Growth Performance and Carcass Traits of Pigs Subjected to Marginal Dietary Restrictions During the Grower Phase[1,2]

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ABSTRACT: Sixty-four individually housed pigs were used to investigate the effect of amino acid content of finisher diets on growth performance of pigs subjected to marginal dietary amino acid restrictions (80% of the 1988 NRC lysine recommendation) during the grower phase. In each of the two trials, low- and high-amino-acid grower diets (.421 and .765 g lysine/MJ DE, respectively) and four finisher diets (.421, .516, .612, and .707 g lysine/MJ DE) were randomly assigned within sex to 16 gilts and 16 castrated males weighing 23.0 ± 2.0 kg in a 2 × 4 factorial arrangement of treatments. The average weight of pigs after a completion of diet change was 50.4 ± 2.1 kg. All pigs were slaughtered at an average weight of 105.2 ± 4.1 kg. Ultrasound backfat thickness was measured at the time of diet change and before slaughter. Pigs were allowed ad libitum access to feed and water. During the grower phase, pigs fed the high-amino-acid diet grew faster ($P < .001$) and more efficiently ($P < .001$) and had less ultrasound backfat ($P < .001$) than those fed the low-amino-acid diet. The grower diet had no effect on weight gain during the finisher phase. Consequently, pigs fed the high-amino-acid grower diet had better overall weight gain ($P < .01$) than those fed the low-amino-acid diet. The rate of lean accretion was, however, similar between the two groups of pigs. Furthermore, pigs fed the low-amino-acid grower diet seemed to have better carcass quality, as indicated by less ultrasound backfat ($P < .01$) and larger carcass longissimus muscle area ($P < .05$). Average and 10th rib carcass backfat decreased linearly ($P \leq .05$) and lean accretion rate improved linearly ($P < .05$) as the amino acid content of finisher diets increased, but there was no grower × finisher diet interaction in these and other response criteria. Although no evidence of compensatory weight gain was observed, it is possible that compensatory lean tissue growth may have occurred in pigs subjected to early amino acid restrictions at the expense of fatty tissue growth.

Key Words: Pigs, Amino Acids, Undernutrition, Compensatory Growth

 J. Anim. Sci. 1999. 77:1769–1776

Introduction

Grower pigs respond positively to higher concentrations of amino acids than those recommended by the NRC (1988) (e.g., Campbell et al., 1985; Chiba et al., 1991a,b). The effect of enhanced growth during the early phase of development on subsequent and overall performance is, however, not well established. Compensatory growth responses after a period of amino acid restrictions in young pigs have been reported (e.g., Chiba, 1994, 1995); thus, early nutritional history may have lesser importance in terms of overall rate and efficiency of growth.

In addition, the effect of amino acid content of realimenting diets on subsequent growth performance and(or) carcass quality of pigs subjected to dietary restrictions during the early phase of development is not clear. If pigs are acclimated to a specific diet, they may not be able to consume adequate daily nutrient allowances following alterations in dietary nutrient density. Furthermore, the mass of metabolically active visceral organs increases in pigs fed high-amino-acid diets (e.g., Chiba, 1994; Chiba et al., 1995), indicating that the heat loss associated with maintenance may increase (Ferrell, 1988). Moreover, whole-body protein turnover, which has a high energy expenditure, can be increased by feeding diets high in amino acid content (Reeds et al., 1981, 1982). Pigs, therefore, may need diets that contain proportionally higher concentrations of amino acid during the latter phase of

[1]This paper was published as Journal Series No. 4-975810, Alabama Agric. Exp. Sta., Auburn Univ., AL.

[2]The technical assistance of M. Carroll, J. Deal, C. Dowdell, R. Johnson, L. Mikel, C. Morgan, and P. Tyler is gratefully acknowledged.

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Received April 7, 1998.

Accepted February 10, 1999.

growth to consume adequate amounts of nutrients or to sustain metabolic and(or) physiological alterations that might be associated with the earlier period of enhanced growth.

