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Dietary lysine-to-energy ratios for managing growth and pubertal development in replacement gilts

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Abstract

Objective: Our objective was to determine growth rates, body composition, and pubertal development of replacement gilts fed diets with different ratios of standardized ileal digestible (SID) lysine to ME.

Materials and Methods: Diets with low, medium, and high ratios of SID lysine to ME (grower: 2.3, 2.6, and 2.8; and, finisher; 1.7, 1.9, and 2.1 g/Mcal) were fed from 100 to 200 d of age, after which gilts were moved from the gilt development unit to sow farms. Boar exposure and estrus detection began at 160 d of age and continued until first detected estrus. Estimates of BW and body composition were determined at 100, 142, 160, and 200 d of age and at puberty.

Results and Discussion: Body weights and growth rates were reduced ($P < 0.05$) as dietary SID lysine–to–ME ratio decreased. Greater SID lysine–to–ME ratios increased the number of gilts that exhibited estrus upon boar exposure, increased the number of gilts with a spontaneous first estrus, reduced the number of gilts requiring P.G.600 (Merck Animal Health, Kenilworth, NJ), and decreased age at first estrus ($P < 0.05$). Slower growing gilts that weighed less with less backfat were more likely to require P.G.600 to induce puberty ($P < 0.05$).

Implications and Applications: Reducing SID lysine– to–ME ratios in gilt diets can increase the number of gilts within optimal BW range at first estrus, but overall pubertal development is delayed if ratios are reduced below 2.8 and 2.1 g of SID lysine to megacalorie of ME in grower and finisher diets, respectively.

Keywords

gilt, growth, puberty, diet, lysine

Disciplines

Agriculture | Animal Experimentation and Research | Animal Sciences

Comments

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PRODUCTION AND MANAGEMENT: *Original Research*

Dietary lysine-to-energy ratios for managing growth and pubertal development in replacement gilts*

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ABSTRACT

Objective: Our objective was to determine growth rates, body composition, and pubertal development of replacement gilts fed diets with different ratios of standardized ileal digestible (SID) lysine to ME.

Materials and Methods: Diets with low, medium, and high ratios of SID lysine to ME (grower: 2.3, 2.6, and 2.8; and, finisher; 1.7, 1.9, and 2.1 g/Mcal) were fed from 100 to 200 d of age, after which gilts were moved from the gilt development unit to sow farms. Boar exposure and estrus detection began at 160 d of age and continued until first detected estrus. Estimates of BW and body composition were determined at 100, 142, 160, and 200 d of age and at puberty.

Results and Discussion: Body weights and growth rates were reduced ($P < 0.05$) as dietary SID lysine–to–ME ratio decreased. Greater SID lysine–to–ME ratios increased the number of gilts that exhibited estrus upon boar exposure, increased the number of gilts with a spontaneous first estrus, reduced the number of gilts requiring P.G.600 (Merck Animal Health, Kenilworth, NJ), and decreased age at first estrus ($P < 0.05$). Slower growing gilts that weighed less with less backfat were more likely to require P.G.600 to induce puberty ($P < 0.05$).

Implications and Applications: Reducing SID lysine–to–ME ratios in gilt diets can increase the number of gilts within optimal BW range at first estrus, but overall pubertal development is delayed if ratios are reduced below 2.8 and 2.1 g of SID lysine to megacalorie of ME in grower and finisher diets, respectively.

Key words: gilt, growth, puberty, diet, lysine

INTRODUCTION

To improve sow lifetime productivity, managing the replacement gilt to achieve optimum body composition as she enters the breeding herd should be a priority for producers (Baidoo, 2001; Stalder et al., 2004; Bortolozzo et al., 2009). Appropriate strategies to achieve this goal are debated in the US swine industry. Traditionally, breeding herd replacement gilts have been fed grower and finisher diets containing excess AA to promote maximal protein deposition during the development phase (Rozeboom, 1999). In 2012 The Scientific Committee of the National Pork Board (**NPB**) informally surveyed the US commercial swine industry to determine the average levels of AA and energy content in diets fed during gilt development. The results indicated that pork producers feed greater amounts of standardized ileal digestible (**SID**) lysine to replacement gilts than those recommended by the NASEM (2012) or the *National Swine Nutrition Guide* (Whitney and Masker, 2010). Baidoo (2001) recommend that an appropriate gilt development diet should be either moderate in SID lysine (0.6%) with high energy (3.5 Mcal/kg) or high in SID lysine (1.31%) with moderate energy (3.2 Mcal/kg) and that such diets should be limit fed, which is not a common practice in the US pig industry. Reducing growth rate of developing gilts was associated with improved reproductive efficiency through first parity (Klindt et al., 1999, 2001a,b). Others have shown that reducing

The authors declare no conflicts of interest.

