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Optimal dietary energy and amino acids for gilt development: Growth, body composition, feed intake, and carcass composition traits

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Abstract
The objective of this study was to determine if body composition of developing gilts could be altered at the onset of estrus by ad libitum feeding diets differing in standard ileal digestible (SID) lysine and ME using levels that are within those used in practice by pig producers in the United States. Crossbred Large White × Landrace gilts (n = 1,221), housed in groups, were randomly allotted to 6 corn–soybean diets in a 2 × 3 factorial arrangement formulated to provide 2 SID lysine and 3 ME levels. Gilts received grower diets formulated to provide 0.86 (low) or 1.02% (high) SID lysine and 2.94 (low), 3.25 (medium), or 3.57 (high) Mcal of ME/kg from 100 d of age until approximately 90 kg BW. Then, gilts were fed finisher diets containing 0.73 (low) or 0.85% (high) SID lysine and 2.94 (low), 3.26 (medium) or 3.59 (high) Mcal of ME/kg until 260 d of age. The medium SID lysine and medium-ME diets were based on an informal survey from the U.S. commercial swine industry to obtain average levels that are currently being formulated for developing gilts. Gilts were weighed and backfat thickness and loin area were recorded at the beginning of the trial and then every 28 d. Feed intake (FI) was recorded as feed disappearance within the pen at 2-wk intervals. Lysine (g) and ME (Mcal) consumed were calculated based on diet formulations. At approximately 260 d of age, gilts were slaughtered and warm carcass weight and fat thickness were recorded. There were no differences between lysine or ME levels for growth and body composition, except for backfat, which was slightly greater for gilts fed a high-ME diet. Gilts fed high-ME diets had a lower FI but a greater ME intake compared with gilts fed low ME ($P < 0.05$). Additionally, gilts fed the high-ME diet had lower FI and lysine intake per kilogram of BW gain when compared with gilts fed low- or medium-ME diets ($P < 0.05$). However, there was no difference in the megacalories consumed per kilogram of BW gain among treatments ($P > 0.05$). Carcasses from gilts fed the high-ME diet were 3.3 and 2.5 kg heavier than those from gilts fed the low- or medium-ME diets ($P < 0.05$). Despite significant differences in the lysine:ME ratio in the diets, no changes in growth or body composition occurred, likely due to compensatory changes in FI in response to dietary ME content. Caloric efficiency (Mcal to deposit 1 kg of BW) was similar among treatments.

Keywords
body composition, carcass, feed intake, lysine, metabolizable energy, replacement gilts

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Optimal dietary energy and amino acids for gilt development: Growth, body composition, feed intake, and carcass composition traits[1]

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ABSTRACT: The objective of this study was to determine if body composition of developing gilts could be altered at the onset of estrus by ad libitum feeding diets differing in standard ileal digestible (SID) lysine and ME using levels that are within those used in practice by pig producers in the United States. Crossbred Large White × Landrace gilts (n = 1,221), housed in groups, were randomly allotted to 6 corn–soybean diets in a 2 × 3 factorial arrangement formulated to provide 2 SID lysine and 3 ME levels. Gilts received grower diets formulated to provide 0.86 (low) or 1.02% (high) SID lysine and 2.94 (low), 3.25 (medium), or 3.57 (high) Mcal of ME/kg from 100 d of age until approximately 90 kg BW. Then, gilts were fed finisher diets containing 0.73 (low) or 0.85% (high) SID lysine and 2.94 (low), 3.26 (medium) or 3.59 (high) Mcal of ME/kg until 260 d of age. The medium SID lysine and medium-ME diets were based on an informal survey from the U.S. commercial swine industry to obtain average levels that are currently being formulated for developing gilts. Gilts were weighed and backfat thickness and loin area were recorded at the beginning of the trial and then every 28 d. Feed intake (FI) was recorded as feed disappearance within the pen at 2-wk intervals. Lysine (g) and ME (Mcal) consumed were calculated based on diet formulations. At approximately 260 d of age, gilts were slaughtered and warm carcass weight and fat thickness were recorded. There were no differences between lysine or ME levels for growth and body composition, except for backfat, which was slightly greater for gilts fed a high-ME diet. Gilts fed high-ME diets had a lower FI but a greater ME intake compared with gilts fed low ME ($P < 0.05$). Additionally, gilts fed the high-ME diet had lower FI and lysine intake per kilogram of BW gain when compared with gilts fed low- or medium-ME diets ($P < 0.05$). However, there was no difference in the megacalories consumed per kilogram of BW gain among treatments ($P > 0.05$). Carcasses from gilts fed the high-ME diet were 3.3 and 2.5 kg heavier than those from gilts fed the low- or medium-ME diets ($P < 0.05$). Despite significant differences in the lysine:ME ratio in the diets, no changes in growth or body composition occurred, likely due to compensatory changes in FI in response to dietary ME content. Caloric efficiency (Mcal to deposit 1 kg of BW) was similar among treatments.

Key words: body composition, carcass, feed intake, lysine, metabolizable energy, replacement gilts

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INTRODUCTION

In the United States, approximately 54% of breeding sows are replaced annually (PigCHAMP, 2013) and gilts and first parity sows represent the largest proportion of removals. Efforts to improve sow longevity should be directed at replacement gilt management by providing adequate housing and feeding regimes to achieve optimum body composition as the gilt enters the breeding herd. Gilt development diets are often formulated to contain excess AA levels plus other nutrients to encourage maximal protein deposition (Rozeboom, 1999). However, according to Stalder (2007), the key for success in gilt development may be to slow down protein deposition and build fat reserves. Fat reserves could be manipulated by altering AA intake (Rozeboom, 2007). Inadequate availability of AA in the diet restricts lean tissue growth and redirects dietary energy into fat deposition (Voermans et al., 1994; Kitt, 2010). Conversely, energy intake can also affect the ratio between fat and protein deposition in pigs (De Greef, 1992). Baidoo (2001) stated that an appropriate gilt development diet should be either moderate in lysine (0.6%) with high energy (3.5 Mcal/kg) or high in lysine (1.31%) with moderate energy (3.2 Mcal/kg), but he also suggested that such diets should be limit fed, which is not a common practice in the pig industry.

There are few studies comparing gilt development diets fed ad libitum with large numbers of observations or in a commercial setting. The Animal Science Committee of the National Pork Board (Des Moines, IA) commissioned trials to determine the effects of ad libitum–fed gilt development diets on sow lifetime productivity. To determine development diet parameters for a long-term sow trial, this trial was designed to determine if body composition at initial estrus could be altered by ad libitum feeding of developer diets differing in energy and/or AA level. In 2012, a survey of the U.S. commercial swine industry was conducted by the National Pork Board to obtain average levels that are currently being fed to developing gilts in the United States. Results from the survey (Scientific Committee of the National Pork Board, Des Moines, IA) showed that U.S. pig producers consistently use higher values for standard ileal digestible (**SID**) lysine than, but values for ME similar to, those recommended by the NRC (2012) or the *National Swine Nutrition Guide* (Whitney and Masker, 2010). It was decided to investigate whether it is possible to manipulate body composition of developing gilts by ad libitum feeding diets differing in SID lysine and ME using values similar to those used in practice by pig producers in the United States. A secondary objective was to evaluate lysine and caloric efficiency between dietary treatments fed to developing gilts from 100 to 260 d of age.

MATERIALS AND METHODS

Care and Use of Animals

This study was approved by the Animal Care and Use Committee of the U.S. Meat Animal Research Center (Clay Center, NE) and was conducted in accordance with the *Guide for the Care and Use of Agricultural Animals in Research and Teaching* as issued by the Federation of Animal Science Societies (2010).

