

# Growth performance, dry matter and nitrogen digestibilities, serum profile, and carcass and meat quality of pigs with distinct genotypes<sup>1</sup>

J. Fabian<sup>2</sup>, L. I. Chiba<sup>3</sup>, D. L. Kuhlers, L. T. Frobish, K. Nadarajah, and W. H. McElhenney

Department of Animal Sciences, Auburn University, AL 36849-5415

**ABSTRACT:** We investigated the effect of distinct genotypes on growth performance, DM and N digestibilities, serum metabolite and hormonal profiles, and carcass and meat quality of pigs. Eight control-line and eight select-line pigs with an equal number of gilts and castrated males per genotype were chosen from the group of pigs subjected to selection for lean growth efficiency. Pigs were housed individually and allowed ad libitum access to common grower, finisher 1, and finisher 2 diets when they reached approximately 20, 50, and 80 kg, respectively, and water throughout the study. Although genotype had no effect on growth performance during the finisher 2 phase and overall, select-line pigs grew faster and more efficiently ( $P < 0.05$ ) during the grower and finisher 1 phases than did control-line pigs. Dry matter and N digestibilities during the grower phase were lower ( $P < 0.05$ ) in select-line pigs compared with control-line pigs. Select-line pigs had less ultrasound backfat ( $P < 0.05$ ) at the end of the grower and finisher 2 phases. Serum urea N ( $P < 0.05$ ) and leptin concentrations were lower in select-line pigs

than in control-line pigs, but the effect of genotype on serum glucose, triglyceride, or insulin concentration was rather inconsistent. Select-line pigs had heavier heart ( $P < 0.05$ ), liver ( $P = 0.08$ ), and kidneys ( $P < 0.01$ ), implying a higher metabolic activity. Less 10th-rib carcass backfat ( $P < 0.01$ ) and a trend for larger carcass longissimus muscle area ( $P = 0.10$ ) were reflected in the greater ( $P < 0.01$ ) rate and efficiency of lean accretion in select-line pigs. Select-line pigs had lower subjective meat color ( $P < 0.01$ ), marbling ( $P < 0.05$ ), and firmness ( $P < 0.01$ ) scores. Final serum leptin concentration was correlated positively with carcass backfat thickness ( $r = 0.73$ ;  $P < 0.01$ ) and negatively with overall feed intake ( $r = -0.77$ ;  $P < 0.01$ ). These results indicate that pigs with distinct genotypes exhibited differences in the growth rate, metabolite and hormonal profiles, and body composition. Further research is necessary to determine whether pigs with distinct genotypes respond differently to dietary manipulations, which would have an effect on developing optimal feeding strategies for efficient and sustainable pig production.

Key Words: Blood Composition, Carcass Quality, Genotypes, Growth Rate, Meat Quality, Pigs

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## Introduction

Selection of pigs for economically important traits over time has been an integral part of the survival and success of commercial pig production. Partly because of those selection efforts, wide variations in the pig's potential for growth and protein accretion con-

tinue to exist in today's pig industry. Pigs with distinct genotypes show differences in the mass of metabolically active organs (Koong et al., 1983; Pond et al., 1988), feed intake (Woltmann et al., 1992), activity of lipogenic enzymes (Steele and Frobish, 1976), concentrations of some metabolites (Pond et al., 1981, 1988) and hormones (Buonomo and Klindt, 1993), and metabolism of adipose tissues (Steele et al., 1974), indicating the physiological and metabolic changes taking place in pigs selected for specific traits.

To maximize economic efficiency, supplying nutrients as close as possible to meeting, but not exceeding, the requirements of the pig would be advantageous (Chiba, 2000). Understanding fully the differences in pigs with distinct genotypes is important in developing environmentally friendly, optimal feeding strategies for efficient and sustainable pig production. Most of the differences reported were, however, observed in pigs with extreme genotypes because of the direct

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<sup>2</sup>Present address: Babolna Feed, Ltd., P.O. Box 16, 2942 Nagygyomand, Hungary.