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prebreeding growth rate did not limit pubertal development (Patterson et al., 2002; Miller et al., 2011) and may be beneficial to first-parity performance (Barnett et al., 2017; Winkel et al., 2018).

There are few publicly available reports in which adequate numbers of females have been used to estimate the effects of feeding gilt diets ad libitum on reproductive development, longevity, and productivity of replacement gilts in commercial production systems. The NPB Sow Lifetime Productivity Research Consortium concluded that additional research was needed to characterize relationships among prebreeding growth rates and body composition of gilts and their contribution to sow lifetime productivity, and that such research should involve diets that could be fed to gilts ad libitum during development. Previous studies using varied concentrations of either ME or SID lysine fed to gilts during development indicated that growth rate, body composition, and reproductive development of gilts were unaffected (Calderón Díaz et al., 2015a,b). Using the SID lysine–to–energy content (g of SID lysine:Mcal of ME ratio) to formulate diets fed to replacement gilts showed these traits could be marginally improved (Calderón Díaz et al., 2017). The present study was conducted within a large commercial production system with the objective to evaluate growth and pubertal development in replacement gilts fed diets with varying SID lysine–to–ME ratios during the growing-finishing phase of development.

MATERIALS AND METHODS

Animals, Diets, and Management

This study was reviewed and approved by the Institutional Animal Care and Use Committee of the US Meat Animal Research Center and conducted in accordance with the *Guide for the Care and Use of Agricultural Animals in Research and Teaching* (FASS, 2010). The study was conducted at a commercial farm in the southwestern United States using maternal-line, sows (n = 1,052) in parities 1 through 8. The Large White × Landrace F1 gilts (n = 2,960) were born over 42 consecutive weeks and were individually identified at 1 d of age. Gilts remained with their dams, and only male piglets were cross-fostered when necessary. Within a weekly group, gilts were blocked by litter of origin and parity of dam before being randomly allocated to pens at 80 d of age. The gilt development unit was naturally ventilated. Pens (24 gilts, 0.93 m^2 per gilt) had fully slatted concrete flooring (slat width = 15.2 cm, space between slats = 2.5 cm) and contained a feeder (5 feeding spaces, 30.5 cm per space) in the center. Access to water was ad libitum via one hanging waterer with 2 nipples in each pen.

Dietary treatments were designated as low, medium, and high based on SID lysine and ME content (g of SID lysine: Mcal of ME ratio; Table 1). The development of diets used in this study was described previously (Calderón Díaz et al., 2017) and based on estimates for the SID lysine requirement developed from modern commercial lean genotypes (Zier-Rush et al., 2013). Calculated and analyzed composition of diets is listed in Table 1. Beginning at 100 d of age, gilts had ad libitum access to the grower diet for approximately 6 wk and were then fed the finisher diet until 200 d of age, when gilts were moved to sow farms. Daily feed intake was estimated in 2-wk intervals and was based on feed disappearance (pen basis). Daily SID lysine (g) and ME (Mcal) consumed in every 2-wk interval were calculated by multiplying the formulated dietary SID lysine and ME content by the pen feed disappearance (kg) per number of pigs in the pen. Feed, total lysine, and ME intake per kilogram of BW were calculated.

At 201 ± 1 d of age, gilts were transferred from the gilt development unit (**GDU**) to a sow farm. Gilts born in wk 1 to 22 were moved to sow farm 1, where they were penned by dietary treatment in a finisher GDU and were provided ad libitum access to an industry-standard gestation diet. Gilts were moved to individual stalls in the breed line by 231 d of age or approximately 10 d before their expected breeding date. When in stalls, gilts were fed a gestation diet at 1.81 kg/d. Gilts in groups 23 to 42 were moved to sow farm 2, where they were placed directly into individual stalls and fed a gestation diet at 1.81 kg/d.