Crossbred Large White × Landrace gilts (n = 1,221) were used in this study. Maternal line gilts for this experiment originated from Murphy Brown LLC facilities in Milford, UT, from sows from parities 2 through 8. Gilts were moved at weaning to group housing (17 to 18 gilts per pen with a minimum 0.95 m^2 per gilt) in 2 naturally ventilated commercial wean–finisher barns at a Murphy Brown LLC facility in Goldfield, IA. Pens (2.3 m wide by 6.6 m long) used in the study had 63% of the area with solid concrete flooring in which a feeder with 4 feeding spaces was centrally positioned. The remaining area had concrete slat (slat width = 12.7 cm and space between slats = 2.5 cm) flooring. All gilts were fed common nursery and grower diets until placed on trial diets at approximately 100 d of age. Gilts were assigned to pens such that the littermates within each group of 6 littermates or less would not end up receiving the same dietary treatment. Pens (12 pens per diet, 36 pens per barn, and 72 pens on trial) were randomly assigned to 6 corn–soybean meal based diets in a 2 × 3 factorial arrangement that provided 2 SID lysine levels (100 [high lysine] and 85% [low lysine], the latter designed to reduce protein deposition) and 3 ME levels (90 [low ME], 100 [medium ME], and 110% [high ME]; Tables 1 and 2). The 100% ME and 100% lysine control diet was based on an average from an informal survey conducted by the National Pork Board to provide a consensus dietary lysine and ME content for gilt development diets commonly used by the U.S. swine industry.

The dietary levels were designed to restrict growth (85% lysine and 90% ME), to provide a control level of growth (100% lysine and 100% ME), and to have diets to alter the developing gilts body composition (i.e., imbalance of lysine and ME, designed to manipulate the lean to fat ratio). Gilts were provided ad libitum access to the diets in 2 phases. First, gilts received a grower diet (Table 1) from 100 d of age until they reached approximately 90 kg BW. Grower diets were formulated to provide 0.86% (2.92, 2.64, or 2.41 g/Mcal for the low-, medium-, and high-ME diets, respectively) or 1.02% SID lysine (3.47, 3.14, or 2.86 g/Mcal for the low-, medium-, and high-ME diets, respectively). Then, gilts were provided ad libitum access to a finisher diet (Table 2) until they were slaughtered at approximately 260 d of age.

Table 1. Experimental grower diets composition used to feed to maternal line[1] gilts to evaluate 2 Lys and 3 ME levels and determine their effects on growth and body composition, as-fed basis

Ingredient, %	85% Lys × 85% ME	85% Lys × 100% ME	85% Lys × 115% ME	100% Lys × 85% ME	100% Lys × 100% ME	100% Lys × 115% ME
Corn	38.98	56.48	60.56	37.86	56.33	59.81
Soy bean mean (47% CP)	19.30	24.90	26.30	20.50	24.90	26.30
Wheat middlings	30.00	0.00	0.00	30.00	0.00	0.00
Distiller's dried grains with solubles (8% fat)	7.55	15.00	3.35	7.30	15.00	3.90
AV[2] fat blend	0.50	0.75	6.75	0.50	0.70	6.75
Limestone	1.27	0.97	0.75	1.21	0.97	0.76
Dicalcium phosphate (18.5%)	1.35	1.01	1.34	1.44	1.01	1.33
L-Lys (98%)	0.13	0.04	0.05	0.30	0.24	0.26
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Methionine hydroxy analog, 84% dry	0.09	0.06	0.09	0.08	0.06	0.09
L-Thr	0.07	0.03	0.05	0.05	0.03	0.05
Sow trace mineral premix[3]	0.18	0.18	0.18	0.18	0.18	0.18
Sow vitamin premix[4]	0.05	0.05	0.05	0.05	0.05	0.05
Stafac 20[5]	0.03	0.03	0.03	0.03	0.03	0.03
Ronozyme P CT 10,000[6]	0.02	0.02	0.02	0.02	0.02	0.02
Chemically determined values, %						
CP	20.79	19.98	17.95	20.55	21.77	19.08
Ile	0.82	0.84	0.77	0.83	0.87	0.83
Lys	1.17	1.02	0.97	1.28	1.24	1.23
Met	0.32	0.34	0.28	0.31	0.33	0.30
Thr	0.80	0.78	0.70	0.81	0.82	0.79
Trp	0.25	0.21	0.20	0.26	0.24	0.22
Calculated values,[7] %						
CP	18.97	20.01	17.78	19.51	20.23	18.01
SID[8] Ile	0.41	0.57	0.52	0.44	0.57	0.53
SID Lys	0.86	0.86	0.86	1.02	1.02	1.02
SID Met	0.33	0.33	0.34	0.33	0.34	0.34
SID Thr	0.61	0.61	0.61	0.61	0.61	0.61
SID Trp	0.18	0.18	0.18	0.18	0.18	0.18
ME, Mcal/kg	2.94	3.25	3.57	2.94	3.25	3.57
SID Lys:ME, g/Mcal	2.92	2.64	2.41	3.47	3.14	2.86

[1]Maternal line is Large White × Landrace.

[2]AV = Animal- vegetable.

[3]Premix provided the following minerals per kilogram: 19 mg Mn, 77 mg Zn, 77 mg Fe, 12 mg Cu, 171 mg Se, 400 mg I, and 114 mg Cr.

[4]Premix provided the following vitamins per kilogram: 20,566,783 IU vitamin A, 2,932,099 IU vitamin D_3, 117,504 IU vitamin E, 73 mg vitamin B_{12}, 589 mg biotin, 9,700 mg menadione, 14,698 mg riboflavin, 58,790 mg d-pantothenic acid, 88,183 mg niacin, and 4,409 mg folic acid.

[5]Phibro Animal Health Corporation, Teaneck, NJ.

[6]Roche Vitamins Inc., Parsippany, NJ.

[7]Calculated using ME values for the ingredients obtained from the NRC (2012).

[8]SID = standard ileal digestible; calculated using SID coefficients for the various ingredients obtained from the NRC (2012).

Finisher diets were formulated to provide 0.73% (2.48, 2.20, or 2.0 g/Mcal for the low-, medium-, and high-ME diets, respectively) or 0.85% SID lysine (2.89, 2.60, or 2.37 g/Mcal for the low-, medium-, and high-ME diets, respectively). The formulated ME and SID AA content of the diets were estimated by multiplying the total amount of each ingredient by the ME and SID value for each ingredient obtained from the NRC (2012) and summing the values. Additionally, diets samples were sent to the University of Missouri Agricultural Experiment Station Chemical Laboratories (University of Missouri at Columbia, MO) for proximate analysis to determine AA concentrations in the diets.

