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1997

Effects of Clinoptilolite on Growth Performance and Carcass Composition of Growing-Finishing Pigs and on Fecal Nitrogen and Phosphorus Content

Dean R. Zimmerman
Iowa State University

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Recommended Citation

Effects of Clinoptilolite on Growth Performance and Carcass Composition of Growing-Finishing Pigs and on Fecal Nitrogen and Phosphorus Content

Dean Zimmerman, professor
Department of Animal Science

ASL-R1370

Summary and Implications

For both period and cumulative growth performance data, there were trends for increased feed intake and increased feed to gain ratios associated with increasing concentrations of dietary clinoptilolite. If, however, efficiency was expressed as daily intake of megacalories of metabolizable energy, there were no treatment effects. This lack of treatment response is illustrated by overall cumulative efficiencies of 4.39, 4.39, 4.40, and 4.31 Mcal. metabolizable energy/pound of weight gain for pigs fed diets containing 0, 2, 4, and 8% clinoptilolite.

The decreased carcass backfat and increased carcass lean content associated with increasing concentrations of dietary clinoptilolite are responses that were probably caused by the concomitant increases in dietary protein (amino acid) to metabolizable energy ratios.

Chemical analyses of feces for nitrogen and phosphorus revealed two relationships with dietary clinoptilolite concentration. First, both nitrogen and phosphorus concentrations in feces decreased with increasing dietary clinoptilolite concentrations. These responses likely resulted because the clinoptilolite increased the volume of feces. Second, the ratio of nitrogen to phosphorus increased with increasing dietary clinoptilolite concentration. This response probably resulted because ammonia nitrogen was sequestered by clinoptilolite because of its ion exchange properties.

Introduction

The growth performance responses to clinoptilolite that are reported in the literature are, in general, favorable. Both rate and efficiency of body weight gain of pigs were improved with inclusion rates from 2 to 10% of the diet. The variation in response from trial to trial may be the result of a number of unidentified feed and environmental variables. The mode of action of clinoptilolite has not been defined. Some workers believe it functions by decreasing toxic ammonia levels in the intestine and others believe it may reduce toxicity from heavy metals.

Recently, odors from swine buildings and manure storage facilities have become a major issue. Methods to reduce odors include the use of additives to feeds and to manure pits. Because of its ion exchange properties, it is possible that clinoptilolite alters the gases (odors) emitted from swine waste.

Materials and Methods

The 144 (Landrace x Yorkshire) x (Hampshire x Duroc) pigs were housed in 24 pens with 6 pigs per pen. The four diet treatments were allotted randomly to the pens in each block. Pigs were allotted randomly to pens within blocks from outcome groups based on initial body weight and ancestry with the restriction that there be three barrows and three gilts in each pen.

Pens of pigs initially averaged 50.7±.6 lb. body weight. Pigs were individually identified with ear notches. Pigs were weighed every two weeks and feed consumption was measured. Pigs were marketed at an average body weight of 261 lb.

Experimental treatments were diets containing 0, 2, 4, and 8% clinoptilolite. Diets (Table 1) were based on corn, soybean meal, minerals, and vitamins. Clinoptilolite additions were added at the expense of corn and soybean meal, with no adjustment for energy differences. Lysine, calcium, and phosphorus concentrations were equalized across clinoptilolite treatments. Diet formulas were changed at approximately 110 and 170 lb. body weight. Diets contained from 50 to 110, 110 to 170, and 170 to 240 lb. body weight with calculated concentrations of .95, .80 and .70% lysine; .65, .60, and .55% calcium; and .55, .50, and .45% phosphorus, respectively.

Diets were mixed in 1000 lb. batches and stored in 50 lb. bags. Each batch of feed was sampled. Batch samples were composited for each experimental diet. These samples (12) were analyzed for crude protein, dry matter, ash, and gross energy. All corn purchases during the experiment were sampled and analyzed for presence of mycotoxins, and all samples were found to be negative.