Measurements

Birth weight, BW and other growth traits (ultrasound, caliper, flank to flank) were recorded for each gilt at 100, 142, 160, and 200 d of age and at each recorded estrus. Body weight was recorded using a digital scale (Digi-Star SW4600EID Digital RFID, VID Recording scale; Digi-Star LLC, Fort Atkinson, WI). Average daily gain was calculated using the standard formula [(final BW − initial BW)/days]. A trained technician obtained ultrasonic images using an EXAGO ultrasound (S. E. C. Repro Inc., Québec, Canada) at the 10th rib. Ultrasonic images were interpreted using the Biosoft Toolbox II for Swine (Biotronics Inc., Ames, IA) to measure backfat thickness (**BF**) and loin depth (**LD**). A caliper was used to estimate backfat at the last rib (Knauer and Baitinger, 2015). A cloth tape was used to measure the distance from flank to flank on each animal. Fat-free-lean meat was calculated with the equation for live hogs using real-time ultrasound measures (Burson, 2006): 0.379 × 2 − [0.649 × 10th rib of fat depth (mm)] + [0.841 × 10th rib loin muscle area (cm^2)] + [0.132 × live BW (kg)] − 0.243. A fat-to-lean ratio was calculated as BF divided by LD. Reasons for removing gilts from the study were based on the trial manager's decisions at the gilt development facility. Removal reasons were acquired retrospectively from farm records.

Boar Stimulation and Puberty

Boar stimulation and estrus detection began when the average age of gilts in a pen reached 160 d. Vasectomized boars (>10 mo of age) were allowed approximately 10 min

Table 1. Calculated and analyzed composition of grower and finisher diets, as-fed basis[1,2]

	Grower diet			Finisher diet		
Item	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Ingredient, %						
Corn (15%)	47.88	58.50	73.00	49.10	66.13	80.26
Soybean meal (47.5% CP)	14.40	14.40	17.10	7.50	7.50	10.30
De-oiled corn germ	16.00	8.00	0	20.00	7.50	0
Wheat middlings	18.00	15.00	5.00	18.00	15.00	5.00
Dicalcium phosphate (21% P)	1.15	1.27	1.55	0.98	1.10	1.38
Choice white grease	1.00	1.00	1.00	2.90[3]	1.00	1.00
Limestone ground	0.98	0.92	0.76	0.93	0.90	0.77
L-Lysine (50%)	0	0.33	0.60	0	0.29	0.45
Salt	0.40	0.40	0.40	0.40	0.40	0.40
Trace mineral premix[4]	0.10	0.10	0.10	0.10	0.10	0.10
L-Threonine	0	0.04	0.14	0	0.02	0.09
Alimet MHA Liq[5] (methionine)	0	0	0.11	0	0	0.03
Vitamin premix[6]	0.05	0.05	0.05	0.05	0.05	0.05
L-Tryptophan	0	0	0.03	0	0	0.02
Biotin (200 mg/L)	0.03	0.03	0.03	0.03	0.03	0.03
Red iron oxide	0	0	0.15	0	0	0.15
FC&C blue #1	0.03	0	0	0.03	0	0
Calculated values, %						
ME, Mcal/kg	2.95	3.07	3.21	3.08	3.13	3.27
NE, Mcal/kg	2.36	2.44	2.56	2.46	2.49	2.59
CP	16.94	15.66	14.89	14.70	12.83	12.10
Total L-lysine	0.81	0.90	0.99	0.65	0.70	0.76
SID[7] lysine	0.64	0.77	0.91	0.49	0.58	0.67
SID lysine:ME ratio, g/Mcal	2.3	2.6	2.8	1.7	1.9	2.1
Free lysine equivalent[8]	0	0.16	0.30	0	0.14	0.22
SID threonine	0.48	0.49	0.59	0.39	0.39	0.45
SID isoleucine	0.27	0.27	0.33	0.14	0.14	0.20
SID methionine	0.25	0.24	0.32	0.22	0.20	0.22
SID tryptophan	0.16	0.15	0.16	0.13	0.11	0.12
Linoleic acid, %	1.30	1.48	1.68	1.50	1.57	1.76
Chemical determined values, %						
CP	16.95	15.53	14.95	14.92	12.80	12.34
Total lysine	0.78	0.87	0.99	0.73	0.70	0.76
Free lysine	0.02	0.16	0.27	0.03	0.15	0.21
Methionine	0.26	0.24	0.24	0.26	0.22	0.21
Methionine + cysteine	0.56	0.52	0.51	0.56	0.48	0.45
Threonine	0.62	0.60	0.67	0.60	0.50	0.53
Tryptophan	0.20	0.15	0.18	0.18	0.14	0.14

[1]Low, medium, and high are based on SID lysine:ME ratio listed in table (g/Mcal).