In both the grower and finisher diet, the estimated SID lysine used was higher than SID lysine estimated requirements recommended by the NRC (2012) and the *National Swine Nutrition Guide* (Whitney and Masker, 2010). The NRC (2012) recommends 0.77 to 0.87% (2.32 to 2.59 g/Mcal) for gilts between 50 and 100 kg of BW and 0.64 to 0.77% (1.93 to 2.59 g/Mcal) for gilts above 100 kg of BW. Conversely, the *National Swine Nutrition Guide* (Whitney and Masker, 2010)

Table 2. Experimental finisher diets composition used to feed to maternal line[1] gilts to evaluate 2 Lys and 3 ME levels and evaluate their effects on growth and body composition, as-fed basis

Item	85% Lys × 85% ME	85% Lys × 100% ME	85% Lys × 115% ME	100% Lys × 85% ME	100% Lys × 100% ME	100% Lys × 115% ME
Corn	43.30	37.42	67.73	43.04	37.32	67.14
Soy bean mean (47% CP)	13.40	14.20	20.65	13.40	14.20	20.65
Wheat middlings	30.00	25.55	0.00	30.00	25.55	0.00
Distiller's dried grains with solubles (8% fat)	9.10	15.00	1.80	9.15	15.00	2.25
AV[2] fat blend	0.50	5.00	6.75	0.50	4.95	6.75
Limestone	1.19	1.28	0.72	1.09	1.28	0.73
Dicalcium phosphate (18.5%)	1.54	0.61	1.46	1.70	0.61	1.45
L-Lys (98%)	0.14	0.12	0.07	0.30	0.27	0.22
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Methionine hydroxy analog, 84% dry	0.03	0.03	0.03	0.03	0.03	0.03
L-Thr	0.04	0.03	0.03	0.04	0.03	0.03
Sow trace mineral premix[3]	0.18	0.18	0.18	0.18	0.18	0.18
Sow vitamin premix[4]	0.05	0.05	0.05	0.05	0.05	0.05
Stafac 20[5]	0.03	0.03	0.03	0.03	0.03	0.03
Ronozyme P CT 10,000[6]	0.02	0.02	0.02	0.02	0.02	0.02
Chemically determined values, %						
CP	18.2	18.72	16.64	18.06	18.88	16.72
Ile	0.74	0.72	0.68	0.69	0.75	0.71
Lys	1.05	0.97	0.92	1.08	1.13	1.04
Met	0.31	0.3	0.26	0.27	0.29	0.26
Thr	0.71	0.72	0.62	0.67	0.71	0.64
Trp	0.2	0.21	0.2	0.21	0.21	0.18
Val	0.89	0.87	0.77	0.84	0.91	0.8
Calculated values,[7] %						
CP	16.97	17.83	15.23	17.11	17.97	15.49
SID[8] Ile	0.31	0.36	0.40	0.31	0.36	0.41
SID Lys	0.73	0.73	0.73	0.85	0.85	0.85
SID Met	0.26	0.26	0.26	0.26	0.26	0.26
SID Thr	0.50	0.50	0.51	0.50	0.50	0.51
SID Trp	0.15	0.15	0.15	0.15	0.15	0.15
ME, Mcal/kg	2.94	3.26	3.56	2.94	3.26	3.56
SID Lys:ME, g/Mcal	2.48	2.23	2.03	2.89	2.60	2.37

[1]Maternal line is Large White × Landrace.

[2]AV = Animal-vegetable.

[3]Premix provided the following minerals per kilogram: 19 mg Mn, 77 mg Zn, 77 mg Fe, 12 mg Cu, 171 mg Se, 400 mg I, and 114 mg Cr.

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[5]Phibro Animal Health Corporation, Teaneck, NJ.

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[7]Calculated using ME values for the ingredients obtained from the NRC (2012).

[8]SID = standard ileal digestible; calculated using SID coefficients for the various ingredients obtained from the NRC (2012).

recommends 0.74 to 0.92% (2.22 to 2.74 g/Mcal) for gilts between 50 and 100 kg and 0.56 to 0.74% (2.0 to 2.22 g/Mcal) for gilts above 100 kg. However, the medium ME levels, which were used as the control diet, were the same values recommended by both the NRC (2012) and the *National Swine Nutrition Guide* (Whitney and Masker, 2010). Gilts had ad libitum access to water via a nipple drinker in each pen.

Additionally, starting at 160 d of age, gilts were exposed daily to vasectomized boars and observed for behavioral estrus. At approximately 260 d of age, gilts were slaughtered and their reproductive tract was collected. Each reproductive tract was examined to determine whether the gilt was cyclic, the stage of estrous cycle, the ovulation rate, the uterine length, and the ovary length and width (data not shown; results presented in a companion submitted manuscript). Gilts were slaughtered at 260 d to provide all gilts with opportunity to cycle naturally.

Measurements

Body Composition. Gilts were individually weighed using a digital scale (Digi-Star SW4600EID Digital RFID, VID Recording scale; Digi-Star LLC, Fort Atkinson, WI) and backfat thickness and loin eye area were measured at the 10th rib using real-time ultrasound PIE Medical – Aquila apparatus with a 18-cm science probe (Pie Medical Equipment B.V., Maastricht, Netherlands). Images were captured by a trained technician using Sensoray 2225 and stored and interpreted using the Biosoft Toolbox II for Swine (Biotronics Inc., Ames, IA) at 100 d of age and then every 4 wk until slaughter. The last on-farm data collection was when gilts were approximately 250 d of age. Fat free lean meat content was calculated using the following equation (adapted to metric units) developed by the National Pork Board (2000) for live hogs using real–time ultrasound: 0.379 × [sex of the pig (barrow = 1 and gilt = 2)] – [0.649 × 10th rib fat depth (mm)] + [0.841 × 10th rib loin muscle area (cm^2)] + [0.132 × live BW (kg)] – 0.243.

Table 3 shows the descriptive statistics for the measurements recorded at the beginning of the trial (i.e., 100 d of age).

Feed Intake and Feed Efficiency Traits. Feed intake (**FI**) was recorded as the feed disappearance per pen every 2 wk. Lysine (g) and ME (Mcal) consumed every 2 wk were calculated by multiplying the formulated dietary lysine and ME content by the feed consumed (kg). Additionally, average daily feed, lysine, and ME intake per pig were calculated by dividing the total FI and lysine and ME intake by the number of pig days (i.e., number of pigs in the pen multiplied by the number of days each pig remained in the pen) per pen. Average daily gain was calculated for each 4-wk interval. Furthermore, feed, lysine, and ME intake per kilogram of BW gain were calculated.

Gilts Removed from Trial. Reasons for gilt removals (including sick animals that needed to be moved to a sick pen, culling, and deaths) from the study were based on decisions made by the trial manager at the wean–finisher facility and were retrospectively acquired from the farm records.

Carcass Traits. Warm carcass weight and fat thickness were recorded by the personnel of Natural Products Holding harvesting plant (Sioux Center, IA). Fat thickness was measured at the 10th rib using a stainless steel ruler in a 7-point scale in increments of 0.2 cm from 0.39 to 1.4 cm. To calculate fat free lean meat, the center value for each fat thickness category was used. Fat free lean meat content was calculated using the following equation developed by the National Pork Board (2000) for unribbed carcasses using last rib backfat thickness measured with a stainless steel ruler: 23.568 – [21.348 × last rib fat depth (cm)] + [0.503 × warm carcass weight (kg)]. Body weight at slaughter was estimated as follows: BW at 250 d + (ADG from 220 to 250 d × number of days from last weight to slaughter). To calculate dressing percentage, as the real BW at slaughter was not available and to avoid an overestimation, data for gilts that were within ± 2 SD of the mean dressing percentage were used for the analysis.

Statistical Analysis

Pen was considered the experimental unit. Predicted variables were evaluated for normality using the Shapiro-Wilk test and examining the normal plot. Data were analyzed using mixed model equation methods (SAS version 9.4 PROC MIXED; SAS Inst. Inc., Cary, NC). Models for body composition, FI, and feed efficiency included lysine and ME content, data recording day, and their interactions as fixed effects. Body weight at the beginning of the study (i.e., at 100 d of age) was used as a linear covariate in the models to account for the fact that not all gilts started the trial at the exact BW. The model for carcass traits included lysine and ME content and their interactions as fixed effects and BW at slaughter was included as a linear covariate. Pen within lysine × ME level × barn was included as a random effect for all the traits analyzed. Statistical differences were reported when model source of variation was $P \leq 0.05$. When a main effect was a significant source of variation, levels from each main effect were separated using the PDIFF option and a Tukey–Kramer adjustment was used to account for multiple comparisons between levels. Results for fixed effects are reported as least-square means ± SE. Results for continuous variables are reported as the regression coefficient (**REG**) ± SE.

