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Decreasing dietary phosphorus to not exceed requirements decreased phosphorus excretion and improved phosphorus mass balance in feedlot pens.

Summary

Four experiments were conducted, two with calves in the winter/spring and two with yearlings during the summer, to evaluate the effects of decreasing dietary phosphorus on nutrient balance in the feedlot. The control diets averaged .38% phosphorus, whereas the experimental diets were formulated to not exceed requirements (~.25%). Phosphorus excretion was reduced by feeding the lower phosphorus diet. Phosphorus removed in manure at cleaning was not different. However, when manure was corrected for soil phosphorus, phosphorus removal was decreased by 59% in the summer trials and 38% in the calf trials during the winter/spring by feeding the experimental diet.

Introduction

When manure is used as a fertilizer, either excess P is applied to the land base or extra fertilizer N needs to be applied to optimize crop yields. The ratio is typically much lower than 5:1 (required by most crops) because 50 to 70 % of the N volatilizes from the pen after excretion in either the feces or urine, whereas P is conserved. Increasing the N or decreasing the P will add value to the manure relative to crop needs.

From an environmental perspective, decreasing P excretion would be advantageous to improve the sustainability of the beef industry. If P excretion is decreased, less P will be present in manure. With lower P in manure, fewer acres would be required to apply manure in an environmentally sustainable manner.

Our objective was to formulate a diet to meet the animal's requirement for protein and phosphorus, and to determine the effects on animal performance and more importantly nutrient balance in the feedlot.

Procedure

Four experiments were conducted, two with 96 yearling steers each fed through the summer months and two with 96 calves each fed through the winter/spring months. Steers were randomly assigned (8 head/pen) to either the control (CON) or the experimental treatment (EXP). Yearlings were fed for an average of 137 days from May to October and implanted twice with Revalor-S with the second implant about 70 days from slaughter. Yearlings were stepped-up to highest energy diet in 21 days with four diets containing 45, 35, 25, and 15 % alfalfa hay which were fed for 3, 4, 7, and 7 days respectively.

The control diet (Table 1) was formulated to provide .35 % phosphorus (P) with all supplemental P from dicalcium phosphate. The control diet was considered typical for this region, based on published surveys. The experimental diet was formulated using the 1996 NRC

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Table 1. Diet composition (% of DM) for yearlings and calves.

	Yearlings				Calves								
		Exp				Exp							
Item[a]	CON	1	2	3	CON	1	2	3	4	5	6	7	8
DRC	81.3				82.5	82.5	82.5	82.5	82.5	59.5	35.0	4.5	
HMC		67.4	64.6	61.4						16.5	36.5	61.0	57.5
C.bran		17.2	19.9	23.1						6.5	11.0	17.0	25.0
Liq-32	6.2				5.0								
Molasses						5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Fat		3.0	3.0	3.0									
Alfalfa	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Suppl.	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Dical P	.48				.47	.10	.04						
P (%)	*.36*	*.25*	*.24*	*.22*	*.41*	*.31*	*.30*	*.29*	*.28*	*.27*	*.26*	*.23*	*.22*

[a]CON is control and EXP is experimental treatments, Dry-rolled corn, high-moisture corn, corn bran, Liquid-32 is a molasses based supplement.

model to not exceed P requirements. Since both DRC and HMC contain .25 to .30% P and the requirement is .23 % P, the EXP treatment also contained corn bran (0.10 % P) to meet but not exceed the P requirement predicted by the NRC model. Since the P requirement changes with days on feed, EXP finishing diets 1, 2, and 3 were fed for 28, 28, and an average of 54 days, respectively, with corn bran replacing HMC.

In the two calf trials, steers were fed for an average of 192 days from November to May. Steers were implanted twice with Revalor-S with the second implant about 85 days from slaughter. Cattle were adapted to finisher diets (7.5 % alfalfa) similar to the yearling trials except each diet was fed for seven days. The control diet was similar to the yearling diets and formulated to provide .35 % P. The experimental diet was formulated using the 1996 NRC model to meet changing calf requirements. The first seven finishers were fed for 14 days each and finisher 8 was fed until slaughter. The P requirement also decreases with increasing weight of the animal so DRC and HMC were gradually replaced with corn bran to prevent overfeeding of P. During the second year, calves were placed on finisher 2 and finisher 1 was skipped due to heavier initial weights than in year 1.

Initial weights were an average of weights taken on two consecutive days following a five-day limit-feeding period. At slaughter, hot carcass weights and liver scores were recorded. Quality grade, yield grade, and fat thickness at the 12th rib were recorded following a 48 hour chill. Final weights were calculated as hot carcass weight divided by a common dressing percentage (62).

Steers were fed in 12 waste management pens. Soil in pens was core sampled (0 to 6 inches) before the trial to estimate nutrient concentration on the pen surface. The animals then were fed in those pens for an average of 132 d over the summer or 183 d over the winter/spring after which pens were cleaned. Manure was sampled during removal and pen soil samples again were collected to estimate nutrient balances after the feeding period. Soil sampling allows adjustment for inevitable cleaning differences from pen to pen. These pens also contain runoff collection basins to determine total runoff from pens on different treatments. Due to pen design, two pens drain into one pond; therefore dietary treatments were assigned randomly in blocks of two pens. All samples including feed and orts were analyzed for P. Manure and soil samples were analyzed by combined nitric and perchloric acid digestion and the filtrate analyzed for P by inductively coupled plasma (ICP) analysis. Feed samples were analyzed by alkalimetric ammonium molybdophosphate method using a spectrophotometer.