[2]Grower diet fed from 100 to 141 d of age; finisher diet fed from 142 to 200 d of age.

[3]More fat was added to provide a minimum of 1.5% linoleic acid.

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

[5]Novus International Inc. (St. Charles, MO).

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

[7]SID = standardized ileal digestible; calculated using SID coefficients for the various ingredients obtained from the NASEM (2012).

[8]Free lysine is computed from the ingredient liquid L-lysine, which is 50% lysine, by multiplying the diet percentage of liquid L-lysine by 0.50. This can be compared with the analyzed free lysine in the diet; the latter accounts only for added synthetic lysine, not that which is ingredient bound as protein.

of daily contact with gilts in their home pen. A single boar entered up to 4 pens per day with up to 24 gilts per pen and was rotated daily among pens so that gilts were stimulated by different boars on consecutive days. Each gilt was assigned a daily estrus score (0 to 3) as described previously (Calderón Díaz et al., 2015b; Calderón Díaz et al., 2017). Scores were based on daily vulva changes and gilt behavior in the presence of the boar. A score of 3 was defined as standing estrus, and puberty was defined as the first day a gilt scored 3. At sow farm 1, boar stimulation continued in pens until gilts were moved to gestation stalls, where they had daily fence-line contact with boars. At sow farm 2, gilts had contact with boars through the front of the stall during daily stimulation and estrus detection. Gilts that failed to display estrus by 220 d of age were injected with P.G.600 (Merck Animal Health, Kenilworth, NJ) to induce estrus.

Blood samples (10 mL) were collected at 210 and 220 d of age from gilts that had failed to display estrus at these age points. Serum was collected by centrifugation (1,500 × *g*; 20 min; 4°C), and concentrations of progesterone were quantified by RIA to determine whether gilts were prepubertal or behaviorally anestrus. Procedures for the assay (ImmuChem Coated Tube RIA kit, MP Biomedicals, Santa Ana, CA) were validated previously (Calderón Díaz et al., 2017). Pools of porcine serum measuring 23.4 and 2.0 ng/mL progesterone were included in each assay. These had intra-assay CV of 6.6 and 9.0%, respectively. Samples were assayed in duplicate, and gilts having serum concentrations of progesterone ≥1 ng/mL were defined as having luteal activity indicative of behavioral anestrus.

Statistical Analysis

A randomized complete block design was applied with pen considered the experimental unit and litter of origin and dam parity as block factors. The Shapiro-Wilk test was used to evaluate growth, ultrasound composition, feed intake, and feed efficiency data for normality. Data were analyzed using mixed model methods (PROC MIXED; SAS version 9.4, SAS Institute Inc., Cary, NC). Models included fixed effects such as dietary treatments (high, medium, and low), data recording days (d 142, 160, and 200), and week of birth. Additionally, the fixed effect for sow farm was used for BW and growth trait analysis. Initial BW at 100 d of age was included as a linear covariate in the models. The pen nested within barn was included as a random effect. Analyses of traits for feed intake and feed efficiency were similar; however, the BW at 100 d of age covariate was excluded in the model because these data represented dietary consumption per animal in a pen rather than per individual pig basis. Covariates of BW at 100 d are reported as the slope or regression coefficient (±SE). Logistic regression that included treatment, birth week, farm, and BW at 100 d of age was used to estimate differences in phenotypic traits between gilts that had spontaneous natural first estrus in the GDU or at the sow farm and those that had first estrus induced with P.G.600 with those that never achieved estrus. Because there is no replication of farm system, the effect of farm is not reported. Fixed and random effects were considered a significant source of model variation at $P \leq 0.05$, and protected post hoc comparisons of LSM (±SE) were made using the Tukey-Kramer test. Frequency data (e.g., number of gilts responding to P.G.600) were analyzed using a chi-squared test (PROC FREQ; SAS).

RESULTS AND DISCUSSON

One of the goals of the NPB's research effort into sow lifetime productivity was to test the response of gilts fed development diets that slow their growth and regulate body composition when provided ad libitum access to feed. The current experiment was developed to apply the dietary SID lysine–to–ME ratios from the study by Calderón Díaz et al. (2017) by feeding gilts in a large-scale study conducted in a commercial setting. Results illustrated that ad libitum–fed diets can be formulated to achieve reduced gilt growth; however, aspects of body composition and pubertal development that may be critical for future gilt productivity were also affected.