Gilt Removed from Trial. Reasons for removing gilts from trial were analyzed using a χ^2 test (SAS version 9.4 PROC FREQ; SAS Inst. Inc.).

RESULTS

One hundred thirty-five gilts (11%) were removed from the experiment before reaching slaughter at 260 d. Forty-three gilts died, and 92 gilts were removed for health or other reasons. The most common causes for removal was leg problems (73.9%); 11.9% did not have a record for removal reason, and the other 14.1% of gilts were removed for several reasons including prolapses, aggression injuries, and respiratory problems. However, there was no difference among dietary treatments in the total number of gilts removed or the number of gilts removed for each removal reason (Table 4).

Table 3. Descriptive statistics for BW, backfat thickness, loin area, and fat free lean meat content of maternal line[1] gilts fed 2 Lys levels and 3 ME levels and their interaction beginning 100 d of age

	BW, kg				Backfat thickness, mm				Loin area, cm^2				Fat free lean meat, kg			
Dietary treatment	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
Lys																
85% Lys[2]	55.0	7.0	35.5	75.5	8.6	1.5	5.1	15.0	19.5	2.9	11.5	26.8	21.4	2.8	13.6	29.8
100% Lys[3]	55.6	7.1	34.1	76.8	8.7	1.6	4.3	15.0	19.5	2.9	11.3	27.3	21.5	2.7	12.8	30.0
ME																
90% ME[4]	55.1	7.3	34.1	76.8	8.5	1.5	5.1	13.0	19.3	2.9	11.3	26.9	21.2	2.8	12.8	30.0
100% ME[5]	55.2	7.2	36.4	75.9	8.7	1.6	4.3	13.2	19.6	2.9	12.3	27.3	21.5	2.8	14.4	29.8
110% ME[6]	55.7	6.7	35.5	72.3	8.9	1.6	4.8	15.0	19.7	2.7	11.5	26.2	21.6	2.6	13.6	27.6
Lys × ME																
85% Lys × 90% ME[7]	56.0	7.0	37.7	76.8	8.4	1.6	5.1	12.4	19.3	19.3	3.0	12.2	21.3	2.8	14.4	30.0
85% Lys × 100% ME[8]	55.2	7.3	39.1	75.9	8.7	1.6	5.3	13.2	19.5	19.5	3.0	12.3	21.4	2.8	15.5	28.8
85% Lys × 110% ME[9]	55.5	6.9	35.5	71.4	9.0	1.6	5.6	15.0	19.8	19.8	2.7	11.5	21.7	2.6	13.6	27.6
100% Lys × 90% ME[10]	54.2	7.4	34.1	71.8	8.5	1.5	5.3	13.0	19.4	19.4	2.9	11.3	21.2	2.8	12.8	27.6
100% Lys × 100% ME[11]	55.2	7.0	36.4	75.5	8.6	1.6	4.3	13.2	19.7	19.7	2.9	12.3	21.6	2.8	14.4	29.8
100% Lys × 110% ME[12]	55.8	6.6	40.0	72.3	8.8	1.5	4.8	15.0	19.6	19.6	2.8	11.8	21.6	2.7	14.7	27.3

[1]Maternal line is Large White × Landrace.
[2]Grower diet: 0.85% standard ileal digestible (SID) Lys; finisher diet: 0.73% SID Lys.
[3]Grower diet: 1.02% SID Lys; finisher diet: 0.85% SID Lys.
[4]Grower diet: 2.94 Mcal of ME; finisher diet: 2.94 Mcal of ME.
[5]Grower diet: 3.25 Mcal of ME; finisher diet: 3.26 Mcal of ME.
[6]Grower diet: 3.56 Mcal of ME; finisher diet: 3.59 Mcal of ME.
[7]Grower diet: 0.85% SID Lys × 2.94 Mcal of ME; finisher diet: 0.73% SID Lys × 2.94 Mcal of ME.
[8]Grower diet: 0.85% SID Lys × 3.25 Mcal of ME; finisher diet: 0.73% SID Lys × 3.26 Mcal of ME.
[9]Grower diet: 0.85% SID Lys × 3.56 Mcal of ME; finisher diet: 0.73% SID Lys × 3.59 Mcal of ME.
[10]Grower diet: 1.02% SID Lys × 2.94 Mcal of ME; finisher diet: 0.85% SID Lys × 2.94 Mcal of ME.
[11]Grower diet: 1.02% SID Lys × 3.25 Mcal of ME; finisher diet: 0.853% SID Lys × 3.25 Mcal of ME.
[12]Grower diet: 1.02% SID Lys × 3.56 Mcal of ME; finisher diet: 0.85% SID Lys × 3.59 Mcal of ME.

Growth and Body Composition

Least square means for growth and body composition are presented in Table 5. There was no difference ($P > 0.05$) in BW, loin muscle area, and fat free lean meat between lysine or among ME content and their interaction. Backfat thickness did not differ ($P > 0.05$) with lysine content in the diet. There was a statistical difference ($P < 0.05$) in backfat thickness among ME levels. However, the biological significance for those differences remains questionable because the backfat difference between the low-ME and high-ME diets was only 2.2 mm. As expected, as time progressed, BW, backfat thickness, loin muscle area, and fat free lean meat increased across treatments. The BW at 100 d covariate was significant, indicating that gilts with heavier BW at 100 d of age were heavier throughout the study (REG = 1.18 ± 0.27; $P < 0.05$). The interaction between lysine or ME level × measuring date was not statistically significant for any of the traits recorded ($P > 0.05$).

Feed Efficiency Traits

Lysine content in the diet had no effect on ADG, FI, and ME intake per kilogram of BW gain ($P > 0.05$). Gilts fed a low-lysine diet

Table 4. Number of maternal line gilts[1] removed from a study comparing 2 Lys and 3 ME levels and their interaction for gilt development diets fed from 100 to 250 d of age

	Lys		ME			Lys × ME					
Removal reason	85% Lys[2]	100% Lys[3]	90% ME[4]	100% ME[5]	110% ME[6]	85% Lys × 90% ME[7]	85% Lys × 100% ME[8]	85% Lys × 110% ME[9]	100% Lys × 90% ME[10]	100% Lys × 100% ME[11]	100% Lys × 110% ME[12]
Aggression injuries	0	1	0	0	1	0	0	0	0	0	1
Back problems	0	3	1	1	1	0	0	0	1	1	1
Sudden death	21	22	14	15	14	7	5	9	7	10	5
Euthanized	2	1	0	2	1	0	2	0	0	0	1
Leg problems	28	40	21	24	23	8	10	10	13	14	13
Prolapse	0	4	1	1	2	0	0	0	1	1	2
Rectum injury	1	0	1	0	0	1	0	0	0	0	0
Respiratory problems	1	0	0	1	0	0	1	0	0	0	0
Unknown	5	6	3	4	4	2	2	1	1	2	3

[1]Maternal line is Large White × Landrace; n = 1,222.

[2]Grower diet: 0.85% standard ileal digestible (SID) Lys; finisher diet: 0.73% SID Lys.