<sup>3</sup>Correspondence: 303C Ann S. Upchurch Hall (phone: 334-844-1560; fax: 334-844-1519; E-mail: lchiba@acesag.auburn.edu).

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selection for a particular trait in many studies, which may have little practical importance. The present study was conducted to investigate the effect of distinct genotypes on growth performance, DM and N digestibilities, serum metabolite and hormone profiles, and carcass and meat quality of pigs subjected to index selection for lean growth efficiency.

## Experimental Procedures

### *Animals and Facilities*

Pigs used in the present study were chosen from the group of Duroc pigs subjected to six generations of index selection for lean growth efficiency (Kuhlers et al., 1996). Selection was based on reduced real-time ultrasound 10th-rib backfat thickness and improved feed conversion using estimated breeding values. A control line of contemporary, randomly selected pigs was also maintained. Eight control line and eight select-line pigs (four gilts and four castrated males per genotype) weighing  $19.6 \pm 1.4$  kg were selected based on litter and weight and housed in individual pens ( $8.9 \text{ m}^2$ ) with solid-concrete floors. The number of pigs per genotype necessary to attain the desired precision was determined based on estimated coefficients of variation of 7 to 8% for growth performance up to 20% for carcass traits and expected treatment differences of 10 to 15% for growth performance up to more than 30% for carcass traits (Cochran and Cox, 1957). Pigs were allowed ad libitum access to feed and water throughout the study. Pig weight and feed consumption data were collected weekly. All pigs were slaughtered at the end of the study. The study was initiated in April and terminated in July. The protocol for animal care was approved by the Institutional Animal Care and Use Committee of Auburn University.

### *Diets*

Three corn-soybean meal-based diets were formulated to meet the NRC (1998) nutrient requirements (Table 1). The grower diet was offered from  $19.6 \pm 1.4$  to  $49.0 \pm 1.5$  kg, the finisher 1 diet from  $49.0 \pm 1.5$  to  $80.8 \pm 1.5$  kg, and the finisher 2 diet from  $80.8 \pm 1.5$  to  $104 \pm 3.8$  kg. Diets fed before and during the fecal collection period contained 0.25% chromic oxide. Feed samples collected from every batch of mixed diets were pooled, and subsamples were analyzed for DM, N or CP (AOAC, 1990), and amino acids (Chiba et al., 1991).

### *Ultrasound Measurements, Digestibility, and Blood Samples*

At the end of the grower phase and before slaughter, backfat thickness was measured 4 to 5 cm from the midline on the right side at the 10th rib using a real-time ultrasound instrument (SSD-500; Aloka Co.,

**Table 1.** Composition of diets on an as-fed basis<sup>a</sup>

Item	Grower	Finisher 1	Finisher 2
Ingredients, g/kg			
Corn	722.0	797.2	853.1
Soybean meal (48% CP)	252.4	179.7	125.2
Dicalcium phosphate	12.1	11.0	9.5
Limestone	8.0	6.6	6.7
Salt	3.5	3.5	3.5
Trace mineral-vitamin premix <sup>b</sup>	2.0	2.0	2.0
Calculated composition			
DE, MJ/kg	14.5	14.5	14.5
CP, g/kg	179.8	151.5	130.5
Lysine, g/kg	9.5	7.5	6.0
Ca, g/kg	7.0	6.0	5.5
P, g/kg	6.0	5.5	5.0
Analyzed composition, g/kg <sup>c</sup>			
CP	168.9	135.4	122.0
Lysine	8.1	6.0	5.3
Threonine	6.6	5.2	4.6
Isoleucine	6.0	4.8	4.3
Valine	6.9	5.5	5.2
Histidine	4.2	3.4	3.2

<sup>a</sup>Offered grower diet from  $19.6 \pm 1.4$  to  $49.0 \pm 1.5$  kg, finisher 1 diet from  $49.0 \pm 1.5$  to  $80.8 \pm 1.5$  kg, and finisher 2 diet from  $80.8 \pm 1.5$  to  $104.1 \pm 3.8$  kg.

