2002

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Effects of dietary energy concentration during the grower period on the accuracy of determining lean gain potential during the finisher period for pigs selected during the grower period by either a lean gain formula or by plasma urea nitrogen concentration as an indicator of lean gain

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SWINE 2001-13

It is generally thought that pigs eat to satisfy their demand for energy and the amount of feed consumed is dependent on the energy density of the diet. Therefore, the amount of feed consumed when an energy-dense diet is fed will be lower than when a low energy diet is fed. Protein is the nutrient that is most frequently adjusted as energy density in the diet is changed. Energy intake influences the rates of deposition of lean and fat tissue. Nitrogen accretion is generally limited by voluntary intake of energy for pigs weighing less than 50 kg but not for pigs weighing over 50 kg body weight. When the rate of protein deposition reaches a plateau for a given gender and genotype of pig, further increases in energy intake result in an increased deposition of fat tissue. It is thought that lean gain/day is negatively correlated with plasma urea nitrogen (PUN) concentrations. In a diet with proper balance of amino acids, PUN levels will increase as the protein concentration of the diet exceeds the protein requirement of the pigs. Pigs with higher lean growth require a higher concentration of amino acids. When a group of pigs are fed a given protein concentration, pigs with a higher lean gain/day are expected to have lower PUN concentrations.

To maximize efficient production, there would be merit to sorting pigs by their lean gain potential enabling the producer to better match the nutritional needs of each genotype with the pig's ability to partition energy toward lean and away from fat deposition. The objective of this study was to evaluate the effect of energy concentration of the grower diet on the ability to sort pigs from a contemporary farrowing group based on high or low lean growth potential estimated by (a) lean gain/day (LGPD) based on the NPPC (1991) formula using gain and ultrasound measurements during the grower period or (b) PUN concentrations at the end of the grower period.

(Key Words: Lean growth, Pigs, Grower/finisher, Grower energy concentration.)

Experimental Procedure

Grower Phase, Selection Stage. One hundred sixty pigs (80 gilts and 80 barrows of a contemporary farrowing group) were allotted to grower diet treatments at an average initial weight of 32 kg. The basal diets (low energy, LE) fed to one half of each gender of pig were formulated to meet the nutrient requirements of high lean gain gilts and barrows for the second grower phase (UNL/SDSU Swine Nutrition Guide). Because energy is often a limiting factor for protein deposition in the grower phase, one half of the pigs were fed diets with 4% added animal fat (high energy, HE) supplemented with crystalline lysine to establish a consistent ratio of this most limiting amino acid to the caloric density for diets fed to a given sex. The grams of lysine/Mcal ME of the diet were 2.71 and 2.96 for barrows and gilts, respectively. Experimental diets are shown in Table 1 with calculated nutrient and energy concentrations.

During the grower phase, pigs were housed eight per pen on slatted floors in an environment-modified confinement building. Diets (HE and LE) were assigned randomly to pens within the two genders. Pigs were taken off test on a pen basis on the weigh day (7-day intervals) that an average body weight of 60 kg was attained within an individual pen. On that day, 10th rib fat depth and longissimus muscle area, determined by real-time ultrasound, were recorded. Lean gain per day with 5% fat was computed for each pig using the NPPC (1991) equation utilizing the ultrasound and gain information. Each pen that reached the target weight had feed withdrawn at 4:00 p.m. Feed was reintroduced at 9:00 a.m. the next day and pigs were bled by vena cava puncture 5 to 6

hours later. PUN concentrations were determined on individual pig plasma samples.

Pigs were then selected to continue on through the finisher period. Pigs within a sex group were retained from the pools of pigs that had received either HE or LE during the grower period if their LGPD was at least one standard deviation higher (HLG) or lower (LLG) than the mean. In the same manner, pigs were retained if their PUN concentrations were at least one standard deviation higher (LLG) or lower (HLG) than the mean PUN concentration within a sex and diet group. Although the pigs were fed together within gender groups during the finishing phase, the pigs selected were evaluated as two separate pools.