[3]Grower diet: 1.02% SID Lys; finisher diet: 0.85% SID Lys.

[4]Grower diet: 2.94 Mcal of ME; finisher diet: 2.94 Mcal of ME.

[5]Grower diet: 3.25 Mcal of ME; finisher diet: 3.26 Mcal of ME.

[6]Grower diet: 3.56 Mcal of ME; finisher diet: 3.59 Mcal of ME.

[7]Grower diet: 0.85% SID Lys × 2.94 Mcal of ME; finisher diet: 0.73% SID Lys × 2.94 Mcal of ME.

[8]Grower diet: 0.85% SID Lys × 3.25 Mcal of ME; finisher diet: 0.73% SID Lys × 3.26 Mcal of ME.

[9]Grower diet: 0.85% SID Lys × 3.56 Mcal of ME; finisher diet: 0.73% SID Lys × 3.59 Mcal of ME.

[10]Grower diet: 1.02% SID Lys × 2.94 Mcal of ME; finisher diet: 0.85% SID Lys × 2.94 Mcal of ME.

[11]Grower diet: 1.02% SID Lys × 3.25 Mcal of ME; finisher diet: 0.853% SID Lys × 3.25 Mcal of ME.

[12]Grower diet: 1.02% SID Lys × 3.56 Mcal of ME; finisher diet: 0.85% SID Lys × 3.59 Mcal of ME.

consumed 5 g of lysine less per kilogram of BW compared with gilts fed a high-lysine diet ($P < 0.01$; Table 6). Average daily gain and ME intake per kilogram of BW gain did not differ among ME content in the diets. Gilts fed the low-ME diet consumed 0.34 and 0.72 kg more feed per kilogram of BW gain than gilts on the medium-ME and high-ME diet, respectively ($P < 0.05$). Additionally, gilts fed the low-ME diet consumed 2.7 and 5.7 g more lysine per kilogram of BW gain than gilts fed the medium-ME and high-ME diets, respectively ($P < 0.05$). There was no lysine × ME content interaction ($P > 0.05$) for any of the feed efficiency traits recorded. Average daily gain decreased as the trial progressed ($P < 0.05$) and feed, lysine, and ME intake per kilogram of BW gain increased approximately 2.5 times from 100 to 250 d across treatments ($P < 0.05$; Table 6). Average daily gain decreased (REG = –0.003 ± 0.001; $P < 0.05$) and lysine and ME intake per kilogram of BW gain increased with every increase of 1 kg at 100 d of age (REG = 0.14 ± 0.04 and REG = 57.0 ± 15.77, respectively; $P < 0.05$).

Feed Intake Traits

Gilts fed the low-ME diet had 7.3 and 14.9 kg greater feed consumption and 0.06 and 0.12 kg greater lysine consumed than gilts fed medium-ME and high-ME diets, respectively ($P < 0.05$). However, in spite of the greater FI, gilts fed the low-ME diet consumed fewer megacalories across the experiment and had lower average daily ME intake than gilts fed the medium-ME and high-ME dietary treatments ($P < 0.05$). Additionally, ADFI and average daily lysine intake were greater ($P < 0.05$) for gilts fed the low-ME diet compared with gilts fed the medium-ME and high-ME diets. There was no lysine treatment effect ($P > 0.05$) for FI, ME intake, ADFI, and average daily ME intake. Unsurprisingly, gilts fed a high-lysine diet had a greater total lysine intake ($P < 0.05$) and a greater average daily lysine intake ($P < 0.05$) compared with gilts fed the low-lysine diet. Overall, FI traits increased from 100 to 190 d on trial and decreased by 250 d ($P < 0.05$; Table 7). Feed intake increased with every increase in 1 kg of BW at 100 d of age (REG = 0.27 ± 0.04; $P < 0.05$).

Carcass Traits

There was no difference between lysine levels for any carcass measures evaluated ($P > 0.05$). Warm carcass weight and fat free lean meat were greater for gilts fed the high-ME diet when compared with gilts fed the low- or medium-ME diet ($P < 0.05$). There was a statistical difference for fat thickness ($P < 0.05$) with gilts fed the high-ME diet being fatter at slaughter than the gilts fed the low- or medium-ME diets (Table 8). Also, dressing percentage was 1.1 and 0.9% higher for gilts fed the high-ME diet than for gilts fed the low- or

Table 5. Average BW and body composition (least square means [LS mean] ± SEM) for different periods between 130 and 250 d of age of maternal line[1] gilts fed 2 Lys and 3 ME levels from 100 d of age until slaughter

	Lys			ME			
	85%[2]	100%[3]		90%[4]	100%[5]	110%[6]	
Traits	LS mean	LS mean	SEM	LS mean	LS mean	LS mean	SEM
BW, kg		*			NS[7]		
130 d	84.5[a†]	85.9[a†]	1.3	84.8	85.9	85.0	1.6
160 d	113.5[b†]	113.5[b†]	1.3	112.7	114.0	113.8	1.6
190 d	142.4[c†]	143.5[c†]	1.3	142.5	143.0	143.3	1.6
220 d	166.1[d†]	169.3[d†]	1.3	167.5	168.2	167.4	1.6
250 d	186.8[e†]	192.8[e†]	1.3	187.8	190.8	190.9	1.6
Backfat thickness, mm		NS			*		
130 d	11.0	11.2	0.3	10.5[a†]	11.3[a†]	11.5[a†]	0.4
160 d	14.6	14.6	0.3	13.5[b†]	14.6[b‡]	15.7[b‡]	0.4
190 d	19.5	19.5	0.3	18.4[c†]	19.2[b†]	20.9[c‡]	0.4
220 d	26.0	26	0.3	25.1[d†]	25.4[d†]	27.4[d‡]	0.4
250 d	31.5	31.3	0.4	30.3[e†]	31.0[e†]	32.9[e‡]	0.4
Loin area, cm^2		NS			NS		
130 d	28.5	29.7	0.4	29	29.4	28.9	0.5
160 d	35.8	36.4	0.4	35.8	36.7	35.9	0.5
190 d	41.9	42.3	0.4	41.8	42.7	41.8	0.5
220 d	46.5	46.7	0.4	46.6	46.8	46.3	0.5
250 d	50.5	50	0.4	50.3	50.7	49.7	0.5
Fat free lean meat, kg		NS			NS		
130 d	32.4	33.4	0.5	32.9	33.2	32.6	0.6
160 d	42.1	42.7	0.5	42.3	42.9	42.1	0.6
190 d	51.0	51.6	0.5	51.1	51.9	50.9	0.6
220 d	57.0	57.4	0.5	57.5	57.2	56.9	0.6
250 d	61.9	61.5	0.5	61.7	62.2	61.1	0.6

[a–e]Within columns, significant difference between periods ($P < 0.05$).

[1]Maternal line is Large White × Landrace.

[2]Grower diet: 0.85% SID Lys; finisher diet: 0.73% SID Lys.

[3]Grower diet: 1.02% SID Lys; finisher diet: 0.85% SID Lys.

[4]Grower diet: 2.94 Mcal of ME; finisher diet: 2.94 Mcal of ME.

[5]Grower diet: 3.25 Mcal of ME; finisher diet: 3.26 Mcal of ME.

[6]Grower diet: 3.56 Mcal of ME; finisher diet: 3.59 Mcal of ME.

[7]Nonsignificant (NS) effect of predictor variables Lys and ME by period ($P > 0.05$).

†Within rows, significant differences between predictor variables Lys and ME ($P < 0.05$).

