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Effect of Increasing Dietary Concentrations of Dried Distillers Grains plus Solubles on Phosphorus Balance in Finishing Steers[1]

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Summary

Eight crossbred steers (initial BW = 972.2 ± 33.5 lb) were used in a replicated Latin square design to determine the effect of increasing dietary concentrations of dried distillers grains plus solubles (DDGS) on phosphorus (P) balance in finishing steers. The control (CON) diet contained 79% dry rolled corn (DRC), 10% cottonseed hulls, 6% soybean meal (SBM), and 5% mineral supplement (total diet P concentration = 0.26%). In each of the remaining three diets, all of the SBM and a portion of the DRC were removed and replaced with DDGS at 12%, 24%, and 36% of the diet (total diet P concentrations = 0.28%, 0.33%, and 0.37%, respectively). Steers were housed in indoor, slatted-floor pens (5.6 x 8.5 ft) during a 21-d diet acclimation period prior to a 5-d total fecal and urine collection period. All samples (feed ingredients, feed refusals, feces, and urine) were analyzed for P concentration. Phosphorus intake increased from 18.6 to 27.8 g/d as the concentration of DDGS was increased in the diet. Fecal P was not affected by treatment. Urinary P, total P excretion, and P retention increased as the level of DDGS in the diets increased. In regression analyses, fecal P, total P excretion, and P retention were influenced by P intake. Urinary P tended to be influenced by P intake. Results of the experiment clearly demonstrate that as the levels of DDGS in the diets of finishing steers increases P excretion increases.

Introduction

Distillers grains are becoming increasingly more prevalent as a feed ingredient in the diets of growing and finishing cattle. Previous research suggests that dried distillers grains (DDGS) can be substituted for corn in finishing diets, up to approximately 30% of the diet dry matter (DM), without sacrificing animal performance. Researchers from the University of Minnesota (Spiehs et al., 2002) and from South Dakota State University (Holt and Pritchard, 2004) have also reported the high concentration of P in distillers grains. Research investigating the impact of DDGS on nutrient excretion is limited. Given the increasing implementation of P-based manure application regulations, understanding the impact of DDGS inclusion on manure P concentrations is important for feedlot managers.

This experiment was conducted to determine the effect of DDGS inclusion on P excretion from steers fed a finishing diet.

Materials and Methods

Eight Angus-cross steers (initial BW = 972.2 ± 33.5 lb) were used in a replicated Latin square design. The control diet (CON) contained 79% dry rolled corn, 10% cottonseed hulls, 6% soybean meal, and 5% of a mineral supplement. In each of the remaining three diets, all of the soybean meal and a portion of the dry rolled corn was removed and replaced with DDGS at 12% (12% DDGS), 24% (24% DDGS), and 36% (36% DDGS) of the diet DM (Table 1).

[1] This project was funded by the South Dakota Corn Utilization Council.
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Table 1. Composition of treatment diets

Item	Treatments			
	CON	12% DDGS	24% DDGS	36% DDGS
	% of diet DM			
Cottonseed hulls	10.0	10.0	10.0	10.0
Rolled corn	79.0	73.0	61.0	49.0
Soybean meal	6.0	0.0	0.0	0.0
DDGS	0.0	12.0	24.0	36.0
Supplement[b]	5.0	5.0	5.0	5.0
Nutrient composition				
Dry matter	89.9	90.2	90.8	91.3
Crude protein	10.8	11.1	13.6	16.2
Neutral detergent fiber	18.2	22.3	26.5	30.7
Phosphorus	0.26	0.28	0.33	0.37

[a]DDGS = dried distillers grains plus solubles

[b]Provides vitamins and minerals to meet or exceed nutrient requirements (NRC, 2000).

On d 0 of the experiment, steers were brought into the indoor metabolism experiment facilities and placed in slatted-floor pens (5.6 x 8.5 ft). Steers were acclimated to their respective treatment diets for 21 d and intake to be used during the subsequent collection period was determined. Following the 21-d acclimation period, steers were moved to collection stanchions. While in the stanchions, steers were fed once daily at 9:00 am. Feed ingredients were sampled three times per week, pooled within week, and dried for 24 h at 140°F using a forced air induction oven. Feed refusals were removed, weighed and sampled daily prior to feed delivery.