Main et al. (2008) suggested that a SID lysine–to–ME ratio of approximately 3.1 g/Mcal is optimal for gilts weighing between 50 and 70 kg. This weight range would correspond to the grower period in the current experiment in which SID lysine–to–ME ratio ranged from 2.8 g/Mcal for the high diet to 2.3 g/Mcal for the low diet. In the present study gilts fed the diet with a high SID lysine–to–ME ratio had greater ($P < 0.05$) total lysine intake and greater total lysine intake per kilogram of BW gain when compared with gilts fed the medium and low diets (Table 2). Average total lysine intake for gilts in this trial, however, was consistent with previous reports in which the optimal daily total lysine intake ranged from 10.8 to 26.5 g/d for pigs from 46 to 136 kg of BW (Campbell et al., 1984; Kerr, 1993; Sorensen et al., 1993; Friesen et al., 1995; Hahn et al., 1995; O'Connell et al., 2006). Pigs fed the diets with high and medium SID lysine–to–ME ratios consumed on average between 19 and 21.5 g of total lysine/kg of BW gain during the finishing phase, which is consistent with the reported 20 g of total lysine/kg of BW gain indicated for optimal lean deposition in gilts (De La Llata et al., 2007; Main et al., 2008; Shelton et al., 2011). It should be reiterated that the present study was not designed to test the effects of a discrete level of dietary SID lysine or ME but rather to measure growth and pubertal development in response to diets that varied in SID lysine–to–ME ratios. Nonetheless, total lysine intake of gilts fed the diets with medium and high SID lysine–to–ME ratios in this study was consistent with optimal levels reported in the literature.

Descriptive statistics for the measurements recorded at the initiation of dietary treatments are listed in Table 3. Linear regression coefficients for BW at 100 d as a co-

Table 2. Least squares means and SEM for feed intake traits in different periods between 100 and 200 d of age for maternal-line gilts (Large White × Landrace) fed diets (ad libitum) with different standardized ileal digestible (SID) lysine–to–ME ratios from 100 to 200 d of age

	Dietary treatment[3]			Pooled	
Trait[1,2]	Low	Medium	High	SEM	*P*-value
ADFI, kg					
100–142 d	2.8	2.8	2.8	0.03	0.58
143–160 d	2.7	2.7	2.7	0.04	0.46
161–200 d	3.2	3.2	3.2	0.04	0.35
Feed intake/kg of BW gain, kg					
100–142 d	4.2	4.1	4.1	0.05	0.72
143–160 d	3.4	3.4	3.4	0.06	0.61
161–200 d	3.7	3.7	3.7	0.05	0.58
Average daily total lysine intake, g					
100–142 d	14.5[a]	16.7[b]	18.6[c]	0.19	0.03
143–160 d	14.1[a]	16.3[b]	18.4[c]	0.24	0.04
161–200 d	16.4[a]	19.1[b]	21.5[c]	0.20	<0.0001
Total lysine intake/kg of BW gain, g					
100–142 d	21.5[a]	24.8[b]	27.7[c]	0.31	<0.0001
143–160 d	17.9[a]	20.6[b]	23.4[c]	0.38	<0.0001
161–200 d	19.1[a]	22.2[b]	25.0[c]	0.32	<0.0001

[a–c]Values within rows with different superscripts are significantly different among levels of SID lysine:ME ratio ($P < 0.05$).

[1]BW at 100 d of age was included in the statistical model as a covariate ($P < 0.05$).

[2]Average feed intake as the feed disappearance per pen in 2-wk intervals, and total lysine and ME consumed every 2 wk were calculated by multiplying the formulated dietary SID lysine and ME contents with the feed consumed.