*Significant effect of the interaction between predictor variables Lys and ME by period ($P < 0.05$).

medium-ME diet, respectively ($P < 0.05$). Additionally, there was a lysine × ME interaction effect on dressing percentage where gilts fed the high-ME diets had a higher dressing percentage irrespective of the lysine level in the diet ($P < 0.05$). Warm carcass weight, fat free lean meat, and fat thickness increased and dressing percentage decreased for every increase of 1 kg of calculated BW at slaughter, respectively ($P < 0.05$).

DISCUSSION

Eleven percent of the gilts were removed from this study. Our findings for removal percentage may appear high but are even lower than those reported by Calderón Díaz et al. (2013), Lucia et al. (2000), and Knauer et al. (2011), when the proportion of gilts removed was 15, 19, and 28%, respectively. Seventy-three percent were removed due to leg problems and this finding agrees with those reported elsewhere for sows and gilts where leg problems is listed as one of the main reasons for removal (D'Allaire et al., 1987; Boyle et al., 1998; Engblom et al., 2007). Leg conformation was scored when gilts were approximately 160 d of age, and none of them received scores reflecting a suboptimal conformation (data not shown). However, as leg conformation was not scored for a second time, it is not possible to know if the dietary treatments affected it. In any case, when number of gilts removed or reasons for removal were examined,

Table 6. Average daily gain and feed, Lys, and ME intake per kilogram of BW gain (least square means [LS mean] ± SEM) for different periods between 130 and 250 d of age of maternal line[1] gilts fed 2 Lys and 3 ME levels and their interaction from 100 d of age until slaughter

	Lys			ME				Lys × ME						
	85%[2]	100%[3]		85%[4]	100%[5]	115%[6]		85% Lys × 85% ME[7]	85% Lys × 100% ME[8]	85% Lys × 115% ME[9]	100% Lys × 85% ME[10]	100% Lys × 100% ME[11]	100% Lys × 115% ME[12]	
Traits	LS mean	LS mean	SEM	LS mean	LS mean	LS mean	SEM	LS mean	LS mean	LS mean	LS mean	LS mean	LS mean	SEM
ADG, kg		NS[13]			NS						NS			
130 d	1.0[a†]	1.0[a†]	0.02	1.0[a†]	1.0[a†]	1.0[a†]	0.02	0.9[a†]	1.0[a†]	0.9[a†]	1.0[a†]	1.0[a†]	1.0[a†]	0.03
160 d	0.9[b†]	0.9[b†]	0.02	0.9[b†]	0.9[b†]	1.0[a†]	0.02	0.9[a†]	0.9[b†]	1.0[b†]	0.9[b†]	0.9[b†]	0.9[b†]	0.03
190 d	1.0[a†]	1.0[a†]	0.02	1.0[a†]	1.0[a†]	1.0[a†]	0.02	1.0[b†]	1.0[a†]	0.9[a†]	1.0[a†]	0.9[b†]	1.0[a†]	0.03
220 d	0.8[c†]	0.8[c†]	0.02	0.8[c†]	0.8[c†]	0.8[b†]	0.02	0.8[c†]	0.7[c†]	0.8[c†]	0.8[c†]	0.8[c†]	0.8[c†]	0.03
250 d	0.6[d†]	0.6[d†]	0.02	0.5[d†]	0.6[d†]	0.6[c†]	0.02	0.5[d†]	0.6[d†]	0.6[d†]	0.6[d†]	0.6[d†]	0.6[d†]	0.03
Feed intake per kilogram BW gain, kg	NS			*				*						
130 d	2.4[a†]	2.4[a†]	0.1	2.5[a†]	2.4[a†]	2.3[a†]	0.1	2.5[a†]	2.4[a†]	2.3[a†]	2.5[a†]	2.5[a†]	2.3[a†]	0.2
160 d	3.1[b†]	3.27[b†]	0.1	3.5[b†]	3.2[b†]	2.8[b†]	0.1	3.4[b†]	3.2[b†]	2.7[ab†]	3.6[b†]	3.2[b†]	2.9[b†]	0.2
190 d	3.5[c†]	3.6[c†]	0.1	3.9[c†]	3.7[c†]	3.2[b†]	0.1	3.8[c†]	3.6[c†]	3.2[b†]	3.9[b†]	3.8[c†]	3.1[c†]	0.2
220 d	4.7[d†]	4.7[d]	0.1	5.0[d†]	4.8[d†]	4.4[c†]	0.1	4.9[c†]	4.9[d†]	4.3[c†]	5.0[c†]	4.6[d†]	4.5[d†]	0.2
250 d	6.2[e†]	6.2[e†]	0.1	6.9[e†]	6.1[e†]	5.6[d†]	0.1	7.3[d†]	5.9[e†]	5.3[d†]	6.5[d†]	6.2[e†]	5.8[e†]	0.2
Lys intake per kilogram BW gain, g	NS			*				NS						
130 d	20.5[a†]	24.8[a†]	0.8	23.7[a†]	22.6[a†]	21.7[a†]	1.0	21.7[a†]	20.4[a†]	19.6[a†]	25.7[a†]	24.9[a†]	23.8[a†]	1.4
160 d	24.6[b†]	30.6[b†]	0.8	30.5[b†]	27.8[b†]	24.5[a†]	1.0	27.1[b†]	25.3[b†]	21.6[b†]	33.8[b†]	30.4[b†]	27.5[b†]	1.4
190 d	25.9[b†]	30.9[b†]	0.8	30.9[b†]	29.4[b†]	24.9[a†]	1.0	28.1[b†]	26.6[b†]	23.2[b†]	33.7[b†]	32.2[b†]	26.7[b†]	1.4
220 d	34.5[c†]	40.4[c†]	0.8	39.8[c†]	37.7[c†]	34.9[b†]	1.0	36.3[e†]	36.2[c†]	31.1[c†]	43.3[c†]	39.3[c†]	38.8[c†]	1.4
250 d	45.2[d†]	52.4[d†]	0.8	54.1[d†]	48.1[d†]	44.3[c†]	1.0	53.3[d†]	43.3[d†]	38.9[d†]	54.9[d†]	52.8[d†]	49.6[d†]	1.4
ME intake per kilogram BW gain, Mcal	NS			NS				NS						
130 d	7.7[a†]	7.9[a†]	0.3	7.4[a†]	7.8[a†]	8.2[a†]	0.4	7.43	7.7[a†]	8.1[a†]	7.4[a†]	7.9[a†]	8.3[a†]	0.6
160 d	10.0[b†]	10.6[b†]	0.3	10.3[b†]	10.5[b†]	10.1[b†]	0.4	10.04	10.4[b†]	9.7[b†]	10.7[b†]	10.6[b†]	10.5[b†]	0.6
190 d	11.5[c†]	11.8[c†]	0.3	11.5[c†]	12.1[c†]	11.3[c†]	0.4	11.32	11.8[c†]	11.4[c†]	11.7[c†]	12.4[c†]	11.3[c†]	0.6
220 d	15.4[d†]	15.5[d†]	0.3	14.8[d†]	15.6[d†]	15.8[d†]	0.4	14.64	16.2[d†]	15.3[d†]	14.9[d†]	15.1[d†]	16.4[d†]	0.6
250 d	20.0[e6†]	20.1[e†]	0.3	20.2[d†]	19.8[e†]	20.0[e†]	0.4	21.49	19.4[e†]	19.2[e†]	19.0[e†]	20.3[e†]	20.9[e†]	0.6

[a–e]Within columns, Significant difference between periods ($P < 0.05$).

[1]Maternal line is Large White × Landrace.

