiplying manure N concentration by manure amount removed from the pen surface on a DM basis. Manure N values were corrected for soil contamination by subtracting the quantity of N in the soil from quantity of manure N. Runoff N was the N concentration from the runoff multiplied by the gallons of water collected. Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion. In addition to the mass balance technique, ammonia emissions were measured weekly during the last five (WINTER) or six (SUMMER) weeks of the feeding period using forced air wind tunnels and a sulfuric acid trap for 30 minutes in each pen.

Statistical analysis was conducted using the PROC MIXED procedure of SAS to compare the two treatments.

Results

Feedlot Performance

Performance measurements for PHASE were equal to or better than CONTROL in both WINTER

(Continued on next page)

and SUMMER (Tables 2 and 3). In WINTER calves, PHASE tended to have greater (*P*= 0.11) ADG than CONTROL and similar (*P*= 0.20) DMI. However, PHASE calves had significantly lower (*P*= 0.02) F:G. Carcass characteristics were similar (*P*> 0.10) for all measured traits. In SUMMER yearlings, ADG was similar but PHASE had lower (*P*= 0.08) DMI than CONTROL. Even though DMI was lower for PHASE, ADG was not significantly improved compared to CONTROL treatment, therefore, F:G was similar between treatments. CONTROL had greater (*P*= 0.08) fat thickness than PHASE, but all other carcass characteristics were not different from CONTROL. These data demonstrate PHASE cattle were able to perform similar to CONTROL at low levels of CP (< 12%) compared to the industry average of 13.5% CP.

Table 4. Nitrogen mass balance during WINTER expressed as lb/steer.

Item	CONTROL	PHASE	SEM	P-value
N intake	79.0	72.8	0.9	<0.01
N retention[a]	12.8	13.0	0.2	0.51
N excretion[b]	66.3	59.8	0.7	<0.01
Manure N[c]	23.8	25.3	2.7	0.71
Soil core N	4.3	3.0	1.5	0.54
Runoff N	2.7	2.4	0.4	0.55
N lost[d]	35.6	29.2	2.6	0.11
N loss, %[e]	53.7	48.8	2.4	0.44

[a]Calculated using NRC 1996 net protein and net energy equations.
[b]Calculated as N intake minus N retention.
[c]Calculated for pen soil N balance.
[d]Calculated as N excretion minus manure N (corrected for soil) and runoff N.
[e]Calculated as N lost divided by N excreted

Table 5. Nitrogen mass balance during SUMMER expressed as lb/steer.

Item	CONTROL	PHASE	SEM	P-value
N intake	61.8	49.2	1.0	<0.01
N retention[a]	6.9	6.8	0.2	0.74
N excretion[b]	54.8	42.4	0.9	<0.01
Manure N[c]	10.8	8.1	2.0	0.35
Soil core N	4.1	4.7	1.5	0.79
Runoff N	1.3	1.4	0.2	0.81
N lost[d]	38.6	28.2	2.5	0.02
N loss, %[e]	70.4	66.5	2.0	0.58

[a]Calculated using NRC 1996 net protein and net energy equations.
[b]Calculated as N intake minus N retention.
[c]Calculated for pen soil N balance.
[d]Calculated as N excretion minus manure N (corrected for soil) and runoff N.
[e]Calculated as N lost divided by N excreted.

Nutrient Balance

Nitrogen mass balance results are presented in Tables 4 and 5. As designed, PHASE had lower (*P*<0.01) N intakes than CONTROL for both SUMMER and WINTER trials. N retained was similar between CONTROL and PHASE treatments (*P*> 0.10; 12.8 lb/steer WINTER and 6.9 lb/steer SUMMER). Therefore, N excretion was greater (*P*<0.01) for CONTROL cattle than PHASE in both SUMMER and WINTER trials. WINTER PHASE excreted 59.8 lb/steer compared to 66.3 lb/steer for CONTROL treatment. Manure N, soil N, and runoff N were similar (*P*> 0.05) between treatments. However, there was a tendency for WINTER PHASE to have lower N loss than CONTROL (35.6 vs. 29.2 lb/steer, respectively).

SUMMER PHASE excreted 42.4 lb/steer compared to 54.8 lb/steer for the CONTROL treatment. Manure N, soil N, and runoff were similar (*P*> 0.05) between treatments. However, there was a significant (*P*= 0.02) decrease in N lost for PHASE cattle compared to CONTROL (38.6 lb/steer and 28.2 lb/steer, respectively).

WINTER ammonia emissions were not different between the CON and PHASE pens (29.51 and 32.46 g/head/day) as measured by forced air wind tunnel (*2006 Nebraska Beef Report,* pp. 91-93). There was a significant effect of time across wk (*P*<0.01) for ammonia measured with the wind tunnel, but no treatment by time interaction (*P*= 0.24). SUMMER ammonia emissions were also not different between the CON and PHASE pens (19.41 and 19.84 g/head/day) as measured by forced air wind tunnel.

Seasonal ambient temperature differences are positively correlated to volatile N losses. Manure, corrected for soil contamination, contained 19.5% more N in WINTER than SUMMER. Therefore the SUMMER trial experienced more N losses (68%) as a percentage of N excreted than WINTER (51%). Compared to previous research *(2003 Nebraska Beef Cattle Report,* pp. 54-58) PHASE volatile N losses were greater during winter months (29.1 vs 48.8%, respectively) and summer months (56.4 vs 66.5%, respectively). These differences may be attributed to yearly climatic variation. The average temperature during WINTER of this study was 39°F with 14.3 inches of precipitation while the average temperature during the winter *(2003 Nebraska Beef Cattle Report,* pp. 54-58) study was 33°F with 12.8 inches of precipitation. Therefore the moist and warmer winter conditions of this trial can explain the greater volatilization of N than previous research. SUMMER temperatures were similar in this study (71°F) when compared to previously published data (*2003 Nebraska Beef Cattle Report,* pp. 54-58; 71°F) but precipitation was greater in the present study (12.0 inches vs 10.5 inches, respectively).

Phase feeding significantly improved performance in the WINTER and was similar to CONTROL in SUMMER. In both trials N volatilization was reduced without impacting N removed in manure. These data demonstrate that phase feeding may be a viable option to decrease N excretion and volatilization from feedlot pens while maintaining or improving animal performance.

[1]Stephanie Quinn, graduate student; Galen Erickson, assistant professor; Terry Klopfenstein, professor; Rick Stowell, professor; and Dawn Sherwood, graduate student, Animal Science, Lincoln.