[3]Treatment defined by SID lysine:ME ratio (g/Mcal): low = grower diet, 2.3; finisher diet, 1.7; medium = grower diet, 2.6; finisher diet, 1.9; high = grower diet, 2.8; finisher diet, 2.1. The grower diet was fed from 100 to 142 d of age; the finisher diet was fed from 142 to 201 d of age.

variate were 0.52 ± 0.04 for BW; 0.44 ± 0.01 for flank to flank; 0.17 ± 0.07 for BF; 0.04 ± 0.001 for LD; 0.45 ± 0.01 for fat-free-lean meat; 0.008 ± 0.0004 for ADG; and 0.02 ± 0.001 for fat-to-lean ratio, respectively. These linear BW covariates were positive and significant ($P < 0.05$) in the model for each growth trait and are consistent with those for developing gilts previously reported by Calderón Díaz et al. (2017). Gilts fed the diet with a high SID lysine–to–ME ratio had greater ($P < 0.05$) BW and ADG between 100 and 200 d of age when compared with gilts fed the low diet (Table 4). Gilts fed the diet with a medium SID lysine–to–ME ratio had BW and ADG that were intermediate to the gilts fed the other diets. It is recommended that gilts should be bred in a weight range between 135 and 160 kg for optimal lifetime performance (Bortolozzo et al., 2009). Assuming weight gains of 1 kg/d, this means that gilts should reach puberty with an upper BW limit of 140 kg to allow for a full cycle between puberty and breeding. With ad libitum feeding systems, commercial gilts can exceed this weight threshold (Calderón Díaz et al., 2015a). Diets used in the present study, in which the SID lysine–to–ME ratio was reduced compared with standard gilt development diets (Calderón Díaz et al., 2015a), effectively limited gilt growth so that more gilts fit the optimum pubertal BW range (115 to 140 kg; Table 5). This indicates that these diets could optimize lifetime performance by minimizing the risk of gilts being overweight at breeding, which can lead to locomotion and structural problems that result in sow removal at early parities (Bortolozzo et al., 2009).

Calderón Díaz et al. (2017) reduced the SID lysine–to–ME ratio fed to gilts during the grower and finisher phase (100 to 220 d of age) and decreased BW without affecting body composition. In contrast, reducing the SID lysine–to–energy ratio during this period of development in the current study not only decreased BW but affected body composition as well. Ultrasound BF, LD, and calculated fat-free-lean meat were greater ($P < 0.05$) for gilts fed the diet with a high SID lysine–to–ME ratio when compared with gilts fed the low diet, with gilts fed the medium diet having values for these traits that were intermediate to the other dietary treatments (Table 4). When energy or AA levels in the diet are below the requirement of gilts to meet their genetic potential for growth, they compensate by consuming more feed (Calderón Díaz et al., 2015a). In a previous study, Calderón Díaz et al. (2017) observed small but significant increases in feed intake of gilts as the SID lysine–to–ME ratio of the diet was reduced, particularly early in the growing phase. Gilts from the current study were fed the same diets and were from the same genetic line but raised in a different GDU. They consumed more total feed when compared with those in the study by Calderón Díaz et al. (2017), but there were no treatment differences for ADFI (Table 2). Loughmiller et al. (1998) reported that dietary concentrations of 0.6 to 0.9% total lysine had no effect on daily feed intake when diets were fed to late finishing gilts. The total lysine level in finishing diets in the current study ranged from 0.65 to 0.76% (Table 1). Additionally, the diets in the current study included corn germ and wheat middling to increase total dietary NDF as SID lysine–to–ME ratio was reduced, with the expectation that this would limit the maximum daily feed intake of the gilts fed the diets with low and medium SID lysine–to–ME ratios and minimize the potential for difference in ADFI between treatments. Results indicate this strategy was remarkably effective.

Gilts fed the diets with low and medium SID lysine–to–ME ratios grew more slowly and had a greater fat-to-lean ratio during development when compared with gilts fed the high diet ($P < 0.05$; Table 4), indicating that gilts in the low and medium treatments were proportionately fatter, although gilts fed the diets with low and medium SID lysine–to–ME ratios had less ($P < 0.05$) total BF

Table 3. Descriptive statistics for growth and body composition traits at 100 d of age for maternal-line gilts (Large White × Landrace) fed diets (ad libitum) with different standardized ileal digestible (SID) lysine–to–ME ratios