<sup>b</sup>Provided the following (unit/kg): 90 mg of Zn, 80 mg of Fe, 32 mg of Mn, 10 mg of Cu, 0.4 mg of I, 0.3 mg of Se, 5,514 IU of vitamin A, 1,103 IU of vitamin D<sub>3</sub>, 24 IU of vitamin E, 2 mg of vitamin K activity (menadione sodium bisulfite complex), 26  $\mu$ g of vitamin B<sub>12</sub>, 4 mg of riboflavin, 18 mg of pantothenic acid, 26 mg of niacin, and 66 mg of choline.

<sup>c</sup>No analysis for sulfur amino acids and tryptophan.

Ltd., Wallingford, CT). Fecal samples from all pigs were collected before the end of grower ( $46.7 \pm 2.7$  kg) and finisher 2 ( $98.5 \pm 4.3$  kg) phases to determine apparent digestibility of DM and N using the indicator method (Lindahl, 1959). Pigs were fed diets containing chromic oxide for 4 d prior to and during the collection period, and fresh fecal grab samples were obtained once daily from each pig for two consecutive days. Samples from each pig for the 2-d collection period were pooled and stored at  $-20^\circ\text{C}$ . Fecal samples were thawed and dried at  $65^\circ\text{C}$  before grinding in a Wiley mill through a 1-mm screen. Feed and fecal samples were analyzed for DM and N, as described previously, and for chromium (Williams et al., 1962).

Three blood samples were taken from each pig at the beginning of the study (initial), at the end of the grower phase (grower), and before slaughter (final) via vena cava puncture using a sterile needle and a 10-mL evacuated tube. All samples were taken in the morning between 1000 and 1200. Serum was separated by centrifugation, and an aliquot was stored at  $-20^\circ\text{C}$  until analyzed for metabolites and hormones. Serum samples were analyzed for glucose, urea N, and triglycerides (Roche Diagnostics Systems, Inc., Nutley, NJ). Serum samples were also analyzed for hormones using commercially available RIA kits (Linco Research, Inc., St. Charles, MO) for insulin (porcine insulin RIA Kit, # PI-12K) and leptin (multi-species leptin RIA Kit, # XL-85K). For the insulin

analysis, the intraassay coefficient of variation in a single assay was 2.6%, whereas the intraassay and interassay coefficient of variations for the leptin analysis were 2.2 and 6.3%, respectively.

### Slaughter Procedures

At an average weight of  $104.1 \pm 3.8$  kg, pigs were slaughtered at Auburn University's meat laboratory using conventional procedures. To make a gross assessment of metabolic and/or physiological alterations, heart, liver, lungs, and kidneys were collected and weighed separately. The eviscerated carcass was split longitudinally through the vertebrae midline, and warm carcass weight was recorded. After chilling for 24 h at 2°C, the right side was weighed and midline backfat thickness at the first rib, last rib, and last lumbar vertebra was measured. To measure longissimus muscle area, the right side was exposed by a perpendicular cut between the 10th and 11th ribs. The longissimus muscle area was traced using acetate paper, and the subjective meat quality scores (color, firmness, and marbling) were assigned (NPPC, 1991). Backfat thickness at the 10th rib (about  $\frac{3}{4}$  distance along the longissimus muscle toward the belly) was also measured. The rate of carcass lean accretion was estimated by the equation reported by the NPPC (1991):

$$\text{Lean (kg/d)} = [(3.280 + 0.437\text{HCWT} + 0.2726\text{LMA} - 0.3348\text{BF}) - (0.418\text{IWT} - 1.656)]/\text{day}$$

where HCWT is hot carcass weight (kg), LMA is longissimus muscle area ( $\text{cm}^2$ ), BF is 10th rib backfat thickness (mm), IWT is initial weight (kg), and day is days on the study.

