January 2000

The Effects of Compensatory Growth and Form of Amino Acid Supply on Plasma Urea Concentration, Organ Weights and Carcass Characteristics in Gilts

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Summary and Implications

An experiment was conducted to examine the effects of compensatory growth and amino acid supply on plasma urea concentration, organ weights and carcass characteristics. Gilts were fed either a corn-soybean meal diet or a corn-soybean meal diet supplemented with crystalline lysine. Pigs were randomly allotted to either a 21-day ad libitum eating period or a 42-day restricted-realimentated feeding period. The restricted-realimentated feeding period consisted of a 21-day restriction period and a 21-day ad libitum eating period (realimentation). During the restriction period, pigs were fed to maintain body weight. During week one of the ad libitum period, gilts in the restricted-realimentated (RR) group gained weight 41% faster ($P < .01$), consumed 9% less feed ($P < .01$), and were 58% more efficient ($P < .01$) compared to gilts in the ad libitum (AL) group. Ultrasound scanning measurements showed that during the restriction period, gilts had a numerical decrease in backfat and a numerical increase in longissimus muscle area. Results show that the gilts in the RR group exhibited compensatory growth during the first two weeks of the ad libitum eating period. These results also suggest that during a restriction period growing pigs are able to utilize fat stores and repartition body protein to maintain lean muscle deposition.

Introduction

Compensatory or "catch-up" growth is characterized by a period of accelerated growth after a period of feed restriction. Carcass composition, organ size and metabolic activities are altered during a restriction-realimentation period. Therefore, examination of organ adaptations during feed restriction and the expression of accelerated growth rates during refeeding support the use of compensatory growth as a model of rapid growth in pigs.

The primary objective of this research was to investigate the effects of feed restriction and realimentation on the response of plasma urea concentration in gilts fed a traditional corn-soybean meal diet or a lysine-supplemented corn-soybean meal diet. The second objective was to examine organ adaptations and the gilt's ability to deposit lean tissue after a period of feed restriction.

Procedures

Forty-six crossbred gilts with an initial weight of 77 lb were used. Four gilts were randomly selected for an initial slaughter group to determine initial organ weights and carcass composition. Eighteen gilts were allocated to have ad libitum access to either a corn-soybean meal or corn-soybean diet with supplemental lysine. Within this group, six pigs, three from each diet treatment, were slaughtered during week one, two, and three of the experiment. Twenty-four gilts were offered a maintenance level of feed for 21 days. Feed allotments were adjusted every three

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days to minimize weight loss or gain. At the end of the 21-day feed restriction period, the restricted pigs weighted 77 lb. On day 21, six restricted gilts were randomly selected for slaughter. The remaining 18 gilts were allowed ad libitum access to either the corn-soybean meal or the lysine-supplemented diet until slaughter. Within this group, six pigs, three from each diet treatment, were slaughtered during weeks 4, 5, and 6 of the experiment. All pigs were individually penned in an environmentally controlled room.

Diets were corn-soybean meal based and formulated to contain one of two crude protein percentages (16.3 or 14.3%; Table 1). All other nutrient concentrations were equal to, or in excess of, NRC (1998) requirements. During the feed restriction period, gilts were fed the 16.3% CP corn-soybean meal diet. Daily feed allotments during the feed restriction period were based on each pig's maintenance energy requirement. Because nutrient densities were not adjusted during the restriction period, the daily intakes of all nutrients were less than NRC requirements for growth.

Pig weights were recorded weekly during the ad libitum period and every three days during the restriction period. Feed consumption was measured weekly for the ad libitum (AL) groups and daily during the realimentation period for the restricted-realimented (RR) groups. Blood samples were collected weekly for both feeding groups and daily during the first week of ad libitum feeding. Ultrasound scanning measurements were made weekly by a certified technician. Carcass measurements and organ weights were collected at slaughter. Gastrointestinal contents were removed for the determination of empty body weight (live weight minus gastrointestinal content weight).