Finisher Phase, Evaluation Stage. Forty-nine pigs, selected by each of the selection criteria, were penned (three or four per pen) by weight and sex. All barrows were fed a diet containing 15% protein and all gilts were fed a diet containing 17% protein (Table 2). Feed and gain were recorded throughout the finisher period. Individual pigs were removed for slaughter on the weigh day (7-day intervals) on which the individual reached at least 100 kg body weight. Pigs were slaughtered, hot carcass weights were obtained, and, after a 24-hour chilling period, both sides of the carcass were measured to record longissimus muscle area and 10th rib fat. Lean gain/day (5% fat) for the finishing period was calculated from the gain and carcass data using the NPPC (1991) formula. The experiment was analyzed as a completely random design with gender (barrows or gilts), previous energy treatment (HE or LE), and lean gain selection (HLG or LLG) as the main effects. Pigs selected by the NPPC formula and pigs selected by PUN concentration were treated as two independent data sets and analyzed separately. Some individual pigs were represented in both data sets.

Results

Grower Phase, Selection Stage.
Performance of all pigs fed during the grower phase is summarized in Table 3. Gilts gained faster ($P<.05$), had a better feed efficiency ($P<.05$), had more longissimus muscle area ($P<.05$), and had more LGPD ($P<.01$). At 60 kg of body weight, no significant difference in 10th rib fat was detected by real-time ultrasound. The addition of 5% animal fat to the diet with concurrent lysine supplementation (HE) improved daily gain ($P<.001$) and feed efficiency ($P<.05$). Differences in carcass measurements and improvement in LGPD due to HE were not detected ($P>.10$). However, for pigs fed HE, PUN concentrations were lower ($P<.10$) which is consistent with higher LGPD.

Table 4 summarizes the grower performance of the pigs selected for LGPD based on the NPPC (1991) formula utilizing gain and real-time ultrasound measurements. Twenty-two pigs had calculated LGPD at least one standard deviation below the average of their gender groups (LLG). Twenty-seven pigs had LGPD at least one standard deviation above the average (HLG). Besides excelling in LGPD, the selected HLG group gained faster ($P<.001$), was leaner ($P<.001$), and had larger longissimus muscle area ($P<.001$) than the selected LLG group. Plasma urea nitrogen levels were not different between the two groups. Although gender differences in gain, longissimus area, and LGPD were detected within the total unselected population, within the selected pigs no gender differences ($P>.10$) were detected and the only effect of grower energy level was faster gain ($P<.05$) for the selected HE pigs.

Grower period performance of pigs selected for extremes in LGPD as estimated by PUN levels at the end of the grower period is summarized in Table 5. Twenty-four pigs were selected based on PUN concentrations that were at least one standard deviation below the average PUN concentration of all pigs within their gender within their energy treatment group (HLG). Twenty-five pigs were selected because of their high PUN concentrations (LLG). PUN concentrations of the pigs selected for LLG were approximately twice those of pigs selected for HLG. However, LGPD determined by formula was not different between the two groups ($P>.10$). Tenth rib fat was the only variable that was affected ($P<.001$). Within the selected pigs, gender had an effect on longissimus muscle area ($P<.001$) and PUN concentration ($P<.05$). Gender gain and LGPD were not different ($P>.10$) within the selected pigs in contrast to the differences observed for the entire population. Within the selected pigs, grower energy level affected 10th rib fat ($P<.001$) but not gain or LGPD ($P>.10$).

Finisher Phase, Evaluation Stage.
Performance of selected pigs during the finisher

stage is summarized for pigs selected by formula in Table 6 and by PUN concentration in Table 7. Selection group (HLG or LLG), gender (barrow or gilt), and grower energy level (HE or LE) were included in the model and the means of those main effects are included in the tables.

Selecting pigs based on the NPPC (1991) formula utilizing gain and ultrasound measurements (Table 6) from the grower period resulted in different LGPD during the finisher period ($P<.001$). All variables included in the LGPD formula, gain ($P<.10$), 10th rib fat ($P<.001$), and longissimus muscle area ($P.001$) were improved by grower period selection for HLG. Gender differences occurred across selection groups with barrows gaining faster ($P<.01$), exhibiting more 10th rib fat ($P<.001$) and less longissimus muscle area $P<.001$). Barrows also had lower LGPD than gilts ($P<.01$). Grower phase energy level had an effect ($P<.05$) on 10th rib fat, longissimus muscle area, and LGPD.

Selecting pigs for LGPD during the grower period based on PUN concentration (Table 7) resulted in differences in LGPD during the finisher period ($P<.01$). Gain was unaffected ($P<.10$) by selection group, but 10th rib fat was less ($P<.01$) and longissimus muscle area was greater ($P<.05$) for the HLG group. Gender differences ($P<.001$) in gain, 10th rib fat, longissimus muscle area, and LGPD for the finisher period were similar to those obtained with the formula method of selection. Energy level during the grower phase had an effect on final 10th rib fat ($P<.001$) only.