Feed refusals were dried in a forced air induction oven at 140°F until no further water loss occurred. Feed ingredients, feed refusals, and fecal material were ground through a 1 mm screen using a Wiley Mill.

Feces and urine were collected over five consecutive days using fecal collection pans and urine collection bags. Fecal pans were emptied at the end of each 24-h period. Feces was weighed, mixed, and sampled in 5% aliquots prior to being frozen at –4°F. Fecal material was pooled by animal within period on a wet weight per day basis, mixed, and dried in a forced-air induction oven until a constant weight was achieved.

Urine was collected in canvas pouches worn by the steers and vacuumed off immediately into 2.9 gal glass carboys via water aspiration. Carboys contained 5.4 N hydrochloric acid in amounts sufficient to maintain urine pH between 2 and 3. Urine was removed from carboys as needed, but not less than every 24 h. Urine was weighed, filtered through two layers of cheesecloth and quantified volumetrically prior to a being sampled (10% aliquot) and frozen. Urine was analyzed on a wet basis. All samples (fecal, urine, feed refusals, and feed ingredients) were analyzed for total phosphorus content (AOAC 3.4.11, 1995).

Experimental design was a replicated Latin square. One steer had to be removed from the study after period two due to health concerns. All data collected on this animal were removed from statistical analyses. Statistical analyses were performed as an unbalanced replicated Latin square with animal as the experimental unit using the PROC MIXED procedure of SAS. Data were analyzed for linear and quadratic effects. Regression analyses were performed using the PROC REG procedure of SAS to determine the effect of P intake on fecal P, urine P, P retention, and P excretion.

Results and Discussion

Phosphorus balance data are presented in Table 2. The amount of P offered to the animals

daily increased in a linear fashion (P = 0.001) as the concentration of DDGS in the diet increased. No differences were detected in amount of P refused; consequently, P intake also increased linearly (P = 0.007) as the dietary concentration of DDGS increased. Linear increases in urine P (P = 0.001), total P excretion (P = 0.025), and P retention (P = 0.020) were observed as the level of DDGS in the diets increased
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Table 2. Phosphorus balance

	Treatment					Contrasts	
	CON	12% DDGS	24% DDGS	36% DDGS	SEM[a]	Linear	Quadratic
	---------- g/d ----------					---------- *P*-value ----------	
P offered	24.5	27.5	32.8	35.1	2.20	0.001	0.843
P refused	5.9	4.9	7.6	7.3	2.57	0.358	0.853
P intake	18.6	22.6	25.2	27.8	2.94	0.007	0.756
Urine P	3.3	3.8	6.2	7.5	1.05	0.001	0.571
Fecal P	12.7	13.3	17.1	14.8	3.17	0.278	0.528
Excreted P	16.0	17.1	23.3	22.3	3.37	0.025	0.676
Retained P	-1.5	2.7	4.7	5.3	0.91	0.020	0.368

[a]SEM = standard error of the mean.

When regressed on total P intake, urinary P tended to be influenced (P = 0.110) by P intake, but was poorly correlated ($P_{urinary}$ = 0.537 + 0.189 P_{intake}; r^2 = 0.10; Figure 1). Fecal P increased (P = 0.003) as P intake increased and was moderately correlated (P_{fecal} = 0.003 + 0.416 P_{intake}; P = 0.003; r^2 = 0.29; Figure 2). Total P excretion increased as P intake increased (P = 0.001) and was approximately 50% correlated with P intake (P_{total} = 5.324 + 0.605 P_{intake}; r^2 = 0.47; Figure 3). Phosphorus retention increased as P intake increased (P = 0.001) and was also 50% correlated with P intake ($P_{retained}$ = -12.306 + 0.641 P_{intake}; r^2 = 0.50; Figure 4).