This research was designed to investigate the effect of amino acid content of diets offered during the finisher phase (approximately 50 kg to market weight) on subsequent and overall growth performance, carcass quality, and internal organ weights of pigs subjected to amino acid restrictions during the grower phase (approximately 20 to 50 kg).

Experimental Procedures

Animals and Facilities. In each of two identical trials, two grower and four finisher diets were randomly assigned within sex to 16 gilts and 16 castrated males (Yorkshire × Landrace × Duroc and Newsham Hybrids for Trials 1 and 2, respectively) weighing 23.0 ± 2.0 kg in a 2 × 4 factorial arrangement of treatments. Diets were switched and pigs were slaughtered when they reached the target weights. The average weight of pigs after a completion of diet change was 50.4 ± 2.1 kg. All pigs were slaughtered at an average weight of 105.2 ± 4.1 kg to assess carcass traits. Backfat thickness was measured at the time of diet change and before slaughter using an ultrasound instrument (Renco, Minneapolis, MN) 4 to 5 cm from the midline on the right side at the third rib, last rib, and last lumbar vertebra. Pigs were housed in individual pens with solid concrete floors in an open-front building. Trial 1 was initiated in November and terminated in February, and Trial 2 was initiated in April and terminated in August. Average daily minimum and maximum temperatures were 7.8 and 19.8°C, respectively, for Trial 1 and 23.8 and 33.7°C, respectively, for Trial 2. Pigs were allowed ad libitum access to feed and water throughout each trial. Pig weights and feed consumption data were recorded weekly until the diet change, and once every 2 wk thereafter. Near the end of each trial, data were collected more frequently according to the slaughter schedule. The protocol for animal care had been approved by the university's Institutional Animal Care and Use Committee.

Experimental Diets. The purpose of using the two grower diets that differed greatly in amino acid content was to create clear differences in growth performance of pigs during the grower phase (Table 1). The grower diets were designed to be either marginally deficient (.421 g/MJ DE; 80% of the 1988 NRC recommendation) or adequate (.765 g/MJ DE; Chiba et al., 1991a,b) in lysine. The lysine content of four finisher diets ranged from the NRC (1988) recommendation for pigs weighing 50 to 110 kg (.421

Table 1. Composition of grower and finisher diets[a]

Item	Lysine:DE, g/MJ				
	.421	.516	.612	.707	.765
Ingredient, g/kg					
Corn	841.8	793.9	745.8	697.3	668.1
Soybean meal (48% CP)	126.4	175.0	223.8	273.0	302.6
Dicalcium phsophate	18.0	17.1	16.1	15.1	14.6
Limestone	7.8	8.0	8.3	8.6	8.7
Salt	3.5	3.5	3.5	3.5	3.5
Trace mineral-vitamin mix[b]	2.5	2.5	2.5	2.5	2.5
Calculated composition					
DE, MJ/kg	14.4	14.4	14.5	14.5	14.5
CP, g/kg	133	152	172	192	204
Lysine, g/kg	6.1	7.5	8.9	10.3	11.1
Calcium, g/kg	7.5	7.5	7.5	7.5	7.5
Phosphorus, g/kg	6.5	6.5	6.5	6.5	6.5
Analyzed composition, g/kg[c]					
CP	138	148	169	191	195
Lysine	7.4	7.4	8.9	10.4	11.6
Threonine	6.2	6.6	7.6	8.4	9.1
Isoleucine	6.2	6.6	7.6	8.6	9.3
Valine	7.7	8.1	9.1	10.2	11.0
Histidine	4.5	4.4	4.9	5.0	6.0

[a]Diets containing .421 and .765 g lysine/MJ DE were used during the grower phase (23.0 to 50.4 kg), and diets containing .421, .516, .612, and .707 g lysine/MJ DE were used during the finisher phase (50.4 to 105.2 kg).