Results

Gain and carcass characteristics were unaffected ($P > .20$) by dietary treatment in both yearling and both calf trials (Table 2), suggesting supplementation with mineral P is unnecessary to optimize animal performance. Another objective of these four trials was to determine the effects of matching dietary protein to requirements. Animal performance, nitrogen balance, and organic matter balance have been previously discussed for the two-year study (1999 Nebraska Beef Report, pp. 60-63). Feed conversions were influenced by dietary treatment. However, as previously discussed, the response is an energetic response to corn bran depressing conversions in the calf experiments and the

Table 2. Performance of calves and yearlings fed either conventional protein and phosphorus levels (CON) or the experimental diets (EXP) to minimize overfeeding protein and phosphorus combined across both years. Means are an average of 12 reps per treatment (6 pens per treatment per year).

	Yearlings				Calves			
Item	CON	EXP	SEM	P=	CON	EXP	SEM	P=
Initial weight,lb	694	697	1.8	.17	605	608	1.7	.25
Final weight,lb	1242	1256	7.4	.17	1264	1258	8.5	.60
DM Intake,lb	25.2	24.5	.2	.03	20.3	20.7	.2	.21
ADG,lb	3.98	4.07	.05	.27	3.45	3.40	.04	.43
Feed/gain[a]	6.33	6.02		.01	5.88	6.10		.04

[a]Analyzed as gain to feed, the reciprocal of feed to gain.

Table 3. Phosphorus (P) balance in the feedlot for the yearling and calf trials combined across both years and separated by dietary treatment (all values expressed as pounds per head over the entire feeding period).

	Yearlings				Calves			
Item	CON	EXP	SE	P=	CON	EXP	SE	P=
Intake	12.8	7.2	.11	.01	15.0	9.9	.16	.01
Retention[a]	1.9	1.9	.01	.82	2.5	2.4	.01	.24
Excretion[b]	10.9	5.3	.11	.01	12.5	7.5	.15	.01
Manure	5.2	5.5	.28	.54	14.6	12.2	1.2	.24
Runoff	.48	.25	.06	.04	.14	.22	.05	.28
Soil[c]	.6	-3.1	.34	.01	-3.3	-5.2	.34	.02
Difference[d]	4.7	2.7	.25	.01	1.1	.2	.9	.52
Manure+core	5.8	2.4	.33	.01	11.3	7.0	.91	.03

[a]P retention based on ADG, NRC equation for retained energy, retained protein and P.
[b]P excretion calculated as intake minus retention.
[c]Soil is core balance on pen surface before and after trial; negative values suggest removal of phosphorus present before trial.
[d]Difference calculated as excretion minus manure minus soil minus runoff. These values indicate that not all the P that was excreted is being recovered.

high-moisture corn and tallow improving conversions with the yearling experiments.

Feeding EXP decreased ($P < .01$) P intake without affecting ($P > .24$) P retained by the animal (Table 3). Calves did retain more P than yearlings probably due to greater bone growth during the feeding period. Decreasing P to NRC-predicted requirements decreased P excretion by 5 lb per steer (12.4 grams per day) for the calf trials (183 days) and by 5.6 lb of P (19.3 grams per day) for the yearling trials (132 days). When expressed as a percentage of P excreted by CON steers, 49% and 60% of the P was excreted by yearlings and calves fed EXP, respectively.

Decreasing P excretion did not affect P removed in manure removed at cleaning. However, when corrected for P in soil cores, P available for removal was decreased by 59% (3.4 lb) for the yearlings and by 38% (4.3 lb) for the calf trials. P removal was much greater (over 2 times) following the winter/spring feeding period with the calves compared with summer-fed yearlings. One potential explanation is much more soil is removed at cleaning in the spring primarily because pens are wetter and the soil is more thoroughly mixed with the manure. The negative core values suggest that more P was removed from the soil than was present at the initiation of each trial. Over time, the P in soil should gradually decrease if dietary P was decreased. At the initiation of each experiment, pens were reassigned to treatment at random. Some pens that were on the CON (high P) treatment from the previous trial were reassigned to the EXP (low P) treatment. All residual P in the soil from the previous experiment may be removed in manure at cleaning from the EXP pens, resulting in negative core values. In established feedlots, P removal in manure should be similar to P excretion.

In conclusion, it appears that decreasing dietary phosphorus to animal requirements will decrease P excretion. However, we are not accounting for all the P in soil between trials during the summer feeding periods. More P may be removed in the spring cleaning due to more soil being removed and therefore removing more fecal material that is mixed with the pen soil. P analysis is also challenging for measurement in soil and manure. In these trials we've analyzed for total P in soil and manure with no regard for available P. However, the concept is the same whether cleaning in the spring or fall. When manure is corrected for soil P by taking soil cores in open-dirt lots, decreasing dietary P will reduce P intake, P excretion, and subsequently reduce total P either removed in manure or left on the pen surface at cleaning. When expressed as a percentage of P in soil-corrected manure for the CON treatment, only 41% and 62% of the P were removed for the EXP treatment for yearlings and calves, respectively. The percentages in soil-corrected manure are similar to the percentages for P excretion (49 and 60%).

In these experiments, corn bran was added to replace either high-moisture corn or dry-rolled corn to decrease dietary P to NRC-predicted requirements. One management option is to eliminate supplemental P from mineral sources. Therefore, only feed P that would come from basal ingredients such as corn, corn byproducts and the roughage would be fed. In these experiments and previously reported studies (1998 Nebraska Beef Report, pp. 78-80), animal performance has been unaffected by exclusion of P from mineral supplements. Therefore, feedlots could improve the P mass balance if supplemental P is removed from the diet and allow manure to be spread across fewer acres.

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[2]Author acknowledges help of feedlot and lab personnel in collection and analysis of samples.