Both methods of selection of pigs for LGPD during the grower period resulted in greater LGPD during the finisher period. Based upon the success of both methods, one would expect that the same pigs would have been selected for retention for the finisher period evaluation by both methods. However, only five pigs selected to LLG by formula were selected to LLG by PUN concentration. Two pigs were selected to HLG by both methods. In addition, four pigs were selected to opposite lean gain groups (two in each direction). The other pigs (38 in each selection pool) were selected for retention by only one selection method. When examining the performance of selected pigs by the PUN method, it is evident that the major difference during the grower period between HLG and LLG selected pigs, besides PUN concentration, was the level of 10th rib fat. Pigs designated HLG by the PUN concentration method had the same calculated LGPD by formula as pigs designated LLG by the PUN concentration method. Gain was also the same for both PUN selected groups of pigs during both the grower and finisher periods.

For pigs selected by formula, contributions were made by gain, 10th rib fat, and longissimus muscle area to the LGPD selection of grower pigs since each was different between LLG and HLG groups. Pigs designated LLG and HLG by formula were not different in PUN concentration. Gain and carcass measurements were different for LLG and HLG during the finishing period and they contributed to the formula derived LGPD differences observed between selected groups. Although it was assumed that PUN concentration and LGPD derived by NPPC formula were inversely related, it is evident that there is little relationship during the grower period. The fact that, despite this lack of relationship, both PUN concentration and NPPC formula successfully selected growing pigs to groups which exhibited differences in LGPD during the finisher period is unexplained.

Summary

One hundred sixty pigs (80 barrows and 80 gilts) from a contemporary farrowing group were fed from an initial weight of 32 kg to an ending weight of 60 kg. Half of each gender group received a control diet and half received a diet with 4% added fat. At the end of the grower period individual pigs were retained if they had LGPD determined by the NPPC (1991) formula or PUN concentrations at least one standard deviation higher or lower than the mean for their respective gender and dietary treatment group. Forty-nine pigs were retained by each selection method. Pigs selected during the grower period by the NPPC formula and pigs selected by PUN concentration were treated as two independent data sets that were analyzed separately. Some individual pigs were represented in both data sets.

During the finisher period, all barrows were fed a diet containing 15% protein and all gilts were fed a diet containing 17% protein to at least 100 kg. Pigs were slaughtered, hot carcass weights were obtained and longissimus muscle area and 10th rib fat recorded. Lean gain/day (5% fat) for the finishing period was

calculated from the gain and carcass data using the NPPC (1991) formula. Lean gain/day, gain, 10th rib fat, and longissimus muscle area were improved by grower period selection for HLG by formula. Gender differences occurred across selection groups with barrows gaining faster with more 10th rib fat and less longissimus muscle area and lower LGPD than gilts. Grower phase energy level tended to have an effect on 10th rib fat, longissimus muscle area, and LGPD during the finisher period. Selecting pigs for HLG during the grower period based on PUN concentration also resulted in greater LGPD during the finisher period. Gain was unaffected by selection group, but 10th rib fat was less and longissimus muscle area was greater for the HLG group. Gender differences in gain, 10th rib fat, longissimus muscle area, and LGPD for the finisher period were similar to those obtained with the formula method of selection. Energy level during the grower phase had an effect on final 10th rib fat.

Implications

Evidence is provided that higher concentration of energy in the grower diet will lead to greater pig gain but not greater LGPD for the grower period and will not improve the effectiveness of selection of pigs for future LGPD by either NPPC formula or PUN concentration methods. Gilts exhibited greater LGPD than barrows during the grower period and the finisher period when selected by either method. The individual pigs from the same contemporary farrowing group assigned to LLG and HLG pools by the two selection methods during the grower period are largely different, providing little evidence for a relationship between LGPD as estimated by NPPC formula and LGPD as estimated by PUN concentration. However, both formula and PUN methods of selecting pigs for LGPD during the grower period for future LGPD proved effective when extremes were evaluated. It is unclear if the effectiveness would be maintained if pigs less than one standard deviation from the mean were retained in the selected pools.