Results

Growth performance data are shown in Table 2. During week 1 and 2 of the ad libitum feeding period, average daily gain (ADG) was greater (*P* < .05) in the RR gilts compared to the AL gilts. There was a feeding regimen × diet interaction (*P* < .05) observed during week 3 of the ad libitum feeding period for ADG. Average daily feed intake (ADFI) for the AL gilts was about 9% greater (*P* < .05) during week 1 compared to the RR gilts. However, during weeks 2 and 3, the RR gilts consumed more (*P* < .10) feed than the AL gilts. A feeding regimen × diet interaction (*P* < .05) was observed during week 3 for ADFI, with the RR gilts fed the lysine-supplemented diet having the greatest ADFI. Feed efficiency was improved (*P* < .05) in the RR gilts during week 1 compared to the AL gilts. There was also a diet effect (*P* < .05) and a feeding regimen× diet interaction (*P* < .05) during week 1 for feed efficiency. During weeks 2 and 3, there were no differences in feed efficiency between the AL and RR gilts.

Ultrasound backfat (BF) and long-

Table 1. Ingredient and calculated composition of diets, as-fed basis.

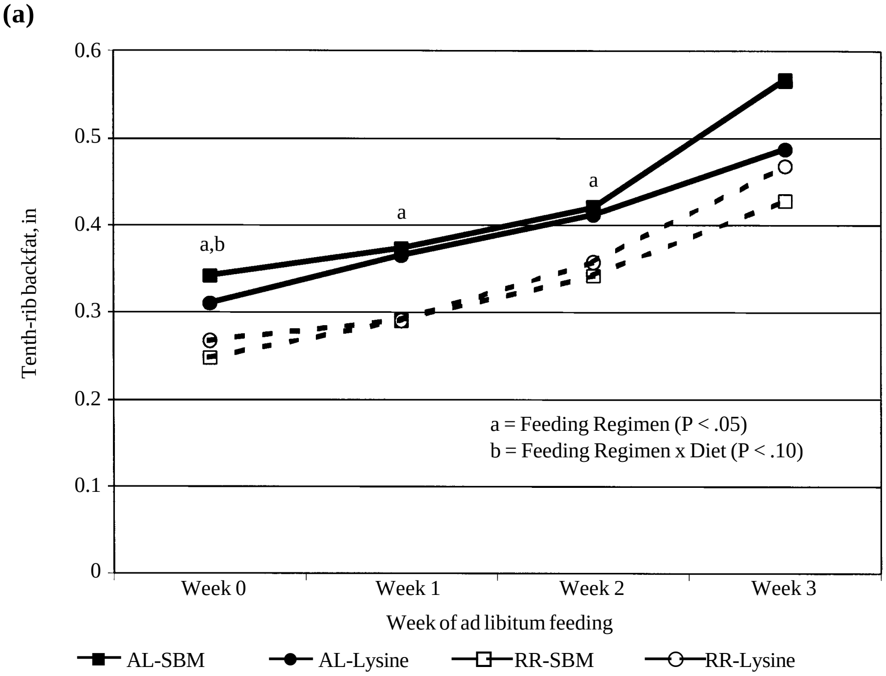
Item	Corn-soybean meal	Corn-soybean meal + lysine
Ingredient, %		
Corn	74.02	77.85
Soybean meal (46.5% CP)	21.40	17.25
Tallow	2.00	2.10
Lysine	—	.15
Dicalcium phosphate	1.05	1.15
Limestone	.43	.40
Salt	.30	.30
Vitamin premix[a]	.70	.70
Trace mineral premix[b]	.10	.10
Calculated nutrient content		
Crude protein, %	16.30	14.30
ME, Mcal/lb	1.55	1.55
Lysine, %	.89	.89
Calcium, %	.65	.65
Phosphorus, %	.55	.55