[b]The following were provided per kilogram of diet: Mg, 269 mg; Zn, 80 mg; Fe, 80 mg; Mn, 40 mg; Cu, 10 mg; I, 1 mg, Co, .4 mg; Se, .3 mg; vitamin A, 5,500 IU; vitamin D_3, 1,760 IU; vitamin E, 16.5 IU; menadione dimethylpyrimidinol bisulfite, 2.2 mg; riboflavin, 4.4 mg; d-pantothenic acid, 17.6 mg; niacin, 35.2 mg; vitamin B_{12}, 27.5 μg; choline, 95 mg.

[c]Diets were not analyzed for sulfur amino acids and tryptophan; means for the two trials are reported.

g lysine/MJ DE) to greater (.707 g lysine/MJ DE) than that recommended by the ARC (1981) for pigs weighing 50 to 90 kg.

Unlike in previous experiments (Chiba, 1994, 1995), corn and soybean meal were used as the only sources of energy and amino acids to formulate practical diets, and an effort was not made to maintain a constant amino acid balance or DE content. The proportions of indispensable amino acids relative to lysine were, however, above the ideal (ARC, 1981) or balanced protein (NRC, 1988), and the DE content was similar for all diets (14.4 to 14.5 MJ/kg). Minerals and vitamins were provided in amounts calculated to meet or exceed the NRC (1988) requirement estimates. Feed samples collected at each mixing during each trial were pooled, and subsamples for each trial were analyzed for amino acids (Chiba, 1994) after the completion of both trials.

Slaughter Procedures. Pigs were slaughtered at the university's meat laboratory using conventional procedures. The heart, liver, lungs, and kidneys were collected and weighed separately. The eviscerated carcass was split longitudinally through the vertebrae midline, and hot carcass weight was recorded. After chilling for 24 h at 2°C, the right side was weighed, and backfat thicknesses were measured at the midline between the second and third rib, last rib, and last lumbar vertebra. The specific gravity of each carcass was determined by hydrostatic weighing of the right side in a tank located in the cooler maintained at 2°C. To measure the area of longissimus muscle, the right side was exposed by a perpendicular cut between the 10th and 11th rib. The longissimus muscle area was traced using acetate paper. Backfat thickness at the 10th rib (¾ distance along the longissimus muscle toward the belly) was also measured. The rate of carcass lean accretion and proportion of carcass lean were estimated by equations reported by NPPC (1991).

Statistical Analysis. Initially, each trial was analyzed separately as a generalized randomized block design (Chiba, 1994), and each response criterion was subsequently tested for homogeneity of variance (Pearson and Hartley, 1956). Data were subjected to the statistical analysis as repeated experiments (Cochran and Cox, 1957) using the GLM procedure of SAS (1988). The initial and final weights were included in the model as covariates for growth performance data, whereas the final weight was used as a covariate for ultrasound backfat, carcass, and internal organ data. Orthogonal polynomials were used to evaluate the effect of finisher diets. The individually housed pig was considered as the experimental unit in the analysis.

Results

General. The initial statistical analysis revealed that variances between the two trials were homogenous, except feed intake during the grower phase and proportion of estimated carcass lean ($P < .05$). Growth performance during the grower phase (Table 2) and proportion of carcass lean (Table 6) are, therefore, presented accordingly. The results of amino acid analysis indicated that dietary amino acid contents were generally similar to calculated values (Table 1). The amino acid content of the diet formulated to contain .421 g lysine/MJ DE was, however, higher than intended values in Trials 1 and 2. The reason for the difference is not apparent.

Grower Phase. Feed intake was not affected by diets offered during the grower phase in Trials 1 or 2 (Table 2). For the two trials combined, pigs fed the high-amino-acid grower diet (.765 g lysine/MJ DE) grew faster ($P < .001$) and more efficiently ($P < .001$) than those fed the low-amino-acid diet (.421 g lysine/MJ DE). Likewise, pigs fed the high-amino-acid grower diet had less ultrasound backfat ($P < .001$) at the end of the grower phase than those fed the low-amino-acid diet.