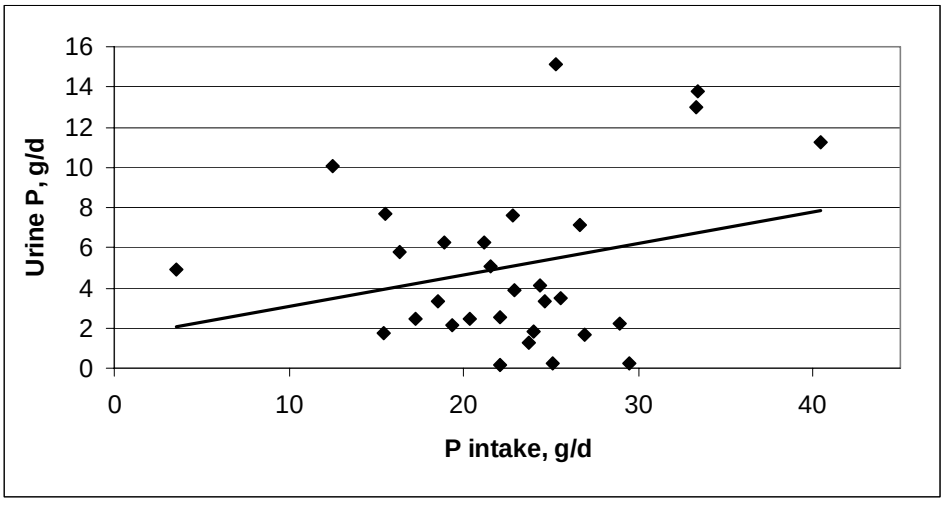

Figure 1. Urinary P regressed on total P intake; P = 0.110; $P_{urinarv}$ = 0.537 + 0.189 P_{intake}; r^2 = 0.10.

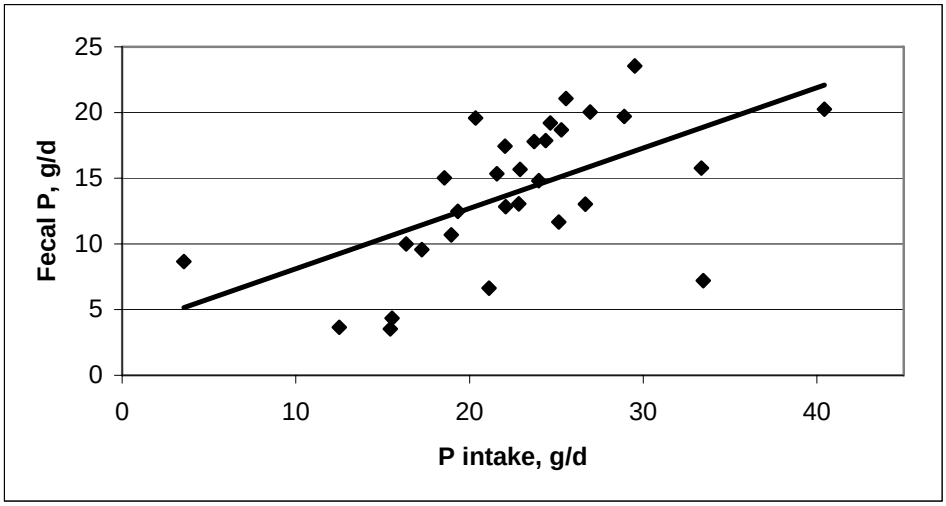

Figure 2. Fecal P regressed on total P intake; $P = 0.003$; $P_{fecal} = 0.003 + 0.416\ P_{intake}$; $r^2 = 0.29$.