### Statistical Analysis

Data were analyzed as a generalized randomized block design (Chiba, 1994) using the GLM procedure of SAS (SAS Inst., Inc., Cary, NC). For the serum metabolite and hormone data, animals and sampling periods were also included in the model, and the treatment effect was tested using the animal effect as the error term. The initial and final weights were included in the model as covariates for the statistical analysis of the growth performance data, whereas the actual weight was used as a covariate for the ultrasound, nutrient digestibility, carcass, and internal organ weight data. To describe the relationship between serum leptin concentration and growth performance or carcass quality traits, residual correlation coefficients were estimated after fitting the model. The model included the effects of genotype, sex, and genotype  $\times$  sex interaction using the MANOVA option of the GLM procedure.

**Table 2.** Effect of genotype on growth performance and ultrasound backfat measurements at the end of the grower and finisher 2 phases<sup>ab</sup>

Item	Genotype		P-value	SEM <sup>c</sup>
	Control	Select		
<b>Grower</b>				
Feed intake, g/d	1,825	1,883	0.297	37
Weight gain, g/d	733	812	0.035	23
Gain:feed, g/kg	402	430	0.043	8
UBF, mm	9.0	7.2	0.021	0.5
<b>Finisher 1</b>				
Feed intake, g/d	2,725	2,816	0.406	74
Weight gain, g/d	804	931	0.027	34
Gain:feed, g/kg	296	330	0.020	9
<b>Finisher 2</b>				
Feed intake, g/d	3,057	3,187	0.676	200
Weight gain, g/d	851	862	0.852	36
Gain:feed, g/kg	287	266	0.434	17
UBF, mm	22.9	17.6	0.035	1.5
<b>Overall</b>				
Feed intake, g/d	2,500	2,551	0.581	60
Weight gain, g/d	803	851	0.229	25
Gain:feed, g/kg	323	332	0.499	9

<sup>a</sup>UBF = ultrasound backfat; feed intake is on an as-fed basis.

<sup>b</sup>Least squares means of eight individually housed pigs per treatment with an equal number of gilts and castrated males; the initial and final weights at each phase ( $19.6 \pm 1.4$  and  $49.0 \pm 1.5$  kg,  $49.0 \pm 1.5$  and  $80.8 \pm 1.5$  kg, and  $80.8 \pm 1.5$  and  $104.1 \pm 3.8$  kg for the grower, finisher 1, and finisher 2 phases, respectively) were included in the model as covariates, whereas the final weight at the end of the grower ( $49.0 \pm 1.5$  kg) or finisher 2 phase ( $104.1 \pm 3.8$  kg) was used as a covariate for the ultrasound backfat data.

<sup>c</sup>Pooled standard error of the mean.

## Results

### General

The results of chemical analysis indicated that the CP and lysine contents of the three diets were lower than expected (Table 1). The reason for the differences is not apparent. It could have been the lower CP content of an ingredient or ingredients because the relative differences between analyzed and calculated values were somewhat similar for most diets. The direct comparison of the results obtained in the present study and the results of published reports and/or recommendations, therefore, should be viewed with such differences in mind.

### Growth Performance and Ultrasound Backfat

Genotype had no effect on feed intake during the grower, finisher 1, finisher 2, or overall phase (Table 2). Select-line pigs grew faster ( $P < 0.05$ ) and more efficiently ( $P < 0.05$ ) during the grower phase and had less ultrasound backfat ( $P < 0.05$ ) at the end of the grower phase than did control-line pigs. Similarly, select-line pigs grew faster ( $P < 0.05$ ) and more efficiently ( $P < 0.05$ ) during the finisher 1 phase compared with control-line pigs. Although genotype had no effect on

**Table 3.** Effect of genotype on apparent digestibility of dry matter and nitrogen<sup>a</sup>

Item	Genotype		<i>P</i> -value	SEM <sup>b</sup>
	Control	Select		
Grower				
DM digestibility, %	87.3	83.6	0.017	0.9
N digestibility, %	82.3	77.1	0.026	1.3
Finisher 2				
DM digestibility, %	84.3	83.2	0.435	0.9
N digestibility, %	76.3	73.9	0.447	2.0

<sup>a</sup>Least squares means based on eight individually housed pigs per genotype with an equal number of gilts and castrated males during the grower (46.7 ± 2.7 kg) and finisher 2 (98.5 ± 4.3 kg) phases; the weight was included as a covariate in the model.