Blood samples were collected from each pig after 3, 8, and 12 weeks of the experiment. Plasma was harvested and plasma urea nitrogen was determined. During weeks 3, 8, and 12, fresh excreta material was collected below each pen. We attempted to collect feces and urine at week 3, but only feces at weeks 8 and 12. Excreta from each pen, at each collection period, was mixed, sampled, frozen, and delivered to MVTL Laboratory, Inc., Nevada, Iowa, for chemical analyses. There were a total of 72 excreta samples. Subjective scoring of fecal material (firmness, color, odor) was made on days of excreta collection.

Pigs were slaughtered at the Hormel packing plant in Austin, Minnesota, and individual data were collected for hot carcass weight, carcass length, average midline backfat, 10th rib off-center backfat, loin water holding capacity, muscle area, color, marbling, firmness, Hunter color, Minolta color, and pH. Pounds of lean and pounds of lean/day were calculated using NPPC formulas with the carcass data

adjusted to a common body weight of 240 lb.

Responses of pigs to concentrations of clinoptilolite were evaluated using the following criteria: average daily body weight gain, average daily feed intake, feed:gain ratio, plasma urea nitrogen, and the carcass measurements outlined above. Performance data are reported for each intermediate growth period and for cumulative growth periods.

Table 1. Experimental diets

Ingredient	Control Diets, lb.		
	50-110	110-170	170-240
Corn	74.00	79.575	83.485
Soybean meal (48% CP)	22.40	17.10	13.40
Animal fat	1.00	1.00	1.00
Dicalcium phosphate	1.14	.96	.75
Calcium carbonate	.84	.87	.87
L-lysine ◊ HCl	.10	.10	.10
Sodium chloride	.25	.25	.25
Vitamin premix	.20	.10	.10
Trace mineral	.05	.025	.025
Selenium premix	.02	.02	.02
	100.00	100.00	100.00
Calculated analyses:			
Lysine, %	.95	.80	.70
Calcium, %	.65	.60	.55
Phosphorus, %	.55	.50	.45
Laboratory analyses:			
Dry matter	88.1	87.5	97.4
Protein	17.4	15.2	13.8
Ash	4.2	4.0	3.4

Results and Discussion

Growth performance of pigs by treatment is outlined in Tables 2 and 3. In general, average daily feed intake was increased slightly by increasing concentrations of clinoptilolite. Feed intake responses by period were affected significantly, however, only in the 0 to 2, 2 to 4, and 12 to 14 week periods and in the cumulative periods of 0 to 2, 0 to 4, and 0 to 6 weeks. The observed feed intake responses suggest that pigs voluntarily increased feed intake of diets containing clinoptilolite because these diets were of lower energy density than the control diet.

In no periods during the feeding trial were rates of average daily gain significantly different among treatment groups.

Diet treatments did affect feed efficiency, expressed as units of feed intake per unit of body weight gain. The differences were evident in most time periods and in all cumulative periods, except the 0 to 2 week period. In general, the responses were linearly related to concentration of clinoptilolite. Increases in clinoptilolite concentrations increased feed:gain ratios. This relationship was expected because clinoptilolite has no energy value for pigs, and,

therefore, acts to dilute the concentration of energy in the diet. Feed efficiencies, expressed as Megacalories of intake per pound of weight gain over 14 weeks, were 4.39, 4.39, 4.40, and 4.31 for pigs fed diets with 0, 2, 4, and 8% clinoptilolite, respectively. These data indicate no treatment difference in efficiency of energy utilization.

Carcass data is summarized in Table 4. The two estimates of backfat thickness were influenced by treatments. As dietary clinoptilolite concentration increased, backfat thickness decreased. This response may be related to the feed:gain responses. Diets were formulated to have similar protein (lysine) concentrations. Consequently, pigs fed clinoptilolite not only consumed more feed per unit weight gain, they also consumed more protein (lysine) per unit of weight gain. This increased protein intake may be responsible for the decreased backfat thickness in carcasses of pigs fed clinoptilolite. The estimate of the pounds of lean in carcasses was increased by increasing concentrations of clinoptilolite in diets. Backfat thickness is used in calculating these estimates, consequently, because backfat was influenced by dietary treatment, these estimates of carcass lean also were influenced by treatments. None of the other carcass measurements were influenced by dietary concentrations of clinoptilolite.