Finisher Phase. Although there was a trend for a grower × finisher diet interaction ($P = .09$) in feed intake during the finisher phase, no interaction was observed in the rate or efficiency of weight gain (Table 3). As the lysine content of finisher diets increased, a cubic response in feed intake was observed in pigs fed the low-amino-acid grower diet. Conversely, feed intake was relatively similar for pigs fed the high-amino-acid grower diet, except for a lower feed intake in pigs fed the finisher diet containing .421 g lysine/MJ DE. The grower diet had no effect on weight gain or efficiency of weight gain during the finisher phase. The efficiency of weight gain improved linearly ($P < .05$) with an increase in the lysine content, but the finisher diet did not affect weight gain.

Grower-Finisher Phase. The interaction observed during the finisher phase was reflected in feed intake of pigs during the grower-finisher phase (grower × finisher, $P < .05$; Table 4). Pigs fed the high-amino-acid grower diet had better overall weight gain ($P < .01$) but had more ($P < .01$) ultrasound backfat at the end of the finisher phase than those fed the low-amino-acid grower diet. The grower diet did not affect the overall efficiency of weight gain. Although weight gain or ultrasound backfat was not clearly affected by the amino acid content of finisher diets, the efficiency of weight gain improved (linear, $P < .05$; quadratic, $P = .10$) as the lysine content of finisher diets increased.

Carcass and Organ Weights. No grower × finisher diet interaction ($P > .10$) was observed in any of the carcass response criteria or internal organ weights (Table 5). Pigs fed the low-amino-acid grower diet had larger longissimus muscle areas ($P < .05$) than those fed the high-amino-acid diet. The grower diet, however, did not affect carcass traits, estimated lean accretion rate, or internal organ weights. Average and 10th rib backfat decreased linearly ($P \leq .05$) and rate of lean accretion increased linearly ($P < .05$) as the

Table 2. Effects of grower diets on growth performance of pigs during the grower phase (23.0 to 50.4 kg) and ultrasound backfat measured at 50.4 kg[ab]

Trial and diet, g lysine/ MJ DE	Feed intake, g/d	Weight gain, g/d	Gain: feed, g/kg	Ultrasound backfat, mm
Trial 1				
.421	2,860	838	298	14.2
.765	2,719	940	355	12.5
P-value[c]	—	.002	.004	.001
SEM	103.7	21.3	12.2	.34
Trial 2				
.421	2.001	716	360	13.0
.765	1,945	836	433	10.9
P-value[c]	—	.001	.001	.005
SEM	51.8	17.4	11.5	.47
Combined				
.421	2,430	776	329	13.6
.765	2,330	889	394	11.7
P-value[c]	NA	.001	.001	.001
SEM	57.0	14.2	8.4	.29

[a]Data for each of the individual trials and combined are presented because of the heterogeneity ($P < .05$) of variance in feed intake between the two trials.

[b]Least squares means were based on 16 and 32 individually fed pigs per diet for each trial and combined, respectively; the initial (25.0 ± 1.9 and 21.0 ± 2.0 kg for Trials 1 and 2, respectively) and final (51.1 ± 2.3 and 49.7 ± 1.9 kg for Trials 1 and 2, respectively) weights were included in the model as covariates for growth performance data, whereas the final weight was used as a covariate for ultrasound backfat data.

[c]*P*-values ≤ .10 are reported; NA = not applicable because of the heterogeneity of variance.

lysine content of finisher diets increased. Similarly, the weight of liver (linear, $P < .01$; quadratic, $P = .06$) and kidneys (linear, $P < .001$; quadratic, $P < .05$) increased with an increase in the lysine content of finisher diets. Carcass specific gravity or longissimus muscle area was not affected by the finisher diet. There was no clear effect of dietary treatments on proportion of carcass lean (Table 6), even though it tended to be higher numerically ($P = .11$) in pigs fed the low-amino-acid grower diet in Trial 1 and seemed to increase numerically (linear, $P = .12$) as the lysine content of finisher diets increased in Trial 2.