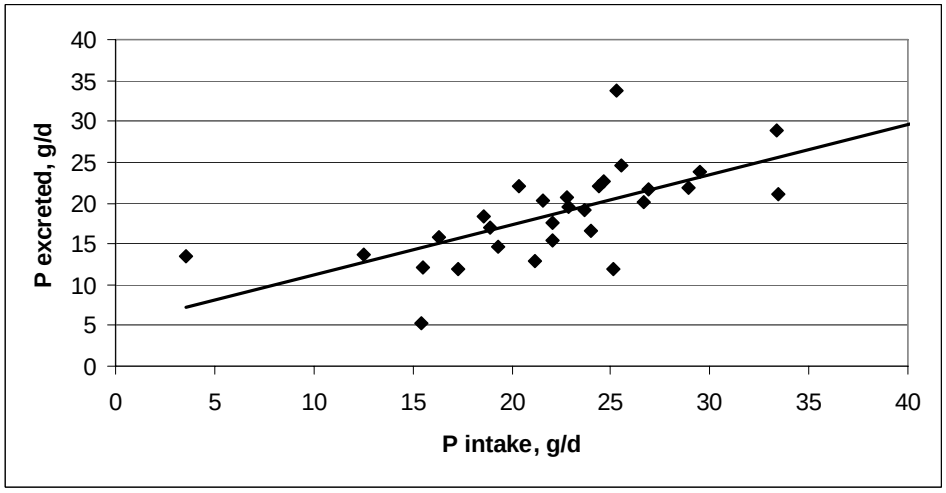

Figure 3. Total P excretion regressed on total P intake; $P = 0.001$; $P_{total} = 5.324 + 0.605\ P_{intake}$; $r^2 = 0.47$.

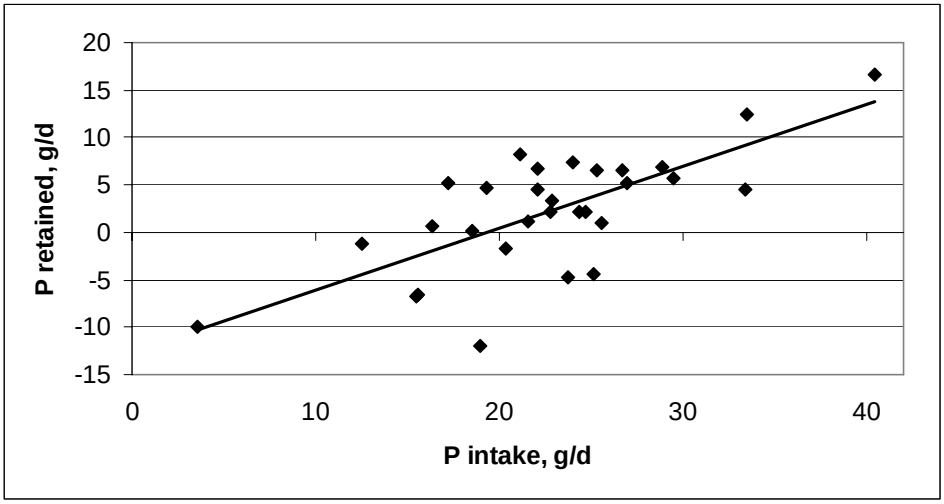

Figure 4. Total P excretion regressed on total P intake; $P = 0.001$; $P_{retained} = -12.306 + 0.641\ P_{intake}$; $r^2 = 0.50$.

Linear increases observed in urinary P and total P excretion are consistent with those reported by Knowlton and Herbein (2001). Knowlton and Herbein (2001) also observed a linear increase in fecal P excretion as P intakes increased (84.7, 135.2, and 161.5 g/d). In the current trial no differences were observed in fecal P contents. As the level of P intake increased, retention of P increased linearly ($P = 0.001$). This effect has not been previously demonstrated. The trend for increased P intake to result in increased P retention can be calculated from the data reported by Geisert et al. (2005) for cattle consuming three levels of P from brewers grits-based diets with inorganic P supplementation. This was not reported or statistically analyzed by the authors.

Results of this experiment clearly demonstrate that as the concentration of DDGS in the diets of finishing steers increases, the amount of P excreted by the animals also increases. Furthermore, these data suggest that a substantial proportion of the total amount of P excreted is contributed by urinary P.

Implications

This experiment demonstrates that as the dietary concentration of DDGS increases, P excretion increases. Beef producers and feedlot managers must be cognizant of increased manure P concentration when developing and implementing manure management plans.

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