<sup>b</sup>Pooled standard error of the mean.

the rate and efficiency of weight gain during the finisher 2 phase, select-line pigs had less ultrasound backfat ( $P < 0.05$ ) than control-line pigs at the end of the finisher 2 phase. Despite the differences in growth performance observed during the grower and finisher 1 phases, genotype had no effect on the overall rate and efficiency of weight gain.

#### *Apparent Dry Matter and Nitrogen Digestibilities*

During the grower phase, select-line pigs had lower DM ( $P < 0.05$ ) and N ( $P < 0.05$ ) digestibilities compared with control-line pigs (Table 3). Genotype had no effect on DM or N digestibility during the finisher 2 phase.

#### *Serum Metabolites and Hormones*

Select-line pigs had lower serum urea N concentrations at the beginning ( $P < 0.05$ ) and at the end of the grower phase ( $P = 0.10$ ; Table 4), which resulted in a lower overall serum urea N concentration (10.9 vs. 13.7 mg/dL;  $P < 0.05$ ) compared with control-line pigs. Genotype × period interactions were observed for serum glucose ( $P < 0.05$ ), triglyceride ( $P < 0.01$ ), and leptin ( $P < 0.001$ ) concentrations. Select-line pigs had a numerically lower serum glucose concentration at the end of the grower phase, but they had a higher final glucose concentration than control-line pigs. Select-line pigs had a higher initial serum triglyceride concentration, but the effect of genotype was not clear at the end of the grower and finisher 2 phases. At the end of the grower phase, select-line pigs had less serum leptin than control-line pigs, and the magnitude of the difference became larger at the end of the finisher 2 phase. Select-line pigs tended to have lower initial insulin concentration ( $P = 0.10$ ) compared with control-line pigs, but the effect of genotype was not clear thereafter.

#### *Organ Weights, Carcass Traits, Lean Growth, and Meat Quality*

Metabolically active organs, heart ( $P < 0.05$ ), liver ( $P = 0.08$ ), and kidneys ( $P < 0.01$ ), were heavier in

select-line pigs compared with control-line pigs (Table 5). Select-line pigs had less 10th-rib backfat ( $P < 0.01$ ) and a tendency for a larger longissimus muscle area ( $P = 0.10$ ), both of which were reflected in their greater ( $P < 0.01$ ) rate and efficiency of estimated lean accretion compared with control-line pigs. Subjective meat color ( $P < 0.01$ ), marbling ( $P < 0.05$ ), and firmness ( $P < 0.01$ ) scores were lower in select-line pigs than control-line pigs.

#### *Correlation Coefficients*

The initial serum leptin concentration was negatively correlated ( $P < 0.05$ ) with carcass longissimus muscle area ( $r = -0.67$ ; Table 6). There was a positive correlation ( $P < 0.01$ ) between the final leptin concentration and carcass backfat thickness ( $r = 0.73$ ). On the other hand, the final leptin concentration was negatively correlated ( $P < 0.01$ ) with the overall daily feed intake ( $r = -0.77$ ). The final leptin concentration was also positively correlated with ultrasound backfat thickness at 50 kg ( $r = 0.69$ ;  $P < 0.01$ ) and with overall gain:feed ratio ( $r = 0.68$ ;  $P < 0.05$ ).

## Discussion

Considering lean accretion rates observed in the present study, it is unlikely that the genetic potential for growth in select-line pigs was limited by the lower analyzed content of CP or lysine in their diets (NRC, 1998). Although genotype had no effect on overall growth performance, select-line pigs grew faster and more efficiently during the grower and finisher 1 phases than control-line pigs. It is well known that protein or muscle accretion is greater during the earlier phase of growth. Therefore, the greater weight gain of select-line pigs during the early phases of the study may be a reflection of a greater rate of lean growth in those pigs. Select-line pigs had less carcass backfat and tended to have a larger longissimus muscle area, and consequently had greater estimated rate and efficiency of lean accretion compared with control-line pigs.