Blood samples were collected for plasma urea nitrogen (PUN) and fecal samples were collected for nitrogen and phosphorus analysis in each of three periods representing times during which diets were fed that were formulated to contain .95, .80, and .70% lysine or 17.4, 15.2, and 13.8% crude protein. A summary of these data is found in Table 5. The PUN values, expressed in milligrams per deciliter, were not affected by dietary clinoptilolite concentration in any of the three periods. Our hypothesis had been that feeding clinoptilolite would sequester ammonia produced in the gastrointestinal tract, decrease the blood ammonia levels, decrease production of urea in the liver, and thereby decrease the urea concentration of blood. We did not see this response; therefore, either ammonia produced in the intestinal tract contributed an insignificant proportion of the nitrogen excreted as urea or the clinoptilolite was ineffective in sequestering the ammonia production.

Both fecal nitrogen and phosphorus were linearly decreased by increasing concentrations of clinoptilolite in diets. These treatment responses were evident in each period. Most likely, these linear decreases resulted because of the diluting effect of an increased dry matter content of feces associated with clinoptilolite.

The ratio between fecal nitrogen and phosphorus concentrations was calculated. If phosphorus was not affected but nitrogen was affected by presence of clinoptilolite, then the N/P ratio would differ between treatments. The fecal nitrogen to phosphorus ratio in each period showed trends for linear increasing ratios with increasing dietary clinoptilolite concentrations. This relationship was highly significant and linear for the ratios averaged over the three collection periods. This response would fit a hypothesis that clinoptilolite is sequestering nitrogen within the feces, but

having no effect on phosphorus. The source of the extra retained nitrogen likely would be from ammonia produced by bacterial fermentation before and/or after the feces was voided by the pigs.

Table 2. Growth performance--period average daily feed intake, average daily gain, and feed:gain ratio.

Item	Period, week	Dietary clinoptilolite, % 0	2	4	8	Sig[a] P<	CV %
ADFI, lb.							
	0-2	2.75	2.85	2.83	3.01	L .01	5.6
	2-4	3.97	4.14	4.21	4.41	L .06	7.4
	4-6	4.56	4.67	4.86	4.91	NS	10.9
	6-8	5.30	5.62	5.68	5.12	NS	15.0
	8-10	6.08	6.20	6.43	6.32	NS	15.0
	10-12	6.84	6.90	6.78	6.91	NS	9.9
	12-14	7.25	7.29	7.31	7.70	L .08	6.1
ADG, lb.							
	0-2	1.24	1.31	1.28	1.32	NS	8.7
	2-4	1.72	1.76	1.77	1.81	NS	7.5
	4-6	1.73	1.63	1.65	1.64	NS	15.9
	6-8	1.82	1.97	1.97	1.59	L .03	12.7
	8-10	2.16	2.01	2.09	2.15	NS	7.5
	10-12	2.11	2.04	1.96	1.96	L .07	6.4
	12-14	2.04	2.16	2.03	2.04	NS	9.5
Feed:gain							
	0-2	2.22	2.18	2.21	2.29	NS	4.6
	2-4	2.30	2.36	2.39	2.44	L .01	3.6
	4-6	2.66	2.94	2.96	3.03	L .05	9.5
	6-8	2.91	2.85	2.88	3.31	L.003 Q .04	7.4
	8-10	2.79	3.07	3.08	2.95	Q .04	7.7
	10-12	3.24	3.40	3.47	3.53	NS	9.3
	12-14	3.57	3.38	3.64	3.81	L .03	6.9

[a]L=linear, Q=quadratic, and NS=nonsignificant.

Table 3. Growth performance--cumulative average daily feed intake, average daily gain, and feed:gain ratio.[a]