TABLE 1. COMPOSITION OF GROWER DIETS (%)

	Barrows		Gilts	
Ingredient	LE	HE	LE	HE
Corn	72.82	66.80	70.02	63.35
Soybean meal, 44%	24.50	26.50	27.33	30.00
Fat, animal	0	4.00	0	4.00
Dicalcium phosphate	1.15	1.18	1.10	1.11
Limestone	.78	.77	.80	.79
Salt	.25	.25	.25	.25
Premix[a]	.50	.50	.50	.50
Total	100.00	100.00	100.00	100.00
Calculated nutrient content (%)				
Crude protein	17.00	17.40	18.00	18.60
Lysine	.89	.94	.97	1.03
Calcium	.65	.65	.65	.65
Phosphorus	.50	.50	.50	.50
Calculated energy				
ME, Mcal/kg	3.28	3.47	3.28	3.47
Lysine ME, g/Mcal	2.71	2.71	2.96	2.96

[a]Provided per kg of complete diet: 100 mg Zn, 75 mg Fe, 7.5 mg Cu, 25 mg Mn, 175 :g I, 1300 :g SE, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2 :g vitamin B_{12}, 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D_3.

TABLE 2. COMPOSITION OF FINISHER DIETS (%)

Ingredient	Barrows	Gilts
Corn	72.82	66.80
Soybean meal, 44%	24.50	26.50
Fat, animal	0	4.00
Dicalcium phosphate	1.15	1.18
Limestone	.78	.77
Salt	.25	.25
Premix[a]	.50	.50
Total	100.00	100.0
Calculated nutrient content, %		
Crude protein	17.00	17.40
Lysine	.89	.94
Calcium	.65	.65
Phosphorus	.50	.50
Calculated energy		
ME, Mcal/kg	3.28	3.47
Lysine:ME, g/Mcal	2.71	2.71

[a]Provided per kg of complete diet: 100 mg Zn, 75 mg Fe, 7.5 mg Cu, 25 mg Mn, 175 :g I, 1300 :g Se, 16.5 IU vitamin E, 3.3 mg riboflavin, 17.6 mg niacin, 13.2 :g vitamin B_{12} 2.2 mg vitamin K_3, 13.2 mg pantothenic acid, 3960 IU vitamin A, and 396 IU vitamin D_3.

TABLE 3. PERFORMANCE OF ALL PIGS DURING THE GROWER PHASE, SELECTION STAGE, SUMMARIZED BY GENDER AND GROWER DIETARY ENERGY LEVEL

	Gender			Energy level			
Item	Barrows	Gilts	P[b]	LE	HE	P	SE
Number of pigs	78	78		79	77		
Average daily gain, kg	.75	.79	*	.75	.79	***	.01
Daily feed intake, kg	1.73	1.64	ns	1.74	1.62	ns	.06
Gain/feed	.43	.48	*	.43	.48	*	.02
10th rib fat, cm	1.34	1.28	ns	1.30	1.32	ns	.04
Longissimus area, cm^{2a}	16.51	17.41	*	17.08	16.85	ns	.30
Lean gain per day, kg	**.27**	**.30**	**	**.29**	**.29**	**ns**	**.01**
Plasma urea N, mg/dL	**16.78**	**17.6**	**ns**	**17.79**	**16.60**	**+**	**.43**

[a]Gender x energy level interaction (P<.05).
[b]Probabilities within main effect: ns (P>.10), + (P<.10), * (P<.05), ** (P<.01), *** (P<.001).

TABLE 4. GROWER PHASE INFORMATION ON PIGS SELECTED FOR EXTREMES IN LEAN GAIN PER DAY DURING THE GROWER PHASE DETERMINED BY FORMULA BASED ON ULTRASOUND MEASUREMENTS AND GAIN

	Gender			Energy level			Selected[b]			
Item	Barrows	Gilts	P[a]	LE	HE	P	LLG	HLG	P	SD
Number of pigs	24	25		26	23		22	27		
Average daily gain, kg	.73	.78	ns	.73	.79	*	.66	.85	***	.10
10th rib fat, cm	1.34	1.30	ns	1.32	1.31	ns	1.63	1.01	***	.28
Longissimus area, cm^2	17.22	17.34	ns	17.76	16.82	ns	15.25	19.32	***	2.23
Lean gain per day, kg	**.27**	**.29**	**ns**	**.28**	**.29**	**ns**	**.21**	**.35**	***	**.04**
Plasma urea N, mg/dL	16.52	17.75	ns	16.72	17.55	ns	17.65	16.62	ns	3.42

[a]Probabilities within mean effect: ns (P>.10), * (P<.05), *** (P<.001).
[b]Selected by NPPC (1991) formula (5% fat) using weight gain and real-time ultrasound measurements. Pigs selected were at least one standard deviation below (LLG) or above (HLG) the mean value within sex and energy treatment for lean gain per day.