[2]Grower diet: 0.85% standard ileal digestible (SID) Lys; finisher diet: 0.73% SID Lys.

[3]Grower diet: 1.02% SID Lys; finisher diet: 0.85% SID Lys.

[4]Grower diet: 2.94 Mcal of ME; finisher diet: 2.94 Mcal of ME.

[5]Grower diet: 3.25 Mcal of ME; finisher diet: 3.26 Mcal of ME.

[6]Grower diet: 3.56 Mcal of ME; finisher diet: 3.59 Mcal of ME.

[7]Grower diet: 0.85% SID Lys × 2.94 Mcal of ME; finisher diet: 0.73% SID Lys × 2.94 Mcal of ME.

[8]Grower diet: 0.85% SID Lys × 3.25 Mcal of ME; finisher diet: 0.73% SID Lys × 3.26 Mcal of ME.

[9]Grower diet: 0.85% SID Lys × 3.56 Mcal of ME; finisher diet: 0.73% SID Lys × 3.59 Mcal of ME.

[10]Grower diet: 1.02% SID Lys × 2.94 Mcal of ME; finisher diet: 0.85% SID Lys × 2.94 Mcal of ME.

[11]Grower diet: 1.02% SID Lys × 3.25 Mcal of ME; finisher diet: 0.853% SID Lys × 3.25 Mcal of ME.

[12]Grower diet: 1.02% SID Lys × 3.56 Mcal of ME; finisher diet: 0.85% SID Lys × 3.59 Mcal of ME.

[13]Nonsignificant (NS) effect of Lys, ME and Lys × ME by period; $P > 0.05$.

†Within rows, significant differences between predictor variables Lys, ME, and Lys × ME ($P < 0.05$).

*Significant effect of the interaction between predictor variables Lys, ME, and Lys × ME by period ($P < 0.05$).

Table 7. Average daily feed, Lys, and ME intake and feed, Lys, and ME intake (least square means [LS mean] ± SEM) for different periods between 130 and 250 d of age of maternal line[1] gilts fed 2 Lys and 3 ME levels from 100 d of age until slaughter

	Lys			ME			
	85%[2]	100%[3]		90%[4]	100%[5]	110%[6]	
Traits	LS mean	LS mean	SEM	LS mean	LS mean	LS mean	SEM
ADFI, kg		*				*	
130 d	3.0^{a†}	3.2^{a†}	0.1	3.3^{a†}	3.1^{ad†}	3.0^{a†}	0.1
160 d	3.4^{b†}	3.4^{b†}	0.1	3.7^{b†}	3.4^{b†}	3.1^{a†}	0.1
190 d	3.5^{c†}	3.6^{c†}	0	3.9^{c†}	3.6^{c†}	3.1^{a†}	0.1
220 d	3.3^{b†}	3.4^{b†}	0.1	3.7^{b†}	3.3^{ab2}	3.1^{a†}	0.1
250 d	2.8^{a†}	2.7^{d†}	0.1	3.0^{a†}	2.8^{d†}	2.6^{b†}	0.1
Average daily Lys intake, g		*				*	
130 d	26.2^{ab†}	31.4^{a†}	0.7	29.9^{ac†}	28.7^{a†}	27.6^{a†}	0.8
160 d	27.1^{a†}	31.5^{a†}	0.4	31.4^{b†}	29.5[2]	26.9^{a†}	0.5
190 d	25.9^{b†}	30.7^{a†}	0.3	31.4^{b†}	28.5^{a†}	24.8^{b†}	0.3
220 d	24.0^{c†}	28.9^{b†}	0.5	29.3^{c†}	25.9^{b†}	24.2^{b†}	0.5
250 d	20.1^{d†}	23.6^{c†}	0.7	23.4^{c†}	22.1^{c†}	19.9^{c†}	0.7
Average daily ME intake, Mcal		*				*	
130 d	9.9^{a†}	10.4^{a†}	0.3	9.8^{a†}	10.1^{a†}	10.5^{a†}	0.3
160 d	11.0^{b†}	11.0^{b†}	0.2	10.8^{b†}	11.6^{b†}	11.1^{b†}	0.2
190 d	11.5^{c†}	11.7^{c†}	0.1	11.7^{c†}	11.8^{c†}	11.3^{b†}	0.1
220 d	10.8^{b†}	11.0^{a†}	0.2	10.9^{b†}	10.8^{ab†}	11.2^{ab†}	0.2
250 d	9.2^{a†}	9.0^{d†}	0.3	8.6^{c†}	9.3^{a†}	9.4^{c†}	0.3

$^{a–e}$Within columns, significant difference between periods ($P < 0.05$).

[1]Maternal line is Large White × Landrace.

[2]Grower diet: 0.85% standard ileal digestible (SID) Lys; finisher diet: 0.73% SID Lys.

[3]Grower diet: 1.02% SID Lys; finisher diet: 0.85% SID Lys.

[4]Grower diet: 2.94 Mcal of ME; finisher diet: 2.94 Mcal of ME.

[5]Grower diet: 3.25 Mcal of ME; finisher diet: 3.26 Mcal of ME.

[6]Grower diet: 3.56 Mcal of ME; finisher diet: 3.59 Mcal of ME.

†Within rows, significant differences between predictor variables Lys and ME ($P < 0.05$).

*Significant effect of the interaction between predictor variables Lys and ME by period ($P < 0.05$).

there was no difference in the number of removed gilts or in the reason for removal between dietary treatments. Future studies should assess possible changes in leg conformation in replacement gilts as well as gait scoring due to dietary treatments over time.

In contrast to our hypothesis, differences in dietary lysine and ME did not alter gilt growth and/or body composition in the present study except for backfat thickness, which was slightly greater for gilts fed the high-ME diets. Because the backfat differences between the treatment groups is so small (approximately 2 mm), the difference is likely to be biologically irrelevant, given that the goal was to provide increased fat in gilts at the time of potential mating. However, backfat levels in the present study around 190 to 250 d of age were between 19 to 31 mm irrespective of dietary treatment. Such values are within those reported in the literature associated with gilt retention in the breeding herd. For instance, Brisbane and Chenais (1996) reported that gilts with a backfat thickness >18 mm were 10% more likely to remain in the herd until at least the fourth parity when compared with very lean gilts (i.e., <10 mm of backfat). Tarrés et al. (2006) reported that backfat thickness >16 mm at the end of the growth period decreases the culling risk after the third farrowing.