Table 3. Effects of grower and finisher diets on growth performance of pigs during the finisher phase (50.4 to 105.2 kg)[a]

Diet, g lysine/MJ DE: Grower	Finisher	Feed intake, g/d	Weight gain, g/d	Gain: feed, g/kg
.421	.421	3,485	968	278
	.516[b]	3,071	893	295
	.612	3,601	988	280
	.707	2,867	961	332
.765	.421	3,246	956	296
	.516	3,523	985	287
	.612	3,526	1,014	294
	.707	3,455	1,034	300
P-value[c]				
Grower		—	—	—
Finisher:				
Linear		—	—	.048
Quadratic		—	—	—
Cubic		.071	—	—
Grower × finisher		.085	—	—
SEM		171.8	45.9	12.1

[a]Least squares means were based on eight individually fed pigs per diet; the initial (50.4 ± 2.1 kg) and final (105.2 ± 4.1 kg) weights were included in the model as covariates.

[b]One pig was removed during the finisher phase in Trial 2.

[c]*P*-values ≤ .10 are reported.

Table 4. Effects of grower and finisher diets on growth performance of pigs during the grower-finisher phase (23.0 to 105.2 kg) and ultrasound backfat measured at 105.2 kg[a]

Diet, g lysine/MJ DE					
Grower	Finisher	Feed intake, g/d	Weight gain, g/d	Gain: feed, g/kg	Ultrasound backfat, mm
.421	.421	3,187	899	286	21.1
	.516[b]	2,728	842	310	21.1
	.612	3,143	891	288	20.0
	.707	2,627	889	338	19.9
.765	.421	2,897	930	324	23.0
	.516	3,166	947	302	23.8
	.612	3,097	973	319	23.4
	.707	3,042	983	328	21.4
P-value[c]					
Grower		—	.008	—	.003
Finisher					
Linear		—	—	.027	—
Quadratic		—	—	.099	—
Cubic		.064	—	—	—
Grower × finisher		.022	—	—	—
SEM		114.0	36.4	10.5	.98

[a]Least squares means were based on eight individually fed pigs per diet; the initial (23.0 ± 2.0 kg) and final (105.2 ± 4.1 kg) weights were included in the model as covariates for growth performance data, whereas the finial weight was used as a covariate in the analysis of ultrasound backfat data.
[b]One pig was removed during the finisher phase in Trial 2.
[c]*P*-values ≤ .10 are reported.

Discussion

Even though the effect of trial was not assessed, pigs used in Trial 1 seemed to consume more feed and grow faster than those used in Trial 2, as indicated by the growth performance data during the grower phase. Conversely, pigs used in Trial 2 seemed to have better carcass quality than those used in Trial 1, as indicated

Table 5. Effects of grower and finisher diets on carcass traits and internal organ weights of pigs at 105.2 kg and rate of estimated lean accretion in pigs growing from 23.0 to 105.2 kg[ab]

Diets g lysine MJ DE	SG	Avg BF, mm	10th BF, mm	LMA, cm^2	Lean, g/d	Liver, g	Kidney, g
Grower							
.421	1.0480	30.8	25.9	40.1	339	1,588	283
.765	1.0491	31.7	27.3	36.8	347	1,597	284
Finisher							
.421	1.0472	32.0	27.4	35.7	329	1,559	270
.516	1.0487	32.8	28.5	39.8	337	1,517	259
.612	1.0484	30.7	25.9	39.3	353	1,587	282
.707	1.0499	29.5	24.7	39.0	352	1,705	323
P-value[c]							
Grower	—	—	—	.032	—	—	—
Finisher							
Linear	—	.038	.050	—	.020	.007	.001
Quadratic	—	—	—	—	—	.061	.034
Cubic	—	—	—	—	—	—	—
Grower × finisher	—	—	—	—	—	—	—
SEM							
Grower	.00078	.67	.82	1.01	5.4	26.3	7.6
Finisher	.00111	.95	1.15	1.43	7.6	37.3	10.7

[a]SG = carcass specific gravity, BF = backfat thickness, 10th BF = 10th rib backfat, and LMA = longissimus muscle area; least squares means were based on 32 and 16 individually fed pigs per diet for grower and finisher dietary treatments, respectively; the final weight (105.2 ± 4.1 kg) was included in the model as a covariate.
[b]One pig (.421 – .516 g lysine/MJ DE diet combination) was removed during the finisher phase and carcass data were not collected from one pig (.765 – .707 g lysine/MJ DE diet combination) in Trial 2.
[c]*P*-values ≤ .10 are reported.