Pigs selected for obesity may reach compositional maturity at a younger age compared with lean pigs (Mersmann, 1991), implying that the rate of protein accretion would decrease and the rate of fat accretion would increase much earlier in obese pigs compared with lean pigs. It is, therefore, possible that pigs selected for lean growth efficiency may have reached compositional maturity later than control-line pigs, thereby explaining the differences in the rate and efficiency of lean growth observed in the present study. These results indicate that pigs with two distinct genotypes exhibited the difference in the growth rate in terms of weight gain during the grower and early finisher phases and lean accretion. The results of the present study also indicate that six generations of selection for lean growth efficiency was effective.

**Table 4.** Effect of genotype and period on serum metabolites and hormones<sup>a</sup>

Item	Urea N, mg/dL	Glucose, mg/dL <sup>b</sup>	TriG, mg/dL <sup>b</sup>	Insulin, μU/mL	Leptin, ng/mL
Initial					
Control	11.8	110.0	32.3	7.33	1.68
Select	9.5*	115.0	54.9***	4.85†	1.59
Grower					
Control	15.3	131.0	55.0	8.50	1.79
Select	11.5†	106.0	41.9	5.25	1.35*
Final					
Control	14.0	81.4	38.3	6.62	5.91
Select	11.8	101.0*	43.8	7.46	2.14***
<i>P</i> -value <sup>c</sup>					
Genotype	0.043	0.986	0.097	0.157	0.002
Period	0.002	0.010	0.365	0.763	0.001
Genotype × period	0.505	0.047	0.008	0.300	0.001
SEM <sup>d</sup>	0.7	8.7	5.2	1.37	0.35

<sup>a</sup>Least squares means based on eight individually housed pigs per genotype with an equal number of gilts and castrated males at the initial (initiation of the study at 19.6 ± 1.4 kg), grower (end of the grower phase at 49.0 ± 1.5 kg), and final (end of the finisher 2 phase at 104.1 ± 3.8 kg) periods. Genotype differences within the same time period: †*P* < 0.10, \**P* < 0.05, \*\**P* < 0.01, and \*\*\**P* < 0.001.

<sup>b</sup>TriG = triglycerides.

<sup>c</sup>*P*-values for the overall model.

<sup>d</sup>Pooled standard error of the mean.

Blood urea N concentration is directly related to the rate of urea synthesis, and is therefore a reflection of protein metabolism in animals. Blood urea N concentration can be inversely related to the efficiency of N utilization or lean growth (Coma et al., 1995), and its reduction is generally associated with an increase in

the efficiency of N (Berschauer et al., 1983) or lysine (Chiba et al., 1991) utilization. In the present study, select-line pigs had a lower serum urea N concentration compared with control-line pigs, implying that they utilized amino acids more efficiently for growth than control-line pigs.

Select-line pigs generally had heavier metabolically active organs than control-line pigs. Similarly, it has been reported that pigs selected for reduced backfat thickness and/or increased growth rate have heavier visceral organs (Pond et al., 1988; Cliplef and McKay, 1993). The difference in the size of metabolically active organs may be a reflection of the difference in rate of protein metabolism, and it may affect heat loss associated with maintenance (Ferrell, 1988) in pigs with distinct genotypes. Several investigators (Koonig et al., 1983; Tess et al., 1984) reported that the basal metabolic rate was lower in obese pigs than in lean pigs. The lower maintenance requirements, possibly because of less muscle mass and smaller digestive organs, coupled with similar or slightly greater feed intake, might be partly responsible for the observed obesity in the obese line pigs (Mersmann, 1991).