Previous studies reported that differences in dietary essential AA were associated with decreased growth rate and increased body fatness (Noblet and Henry, 1977; Russell et al., 1983; Sørensen et al., 1993; Main et al., 2008; Cia et al., 1998). However, those studies differ from the current study in that dietary lysine levels were lower, animals were younger, BW was lower, or animals did not have ad libitum access to feed. Furthermore, the lack of differences among dietary treatments for the different growth and body composition in the present study can be explained by changes in gilt FI in response to the various diets. Results indicate that gilts adjust their intake according to dietary ME content, which is consistent with previous reports. It has been reported that a decrease in energy content in the diet is associated with a compensatory increase in FI (Tokach et al., 2000) and that the energy intake

Table 8. Warm carcass weight, 10th rib fat thickness measured using a stainless steel ruler, fat free lean meat, and dressing percentage (least square means [LS mean] ± SEM) at 260 d of age from maternal line[1] gilts fed 2 Lys and 3 ME levels and their interaction from 100 d of age until slaughter

Traits	Lys			ME				Lys × ME						
	85%[2]	100%[3]		85%[4]	100%[5]	115%[6]		85% Lys × 85% ME[7]	85% Lys × 100% ME[8]	85% Lys × 115% ME[9]	100% Lys × 85% ME[10]	100% Lys × 100% ME[11]	100% Lys × 115% ME[12]	
	LS mean	LS mean	SEM	LS mean	LS mean	LS mean	SEM	LS mean	LS mean	LS mean	LS mean	LS mean	LS mean	SEM
Warm weight, kg	137.5	138.1	0.3	136.4[a]	137.2[a]	139.7[b]	0.4	136.6	136.8	139.2	136.3	137.6	140.2	0.5
Fat thickness, mm	11.0	11.1	0.1	10.0[a]	10.0[a]	11.1[b]	0.1	10.8	10.9	11.3	10.9	11.0	11.5	0.1
Fat free lean meat, kg	75.7	75.9	0.1	75.2[a]	75.5[a]	76.6[b]	0.2	75.3	75.4	76.4	75.1	75.7	76.9	0.3
Dressing percentage, %	71.0	71.5	0.1	70.8[a]	71.0[a]	71.9[b]	0.1	70.9[a]	70.6[a]	71.7[b]	70.8[a]	71.5[b]	72.2[c]	0.2

[a–c]Significant difference within main effects ($P < 0.05$).

[1]Maternal line is Large White × Landrace.

[2]Grower diet: 0.85% standard ileal digestible (SID) Lys; finisher diet: 0.73% SID Lys.

[3]Grower diet: 1.02% SID Lys; finisher diet: 0.85% SID Lys.

[4]Grower diet: 2.94 Mcal of ME; finisher diet: 2.94 Mcal of ME.

[5]Grower diet: 3.25 Mcal of ME; finisher diet: 3.26 Mcal of ME.

[6]Grower diet: 3.56 Mcal of ME; finisher diet: 3.59 Mcal of ME.

[7]Grower diet: 0.85% SID Lys × 2.94 Mcal of ME; finisher diet: 0.73% SID Lys × 2.94 Mcal of ME.

[8]Grower diet: 0.85% SID Lys × 3.25 Mcal of ME; finisher diet: 0.73% SID Lys × 3.26 Mcal of ME.

[9]Grower diet: 0.85% SID Lys × 3.56 Mcal of ME; finisher diet: 0.73% SID Lys × 3.59 Mcal of ME.

[10]Grower diet: 1.02% SID Lys × 2.94 Mcal of ME; finisher diet: 0.85% SID Lys × 2.94 Mcal of ME.

[11]Grower diet: 1.02% SID Lys × 3.25 Mcal of ME; finisher diet: 0.853% SID Lys × 3.25 Mcal of ME.

[12]Grower diet: 1.02% SID Lys × 3.56 Mcal of ME; finisher diet: 0.85% SID Lys × 3.59 Mcal of ME.

level is slightly lower when compared with pigs fed a higher-energy diet (Henry, 1985). This is in agreement with the present findings. Henry (1985) stated that the lower energy intake in spite of the higher FI in low-energy diets may be explained by gastrointestinal capacity limitation before energy demand is met, a point at which diet bulkiness overrides compensation for energy content.

It has been reported that the pig is able to modify its FI according to its specific requirement for AA (Henry, 1985). However, the present results indicate that dietary lysine content at the levels evaluated did not influence FI. It is possible that intake would have been altered if lower lysine levels had been used in the present study. Loughmiller et al. (1998) also reported that daily FI was not affected by lysine content in the diet. Although gilts fed the high-lysine diet had a higher total lysine and average daily lysine intake, the latter was similar to previous reports of the optimal lysine intake irrespective of dietary treatments. Previous reports of optimal daily lysine intake range from 11.8 to 26.5 g/d for pigs from 46 to 136 kg of BW (Campbell et al., 1984; Rao and McCracken, 1992; Kerr, 1993; Sørensen et al., 1993; Friesen et al., 1995; Hahn et al., 1995). In the present study, gilts consumed an average of 26.9 g lysine/d, which is in the upper range of results of previous reports. Therefore, in this experiment, lysine requirements were likely to be met even for the lowest lysine level provided. Friesen et al. (1994) suggested that total lysine intake greater than 22 g/d did not improve feed efficiency. Similarly, Just (1984) reported that an excess in AA intake did not negatively affect feed efficiency in grow–finisher pigs. Additionally, Friesen et al. (1994) indicated that in pigs over 100 kg of BW, response to increased lysine intake is diminished. This could explain the lack of a lysine response on growth and body composition as the gilts in the present study reached 100 kg at approximately 60 d after the study started.

Although FI per kilogram of BW gain was greater in gilts fed low-energy diets, it does not necessarily mean that those

gilts were less efficient. Caloric efficiency was similar among dietary treatments. Results indicate that the same amount of calories was required to deposit 1 kg of BW irrespective of dietary treatment. Indeed, there was no difference in ADG among treatments. By contrast, there was a difference in lysine utilization among treatments. When the main effect of lysine was examined, gilts fed the low-lysine diets consumed fewer grams of lysine per kilogram of BW gain. This is almost certainly related to FI per kilogram of BW, as the gilts consumed the same amount of feed per kilogram of BW gain but the amount of lysine present in the feed was different. A similar result was observed when examining ME effect on lysine intake per kilogram of BW gain as gilts fed the low-ME diet consumed more grams of lysine to deposit a kilogram of BW and also had greater FI compared with the gilts fed the medium- and high-ME dietary treatments. This is consistent with the fact that lysine intake per kilogram of BW gain in this study was considerably greater than the requirements reported by other studies of 20 g/kg of BW gain (Srichana et al., 2004; De La Llata, 2007; Shelton et al., 2009). Further research is necessary to examine AA needs and AA efficiency in developing gilts with the potential to reach heavy BW as studies are limited regarding this topic.

Warm carcass weight, fat free lean meat, backfat thickness, and dressing percentage were similar regardless of dietary lysine treatment. This agrees with results reported by Friesen et al. (1995) but contrary to the results reported by Ruusunen et al. (2007), where pigs fed low-lysine diets had a lower carcass weight. By contrast, dietary energy treatment level did impact carcass traits, as gilts fed the high-energy diets had a greater warm carcass weight, dressing percentage, and fat free lean meat compared with gilts fed diets with the low or medium energy level. This was an unexpected result as BW and fat free lean meat did not differ during the trial. Although organ weights were not recorded for this study, it is possible that the greater dressing percentage, carcass weight, and fat free lean meat for gilts fed the high-energy diet are related to organ size and organ weight. In the present study, gilts fed low-energy diets had a considerably greater FI. Previous studies have reported that animals with greater FI have larger and heavier organs compared with animals that consumed less feed (Burrin et al., 1992; Thomke et al., 1995; Fischer et al., 2001; Ruusunen et al., 2007). This, in turn, would reduce carcass weight and dressing percentage. Alterations in digestive organs could be advantageous for gilts during subsequent lactations, when it is difficult for some animals to eat enough to meet lactation demands. Whether diets alter digestive organ weights, and whether this could provide an advantage, warrants further study.

In conclusion, under the present study conditions, the growth of developing gilts was not altered when provided with ad libitum access to diets differing in lysine and ME content, and body composition was only slightly altered. Gilts displayed compensatory FI in response to ME content of the diet, suggesting that manipulation of ME in ad libitum gilt development diets is unlikely to be a useful strategy, within the commercially practical range of ME used here. More research is required to determine whether lower lysine levels in gilt development diets can be used to modify body composition by decreasing lean deposition and increasing fat reserves.

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