[a]Supplied per kilogram of diet: retinyl acetate, 3,088 IU; cholecalciferol, 386 IU; α-tocopherol acetate, 15 IU; menadione sodium bisulfite, 2.3 mg; riboflavin, 3.9 mg; d-pantothenic acid, 15.4 mg; nicacin, 23.2 mg; choline, 77.2 mg; vitamin B_{12}, 15.4 µg.
[b]Supplied per kilogram of diet: Zn (as ZnO), 110 mg; Fe (as $FeSO_4 \bullet H_2O$), 110 mg; Mn (as MnO), 22 mg; Cu (as $CuSO_4 \bullet 5\,H_2O$), 11 mg; I (as $Ca(IO_3) \bullet H_2O$, .22 mg; Se (as Na_2SeO_3), .3 mg.

Table 2. Performance of gilts fed a corn-soybean meal or lysine-supplemented, corn-soybean meal diet during two different feeding regimens.

Diets	Corn-soybean meal		Corn-soybean meal + lysine		P-Value[c]		
Feeding regimen[a]	AL	RR	AL	RR	FR	D	FR x D
Item[b]							
Week 1							
ADG	2.21	2.29	3.57	2.81	< .05	< .05	< .05
ADFI	4.41	4.40	4.05	4.02	< .05	NS	NS
ADG/ADFI	.50	.52	.88	.70	< .05	< .05	< .05
Week 2							
ADG	2.18	2.13	2.58	2.62	< .05	NS	NS
ADFI	4.89	4.69	5.39	5.77	< .05	NS	NS
ADG/ADFI	.45	.45	.48	.45	NS	NS	NS
Week 3							
ADG	2.71	2.21	2.36	2.91	NS	NS	< .05
ADFI	5.80	4.94	5.81	6.14	< .10	NS	< .10
ADG/ADFI	.47	.45	.41	.47	NS	NS	NS

[a]AL=ad libitum group, RR=restricted-realimentated group.
[b]ADG = average daily gain, ADFI=average daily feed intake.
[c]FR=feeding regimen, D=diet, and NS=nonsignificant effect, P > .10.



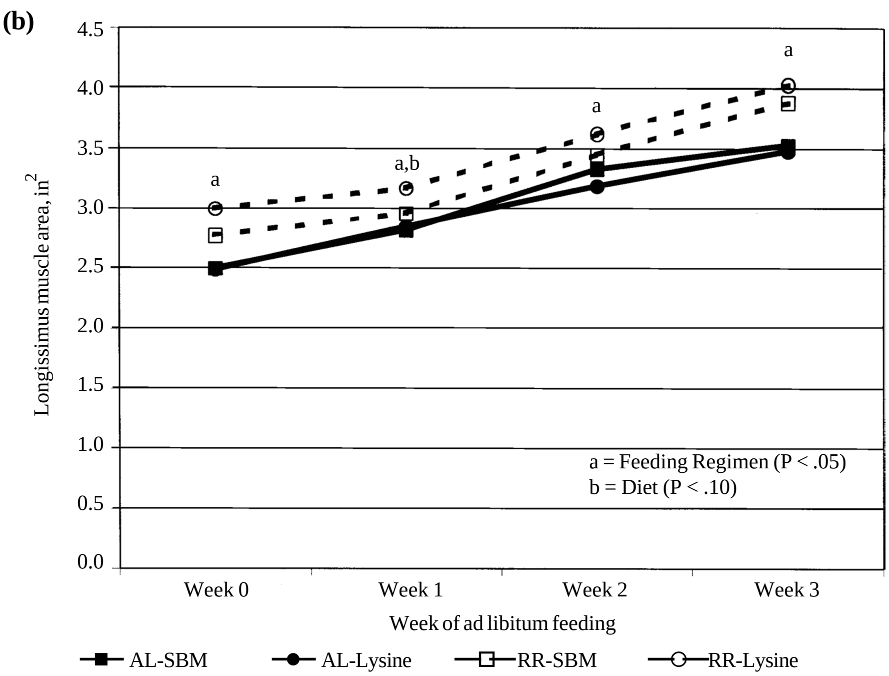


Figure 1. The response of a) backfat (BF) and b) longissimus muscle area (LMA) ultrasound measurements to feeding treatments (ad libitum, AL; restricted-realimentated, RR) and diet treatments (corn-soybean meal, SBM; lysine-supplemented, corn-soybean meal, Lysine).