Item	Period, week	Dietary clinoptilolite, % 0	2	4	8	Sig[a] P<	CV %
ADFI, lb.							
	0-2	2.75	2.85	2.83	3.01	.01	5.6
	0-4	3.37	3.51	3.53	3.72	.02	6.3
	0-6	3.76	3.87	3.96	4.10	.06	7.6
	0-8	4.15	4.31	4.41	4.38	NS	9.6
	0-10	4.50	4.66	4.78	4.74	NS	9.8
	0-12	4.87	5.06	5.12	5.11	NS	9.3
	0-14	5.20	5.34	5.42	5.46	NS	8.5
	to mkt	5.35	5.57	5.67	5.74	NS	7.4
ADG, lb.							
	0-2	1.24	1.31	1.28	1.32	NS	8.7
	0-4	1.49	1.54	1.53	1.57	NS	7.1
	0-6	1.57	1.57	1.57	1.59	NS	9.4
	0-8	1.63	1.67	1.67	1.58	NS	9.9
	0-10	1.73	1.73	1.75	1.68	NS	9.0
	0-12	1.78	1.78	1.78	1.73	NS	7.4
	0-14	1.82	1.83	1.82	1.77	NS	7.0
	to mkt	1.85	1.84	1.84	1.79	NS	6.8
Feed:gain							
	0-2	2.22	2.18	2.21	2.29	NS	4.6
	0-4	2.27	2.28	2.31	2.38	L .002	2.4
	0-6	2.40	2.48	2.53	2.59	L .001	3.2
	0-8	2.55	2.59	2.64	2.77	L.0001	2.6
	0-10	2.60	2.69	2.73	2.81	L.0001	2.2
	0-12	2.72	2.82	2.87	2.95	L.0004	3.0
	0-14	2.85	2.91	2.98	3.08	L.0001	2.8
	to mkt	2.89	3.03	3.09	3.20	L.0006	4.1

[a]L=linear, NS=nonsignificant.

Table 4. Effect of clinoptilolite feeding on carcass measurements.

Item	Dietary clinoptilolite, %				Sig P<	CV, %
	0	2	4	8		
Body wt., lb.	263	259	262	257	L .25	2.91
Hot carcass wt., lb.	194	190	191	188	L .19	3.53
Carcass length, in.	33.15	32.86	33.13	32.90	L .56	1.45
Backfat, midline, in.	1.32	1.24	1.27	1.17	L .04	7.95
Backfat, 10th rib, in.	1.06	.97	1.02	.92	L.004	6.67
Water holding capacity	.227	.308	.303	.268	Q .05	24.04
Loin muscle area, in.^{2}	6.24	6.55	6.48	6.43	L .58	5.71
Color score	3.13	3.08	2.97	3.05	L .33	5.15
Marbling score	2.87	2.67	2.72	2.75	L .63	9.18
Firmness score	2.97	2.83	2.68	2.92	L .84	11.75
Minolta color	22.41	23.73	23.55	22.73	L .99	7.06
Hunter color	47.20	48.52	48.31	46.56	L .44	4.65
Loin muscle pH	5.58	5.58	5.56	5.61	L .47	1.22
Lean in carcass, lb.	84.90	87.98	86.65	88.54	L .02	2.24
Lean growth/ day, lb.	.682	.708	.687	.692	L .94	6.25

Table 5. PUN and Fecal N and P data.

Item	Dietary clinoptilolite, %				CV, %	Probability, P<	
	0	2	4	8		Trt	Linear
PUN, mg./dl.							
A[a]	11.1	11.2	10.7	11.4	11.2	.77	-
B	12.1	11.8	12.1	11.9	13.8	.99	-
C	12.3	12.8	11.6	12.4	11.9	.55	-
Avg	11.8	11.9	11.4	11.9	9.1	.84	-
Fecal N, %							
A	1.19	1.18	1.05	1.12	7.4	.05	.10
B	1.07	1.00	.95	.92	5.8	.007	.001
C	1.02	.93	.96	.87	5.6	.002	.001
Avg	1.09	1.03	.99	.97	4.3	.002	.001
Fecal P, %							
A	1.31	1.24	1.12	1.12	8.5	.02	.005
B	1.58	1.49	1.48	1.26	6.7	.001	.001
C	1.02	.93	.96	.87	17.5	.08	.03
Avg	1.44	1.33	1.32	1.16	7.8	.002	.001
Fecal N/P							
A	.91	.97	.95	1.01	7.3	.14	.04
B	.67	.67	.65	.74	6.8	.02	.02
C	.71	.75	.73	.80	13.8	.49	.17
Avg	.76	.79	.77	.85	4.5	.003	.001

[a]A, B, and C represent initial, intermediate, and final collection dates and were representative of pigs in weight ranges of 23 to 50, 50 to 77, and 77 to 109 kg. body weight.