Table 6. Effects of grower and finisher diets on proportion of estimated carcass lean at 105.2 kg[ab]

Diet, g lysine/ MJ DE	Proportion of carcass lean, g/kg		
	Trial 1	Trial 2	Combined
Grower			
.421	474	540	507
.765	462	519	491
Finisher			
.421	462	510	486
.516	466	524	494
.612	474	537	505
.707	470	547	509
P-value[c]			
Grower	—	—	NA
Finisher			
Linear	—	—	NA
Quadratic	—	—	NA
Cubic	—	—	NA
Grower × finisher	—	—	NA
SEM			
Grower	4.9	11.3	5.9
Finisher	7.0	16.1	8.4

[a]Data for each of the individual trials and combined are presented because of the heterogeneity ($P < .05$) of variance between the two trials; least squares means were based on 16 and 8 individually fed pigs per diet for grower and finisher dietary treatments, respectively, for each trial, and 32 and 16 pigs per diet, respectively, for the combined; the final weight (105.2 ± 4.1 kg) was included in the model as a covariate.

[b]One pig (.421 – .516 g lysine/MJ DE diet combination) was removed during the finisher phase, and carcass data were not collected from one pig (.765 – .707 g lysine/MJ DE diet combination) in Trial 2.

[c]*P*-values ≤ .10 are reprted; NA = not applicable because of the heterogeneity of variance.

by the data for proportion of carcass lean. It is also possible that seasonal temperature variations associated with the naturally ventilated building may have contributed to the apparent differences observed between the two trials. Nevertheless, the responses of pigs to dietary treatments during the grower and finisher phases were similar and consistent for both trials.

The low-amino-acid grower diet designed to be deficient in lysine contained more amino acids than intended, but pigs fed the high-amino-acid diet grew 14.6% faster and 19.8% more efficiently during the grower phase than those fed the low-amino-acid grower diet. In addition, ultrasound backfat at the end of the grower phase was 14.0% less in pigs fed the high-amino-acid grower diet. These results agree with earlier reports (Campbell et al., 1985; Chiba et al., 1991b; Chiba, 1994) that the improved growth performance of grower pigs fed high-amino-acid diets is a result of a greater accretion of lean and less fat. The effort to depress growth performance of one group of pigs during the grower phase through amino acid restrictions was, therefore, successful.

The grower diet, however, had no clear effect on weight gain during the finisher phase. Consequently, pigs fed the high-amino-acid grower diet had better overall weight gain than those fed the low-amino-acid diet. The results are contrary to previous findings (Chiba, 1994, 1995) in which marginal amino acid restrictions during the grower phase did not affect the overall weight gain because of compensatory growth response in pigs subjected to early dietary restrictions. A similar compensatory response has been reported in pigs subjected to a marginal protein restriction during the starter (Zimmerman and Khajarern, 1973; Thaler et al., 1986) or grower (Wahlstrom and Libal, 1983) phase.

The importance of amino acid content of realimenting diets (Kyriazakis and Emmans, 1991) and energy intake in the subsequent phase (Campbell and Dunkin, 1983) on the ability of pigs to exhibit compensatory growth has been suggested. In the present research, a range of amino acid contents of finisher diets would have been broad enough to accommodate the pigs' amino acid needs if they had differential requirements according to their previous nutritional status. Likewise, the use of practical corn-soybean meal diets should not have been a limiting factor. Provided that all the indispensable amino acid requirements are satisfied, pigs can tolerate wide variations in the pattern of amino acids (Lewis, 1991), indicating that a moderate oversupply of some individual amino acids associated with a typical corn-soybean meal diet is not likely to have a clear effect on the performance of pigs, as mentioned before (Chiba et al., 1991a). In addition, energy intake of pigs in the present research may have been adequate because it averaged 43 MJ DE/d during the grower-finisher phase, compared with 39 to 41 MJ DE/d in the previous reports (Chiba, 1994, 1995).