issimus muscle area (LMA) measurements are shown in Figure 1a and 1b, respectively. Week 0 indicates the start of the ad libitum feeding period, which was day 0 for the AL gilts and day 21 for the RR gilts. Ultrasound measurements show that the RR gilts lost ($P < .05$) BF during the restriction period and continued to have less ($P < .05$) BF during weeks 1 and 2 of the ad libitum feeding period. Longissimus muscle area was greater ($P < .05$) in the RR gilts than in the AL gilts at the initiation of the ad libitum feeding period. During weeks 1, 2 and 3, RR gilts continued to have greater ($P < .05$) LMA than the AL gilts. A diet effect was observed during week 1, with the gilts fed the lysine-supplemented diet having a greater ($P < .05$) LMA than gilts fed the corn-soybean meal diet. Plasma urea concentrations were higher ($P < .05$) in gilts fed the corn-soybean meal diet than in gilts fed the lysine-supplemented diet (Figure 2). Also, plasma urea concentrations were greater ($P < .05$) in the RR gilts than in the AL gilts during days 1- 7 and day 20. This observation is surprising because ADFI was lower in RR vs AL pigs during the first week of ad libitum feeding.

Organ weights and carcass measurements are shown in Table 3. Livers of RR gilts were heavier ($P < .05$) than those of AL gilts during weeks 1 and 2 and were heavier ($P < .05$) in gilts fed the corn-soybean meal versus the lysine supplemented diet during week 1. There was a feeding regimen × diet interaction ($P < .05$) observed during week 2 of the ad libitum feeding period for liver weight. Pancreas weights were greater ($P < .05$) in the AL gilts than in the RR gilts during week 1 of the ad libitum period. A feeding regimen × diet interaction was observed in the second week of the ad libitum feeding period for pancreas weight. There were no differences between feeding or diet treatments for tenth rib BF. Longissimus muscle area was greater ($P < .05$) in the RR versus the AL gilts during week 1 and was greater ($P < .05$) in gilts fed the lysine-supplemented diet versus the gilts fed the corn-soybean meal diet during week 1. A feeding regimen × diet interaction ($P < .05$) was observed during week 1 with the gilts in the RR-lysine group having the largest LMA. There was a numerical increase in LMA for gilts fed the RR-lysine supplemented diet during weeks 2 and 3. Hot carcass weight was greater ($P < .05$) during

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Table 3. Organ weights and carcass measurements of gilts fed a corn-soybean meal or lysine-supplemented, corn-soybean meal diet during two different feeding regimens

Diets		Corn-soybean meal		Corn-soybean meal + lysine		P-Value[c]		
Item[b]	Feeding regimen[a]	AL	RR	AL	RR	FR	D	FR x D
Week 1								
Liver wt, lb		1.86	1.66	1.94	1.90	< .05	< .05	NS
Pancreas wt, lb		.17	.17	.15	.16	< .05	NS	NS
Tenth-rib backfat, in		.37	.40	.37	.37	NS	NS	NS
Longissimus muscle area, in^2		3.05	3.35	3.65	4.42	< .05	< .05	< .05
Hot carcass weight, lb		65.16	64.66	63.38	65.63	NS	NS	< .10
Week 2								
Liver wt, lb		1.93	1.86	1.94	2.13	< .05	NS	< .05
Pancreas wt, lb		.19	.17	.18	.21	< .10	NS	NS
Tenth-rib backfat, in		.53	.47	.50	.43	NS	NS	NS
Longissimus muscle area, in^2		4.05	3.75	4.18	4.28	NS	NS	NS
Hot carcass weight, lb		75.74	77.28	74.65	73.81	< .05	NS	< .10
Week 3								
Liver wt, lb		2.35	2.05	2.34	2.38	NS	NS	NS
Pancreas wt, lb		.19	.22	.24	.22	NS	NS	NS
Tenth-rib backfat, in		.67	.63	.63	.60	NS	NS	NS
Longissimus muscle area, in^2		3.87	4.37	4.43	4.80	NS	NS	NS
Hot carcass weight, lb		90.10	91.36	87.78	89.31	NS	NS	NS