Unexpectedly, select-line pigs had lower DM and N digestibilities during the grower phase compared with control-line pigs. Potential maximal protein accretion and associated lean growth rate can determine the nutrient requirements for growth (Schinckel and de Lange, 1996; Whittemore, 1998), and a decrease in blood urea N can be associated with an increase in the efficiency of N or lysine utilization as indicated before. The greater lean growth rate of select-line pigs, along with their lower serum urea N concentrations, indicates that these pigs would have higher amino

**Table 5.** Effect of genotype on organ weights, carcass traits, estimated rate and efficiency of lean growth, and meat quality<sup>a</sup>

Item <sup>b</sup>	Genotype		<i>P</i> -value	SEM <sup>c</sup>
	Control	Select		
Organ weights				
Heart, g	299	342	0.034	12
Liver, g	1,359	1,459	0.084	35
Lungs, g	646	695	0.591	59
Kidneys, g	249	298	0.009	10
Carcass traits				
10th-rib BF, mm	30.8	21.7	0.004	1.7
LMA, cm <sup>2</sup>	30.0	32.8	0.100	1.1
Lean growth				
ADLG, g/d	233	273	0.010	9
LG:F, g/kg	94	107	0.005	2
Meat quality				
Color	2.31	2.00	0.007	0.07
Marbling	3.63	2.75	0.031	0.25
Firmness	3.19	2.50	0.006	0.15

<sup>a</sup>Least squares means based on eight individually housed pigs per genotype with an equal number of gilts and castrated males; the final weight (104.1 ± 3.8 kg) was included in the statistical model as a covariate.

<sup>b</sup>BF = backfat thickness; LMA = longissimus muscle area at the 10th rib; ADLG = average daily lean gain; LG:F = lean gain:feed ratio.

<sup>c</sup>Pooled standard error of the mean.

**Table 6.** Correlation coefficients (r) of error residuals between serum leptin concentrations and ultrasound backfat, carcass characteristics, or overall growth performance<sup>a</sup>

Item	Serum leptin <sup>b</sup>					
	Initial		Grower		Final	
	r	P-value <sup>c</sup>	r	P-value <sup>c</sup>	r	P-value
Ultrasound BF at 50 kg, mm	0.26	0.394	0.28	0.352	0.69	0.009
Ultrasound BF at Final, mm	-0.06	0.858	0.11	0.716	0.12	0.686
Carcass BF, mm	0.11	0.713	0.32	0.279	0.73	0.005
Carcass LMA, cm <sup>2</sup>	-0.67	0.012	-0.02	0.940	-0.13	0.674
Feed intake, g/d	-0.42	0.151	-0.32	0.292	-0.77	0.002
Weight gain, g/d	-0.15	0.616	0.09	0.765	0.01	0.986
Gain:feed, g/kg	0.18	0.558	0.34	0.252	0.68	0.011
ADLG, g/d	-0.30	0.313	-0.10	0.756	-0.16	0.591
LG:F, g/kg	-0.07	0.814	0.10	0.744	0.37	0.215

<sup>a</sup>BF = backfat thickness at the 10th rib; LMA = longissimus muscle area at the 10th rib; ADLG = average daily lean gain; LG:F = lean gain:feed ratio.

<sup>b</sup>Blood samples were collected at the initiation of the study ( $19.6 \pm 1.4$  kg) and at the end of the grower ( $49.0 \pm 1.5$  kg) and finisher 2 ( $104.1 \pm 3.8$  kg) phases.

acid requirements than control-line pigs. Yen et al. (1983) reported that there were no differences in N and energy digestibilities among lean, contemporary, and obese pigs. The obese pigs, however, retained less N than the contemporary and lean pigs, supporting the concept of higher amino acid requirements for pigs with the increased lean growth potential. Therefore, a decrease in N digestibility in select-line pigs would not be expected, especially when there was no difference in feed intake between the two lines of pigs. It is rather difficult to explain the results of the present study.