Weight gain during the finisher phase was, however, not affected by the finisher diet. Although the efficiency of weight gain improved linearly as the lysine content of finisher diets increased, the response of pigs fed the diet with the highest lysine seemed to be primarily responsible for the increase during the finisher (287 to 291 vs 316 g/kg) or grower-finisher (303 to 306 vs 333 g/kg) phase. In addition, there was no grower × finisher diet interaction in the rate or efficiency of weight gain, implying that the finisher diet had no clear effect on these criteria. It is, therefore, unlikely that an inadequate amino acid intake, amino acid balance, or energy intake during the finisher phase limited the expression of compensatory weight gain in pigs subjected to early dietary restrictions. The reason for the difference in compensatory weight gain response between this and previous research is not clear.

To exhibit compensatory growth, pigs may need to have an adequate number of muscle fibers (Handel and Strickland, 1988). Early dietary restrictions may impede hyperplastic development of muscle tissues (Lodge et al., 1977; Campbell and Dunkin, 1983), and inadequate numbers of muscle fibers may reduce the upper limit of protein accretion in the subsequent phase (Campbell and Dunkin, 1983; Chiba, 1994). Thus, although pigs may have the ability to exhibit compensatory responses after a period of dietary restrictions, the compensation may not be complete as de Greef et al. (1992) indicated. Several investigators, however, reported that differences in body composition associated with early dietary restrictions were almost completely compensated by the time pigs reached market weight (Zimmerman and Khajarern, 1973; Campbell and Biden, 1978).

Although no evidence of compensatory weight gain was observed in pigs fed the low-amino-acid grower diet, there was no difference in the estimated lean accretion rate between the two groups. Furthermore, pigs fed the low-amino-acid grower diet had better carcass quality, as indicated by ultrasound backfat measured at the end of the finisher phase and longissimus muscle area. This contention is supported further by consistent numerical trends in average and 10th rib carcass backfat and proportion of carcass lean. These results agree with other reports (Nielsen, 1964; Wyllie et al., 1969; Chiba, 1995). It is, therefore, possible that the compensatory response of lean tissue growth may have occurred in pigs subjected to early amino acid restrictions at the expense of fatty tissue growth.

As the lysine content of finisher diets increased, average and 10th rib backfat decreased linearly, and the rate of lean accretion increased linearly. Similarly, the weight of liver and kidneys increased with an increase in the lysine content of finisher diets, even though the response of pigs fed the diet with the highest lysine seemed to be primarily responsible for the increases. There was, however, no grower × finisher diet interaction in these criteria.

In summary, pigs fed the high-amino-acid diet grew faster and more efficiently during the grower phase and had less ultrasound backfat at the end of the grower phase than those fed the low-amino-acid grower diet. The grower diet had no effect on weight gain during the finisher phase. Consequently, pigs fed the high-amino-acid diet had better overall weight gain than those fed the low-amino-acid diet. There was, however, no difference in the lean accretion rate in the two groups of pigs growing from 23.0 to 105.2 kg. In addition, pigs fed the low-amino-acid diet seemed to have better carcass quality than those fed the high-amino acid diet. Average and 10th rib backfat decreased linearly, and the rate of lean accretion increased linearly as the lysine content of the finisher diet increased, but there was no grower × finisher diet interaction. Although no evidence of compensatory weight gain was observed in pigs subjected to amino acid restrictions during the grower phase, it is possible that the compensatory response of lean tissue growth may have occurred at the expense of fatty tissue growth.

Implications

If pigs can achieve compensatory growth after a period of dietary restriction this will have a positive impact on the overall productivity and efficiency. Although overall weight gain was reduced, pigs subjected to dietary amino acid restrictions during the grower phase had a lean accretion rate similar to and carcass quality better than those fed the grower diet high in amino acids in the present research. Depending on the market incentive to produce lean pigs, there might be an opportunity to reduce feed costs and improve overall efficiency of pig production by early dietary restrictions.

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