[a]AL=ad libitum group, RR=restricted-realimentated group.
[b]FR=feeding regimen, D=diet, and NS=nonsignificant effect, P > .10.

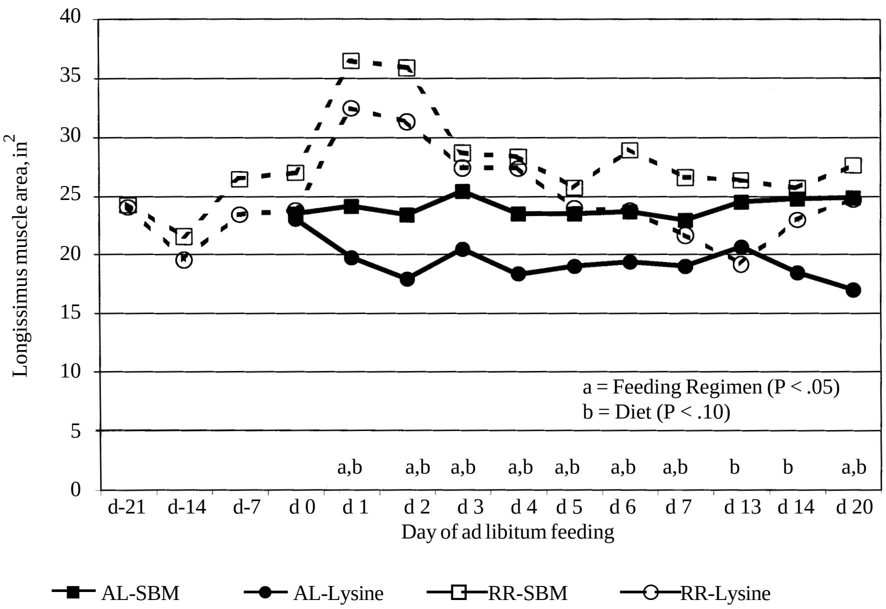

Figure 2. The response of plasma urea concentrations in gilts. Feeding treatments were ad libitum (AL) or restricted-realimentated (RR) and diet treatments were corn-soybean meal (SBM) or lysine-supplemented, corn-soybean meal (Lysine).

week 2 in the AL gilts than in the RR gilts. A feeding regimen× diet interaction ($P < .05$) was observed during weeks 1 and 2 of the ad libitum feeding period for hot carcass weight.

Conclusions

These results indicate that pigs do exhibit a compensatory growth response during restriction-realimentation feeding regimens. This is best illustrated by the increase in ADG during weeks 1 and 2 of the ad libitum feeding period. Plasma urea concentrations of RR gilts were much higher than those of AL gilts during days 1 and 2 of the ad libitum eating period indicating an increase in feed intake, although ADFI for the first 7 d was lower in the RR than in AL gilts. Plasma urea concentrations were consistently lower in pigs fed the lysine-supplemented diet, indicating that a two percentage unit decrease in dietary crude protein concentration is reflected in lower plasma urea concentrations. Carcass measurements showed a trend for a decrease in tenth rib BF and an increase in LMA when pigs were restricted and refed a diet with a reduction in protein concentration and supplemented with lysine. Further research is needed to explore the metabolic pathway by which pigs are able to use fat stores and deposit lean muscle tissue during a period of feed restriction and subsequent refeeding.

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