TABLE 5. GROWER PHASE INFORMATION ON PIGS SELECTED FOR EXTREMES IN LEAN GAIN PER DAY DURING THE GROWER PHASE DETERMINED BY PLASMA UREA NITROGEN CONCENTRATIONS

	Gender			Energy level			Selected[b]			
Item	Barrows	Gilts	P[a]	LE	HE	P	LLG	HLG	P	SD
Number of pigs	22	27		27	22		25	24		
Average daily gain, kg	.73	.75	ns	.73	.75	ns	.77	.72	ns	.10
10th rib fat, cm	1.22	1.33	ns	1.15	1.41	***	1.41	1.15	***	.27
Longissimus area, cm^2	14.76	17.85	***	16.23	16.39	ns	16.78	15.83	ns	2.89
Lean gain per day, kg	.26	.28	ns	.28	.27	ns	.27	.28	ns	.04
Plasma urea N, mg/dL	**17.40**	**18.34**	*	**18.25**	**17.49**	+	**23.60**	**12.14**	***	**1.55**

[a]Probabilities within mean effect: ns (P>.10), + (P<.10), * (P<.05), *** (P<.001).
[b]Selected by plasma urea nitrogen concentration. Pigs selected were at least one standard deviation below (LLG) or above (HLG) the mean value within sex and energy treatment for plasma urea nitrogen.

TABLE 6. FINISHER PHASE INFORMATION ON PIGS SELECTED FOR EXTREMES IN LEAN GAIN PER DAY DURING THE GROWER PHASE DETERMINED BY FORMULA BASED ON ULTRASOUND MEASUREMENTS AND GAIN

	Gender			Energy level[b]			Selected[c]			
Item	Barrows	Gilts	P[a]	LE	HE	P	LLG	HLG	P	SD
Number of pigs	24	25		26	23		22	27		
Average daily gain, kg	.94	.85	**	.89	.89	ns	.86	.92	+	.10
Hot carcass wt, kg	74.4	75.3	ns	74.8	74.9	ns	74.4	75.2	ns	2.47
10th rib fat, cm	2.52	1.84	***	2.09	2.28	*	2.52	1.84	***	.39
Longissimus area, cm^2	36.27	40.76	***	39.79	37.25	*	36.57	40.46	***	3.49
Lean gain per day, kg[d]	**.30**	**.35**	**	**.34**	**.31**	*	**.27**	**.38**	***	**.06**

[a]Probabilities within mean effect: ns (P>.10), + (P<.10), * (P<.05), ** (P<.01), *** (P<.001).
[b]Energy level was the same for all pigs within a gender during the finisher phase, HE and LE were fed during the previous grower phase, selection stage.
[c]Selected by NPPC (1991) formula (5% fat) using weight gain and real-time ultrasound measurements. Pigs selected were at least one standard deviation below (LLG) or above (HLG) the mean value within sex and energy treatment for lean gain per day.
[d]NPPC (1991) formula (5% fat).

TABLE 7. FINISHER PHASE INFORMATION ON PIGS SELECTED FOR EXTREMES IN LEAN GAIN PER DAY DURING THE GROWER PHASE DETERMINED BY PLASMA UREA NITROGEN CONCENTRATIONS

	Gender			Energy level[b]			Selected[c]			
Item	Barrows	Gilts	P[a]	LE	HE	P	LLG	HLG	P	SD
Number of pigs	22	27		27	22		25	24		
Average daily gain, kg	.92	.83	***	.86	.90	ns	.87	.88	ns	.09
Hot carcass wt, kg	74.4	74.9	ns	74.6	74.7	ns	74.8	74.5	ns	2.34
10^{th} rib fat, cm	2.62	1.91	***	2.03	2.50	***	2.42	2.10	**	.47
Longissimus area, cm^2	35.04	40.59	***	38.34	37.29	ns	36.55	39.08	*	4.26
Lean gain per day, kg	**.26**	**.34**	***	**.32**	**.29**	**ns**	**.28**	**.33**	**	**.06**

[a]Probabilities within mean effect: ns (P>.10), * (P<.05), ** (P<.01), *** (P<.001).
[b]Energy level was the same for all pigs within a gender during the finisher phase, HE and LE were fed during the previous grower phase, selection stage.
[c]Selected by plasma urea nitrogen concentration. Pigs selected were at least one standard deviation below (LLG) or above (HLG) the mean value within sex and energy treatment for plasma urea nitrogen.
[d]NPPC (1991) formula (5% fat).