Metabolic differences among pigs with distinct genotypes can be expected in blood concentrations of metabolites and hormones. In his review, Mersmann (1991) indicated that some differences between obese and lean pigs are observed during the postnatal period, but the obese pigs do not seem to be hyperglycemic, hypertriglyceridemic, or hyperinsulinemic. In one study, serum glucose and triglyceride concentrations were generally lower in obese pigs than in lean or contemporary pigs, even though there were some variations (Pond et al., 1981). Although insulin would be expected to have a major endocrine influence on lipid metabolism, there is little evidence that an alteration in insulin concentrations or carbohydrate metabolism is playing a major role in the development of obesity in pigs (Mersmann, 1991). In the present study, there were some genotype differences and genotype  $\times$  period interactions in serum glucose, triglyceride, and insulin concentrations. It is not clear, however, whether those changes reflect differences in carbohydrate and lipid metabolism in response to the selection pressure for lean growth efficiency because of the inconsistency in the results obtained.

Leptin, a recently discovered protein synthesized and secreted by the adipose tissue, may act as a circulating signal of nutritional status to affect feed intake

and energy metabolism (Houseknecht et al., 1998; Barb, 1999), and the expression and secretion of this hormone may be related to the mass of body fat and the size of adipocytes (Houseknecht et al., 1998). In the present study, select-line pigs had 25 and 63% lower serum leptin concentrations at the end of the grower and finisher 2 phases than control-line pigs, but the corresponding ultrasound and carcass backfat thicknesses were lower by only 21 and 30%, respectively. Bünger et al. (1999) reported that the difference in plasma leptin concentration in mice was much larger than in any hormonal or other traits, including the direct selection responses.

The final leptin concentration was positively correlated with the carcass backfat thickness in the present study, which is in agreement with other reports (Ramsay et al., 1998; Robert et al., 1998; Cameron et al., 2000). There was also a negative relationship between the final leptin concentration and overall daily feed intake. It has been demonstrated that the administration of leptin can suppress feed intake in pigs (Barb et al., 1998). On the other hand, Cameron et al. (2000) reported that serum leptin was more highly correlated with fat deposition than with feed intake, indicating that the response in serum leptin in pigs selected for high or low daily feed intake was primarily due to increased fat deposition. As an indicator of fatness, therefore, circulatory leptin concentration may have a potential to be included in selection criteria for carcass leanness (Hossner, 1998; Cameron et al., 2000).

The relationships between lean growth and meat quality traits have not been well defined. In the present study, however, there was a clear indication that the selection for lean growth efficiency had negative impacts on meat quality. Select-line pigs had lower meat color and firmness scores, and had a tendency for a lower marbling score than control-line pigs. Similarly, using the fourth generation of the same two lines

of pigs at this station, Huff-Loneragan et al. (1997) reported a decline in pork quality in castrated males in the absence of the halothane gene. Longissimus muscles from select-line pigs had a lower water-holding capacity, a greater percentage of drip loss, and lower firmness scores and 24-h pH than those from control-line pigs. Similar results were obtained using the fifth generation of the same two lines of pigs (Huff-Loneragan et al., 1998). The results of the present study, along with the earlier data, indicate that the ultimate product quality has declined in select-line pigs, even though substantial improvements in lean growth efficiency and carcass quality have been made.

In summary, although genotype had no effect on overall growth performance, select-line pigs grew faster and more efficiently during the earlier phases of growth, which may have been a reflection of a greater lean growth in those pigs. Select-line pigs had superior carcass traits, which resulted in greater rate and efficiency of lean accretion compared with control-line pigs. In addition, select-line pigs seemed to utilize amino acids more efficiently for growth than control-line pigs, as was indicated by their lower serum urea N concentrations. Serum leptin concentrations were generally lower in select-line pigs, and the final leptin concentration was positively correlated with backfat thickness and negatively with overall daily feed intake. Select-line pigs had lower meat color, firmness, and marbling scores, indicating a decline in pork quality in pigs selected for lean growth efficiency.

### Implications

The results indicate that pigs with distinct genotypes exhibited differences in growth rate, serum profile, and body composition. Further research is necessary to determine whether pigs with distinct genotypes would respond differently to dietary manipulations. Wide variations in the potential of pigs for growth and protein retention continue to exist in the industry today, and the results of the present study may contribute to developing environmentally friendly, optimal feeding strategies for efficient and sustainable pig production.

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