	Low[1] (n = 992)				Medium[2] (n = 984)				High[3] (n = 984)			
Trait	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD	Minimum	Maximum
BW, kg	42.2	7.0	20.86	67.1	42.3	7.0	21.8	61.7	42.3	6.8	15.9	64.4
Flank to flank, cm	56.6	3.9	43.2	68.6	56.5	3.9	45.7	68.6	56.7	3.8	43.2	83.8
Backfat thickness, mm	6.3	1.4	2.9	12.4	6.3	1.4	3.3	12.8	6.3	1.4	2.9	13.9
Loin depth, cm	2.8	0.5	1.3	4.4	2.8	0.5	1.3	4.8	2.8	0.5	1.3	4.5
Fat-free-lean meat, kg	22.6	5.7	11.0	59.5	22.6	5.8	9.7	70.7	22.7	6.22	8.3	67.4
Fat-to-lean ratio[4]	2.2	0.01	0.6	3.7	2.2	0.01	0.9	3.7	2.2	0.01	0.8	3.7

[1]SID lysine:ME ratio (g/Mcal): grower diet, 2.3; finisher diet, 1.7.
[2]SID lysine:ME ratio (g/Mcal): grower diet, 2.6; finisher diet, 1.9.
[3]SID lysine:ME ratio (g/Mcal): grower diet, 2.8; finisher diet, 2.1.
[4]Fat-to-lean ratio was calculated as backfat thickness divided by loin depth.

than gilts fed the high diet (Table 4). Results from the present study were similar to previous work that reported growth and composition differences from gilts fed different level of dietary EAA, especially SID lysine, during growing and finishing phases (Sorensen et al., 1993; Friesen et al., 1994, 1995; Cia et al., 1998; Chang et al., 2000; Main et al., 2008; Miller et al., 2011). Friesen et al. (1994) showed that SID lysine levels less than 0.64% (total dietary lysine, 0.78%), which would have corresponded to the SID lysine content from the grower diet with a low SID lysine–to–ME ratio in the current experiment, increased the fat-to-lean ratio of gilts weighing between 34 and 72 kg. However, gilts fed the diet with a low SID lysine–to–ME ratio had less ($P < 0.05$) BF at first natural estrus compared with gilts fed the high diet (Table 5).

Selection for increased leanness and greater litter sizes in maternal-line gilts creates challenges for gilt feeding programs, which should optimize lean growth and promote development of body fat reserves (Rozeboom, 1999; Baidoo, 2001; Whitney and Masker, 2010; Miller et al., 2011) to support maximal reproduction and longevity (Stalder et al., 2005; Stalder, 2006). In general, backfat has little influence on the rate of pubertal attainment in gilts, so long as protein deposition is not limiting (Beltranena et al., 1993; Patterson et al., 2002). About 12 mm of backfat is the reported minimal amount necessary for adequate lifetime productivity and longevity (Stalder et al., 2005; Williams et al., 2005). In the current study, all gilts averaged 13 mm of backfat or above at first estrus (Table 5), indicating that the experimental diets promoted sufficient accumulation of backfat in developing gilts to support good reproductive productivity and retention. Others reported that gilts with backfat thickness below 16 mm at selection were culled earlier, produced fewer litters, and had fewer pigs weaned per sow lifetime (Gaughan et al., 1995; Tarrés et al., 2006). Gilts in this study have been bred and will be followed for 3 parities. How fatness during development affects lifetime productivity of these gilts will be detailed in future reports.

Although these dietary treatments were implemented in a previous study (Calderón Díaz et al., 2017), only about 30% of gilts in that study exhibited a spontaneous natural estrus. In the current study, approximately 55% of gilts with an estrus experienced a spontaneous natural first estrus (Table 5). Gilts in the study by Calderón Díaz et al. (2017) experienced an outbreak of porcine epidemic diarrhea virus during the feeding period that likely had a negative effect on cyclicity. A greater percentage of gilts in the current study fed the diet with a high SID lysine–to–ME ratio cycled during the first 40 d after boar exposure (before movement to farms) when compared with gilts fed the medium or low diets (9.1, 11.4, and 17.9% for low, medium, and high, respectively; $P < 0.0001$). In the present study, gilts were moved from the research GDU to sow farms at 201 d of age. It is well known that transportation and remixing stimulate the onset of estrus in gilts, and indeed, a large portion of gilts in each treat-

Table 4. Least squares means and SEM for weight and body composition at 142, 160, and 200 d of age and for growth rates in different periods between 100 and 200 d of age for maternal-line gilts (Large White × Landrace) fed diets (ad libitum) with different standardized ileal digestible (SID) lysine–to–ME ratios from 100 to 200 d of age

	Dietary treatment[2]			Pooled	
Trait[1]	Low	Medium	High	SEM	*P*-value
BW, kg					
142 d	67.6[a]	70.4[b]	73.2[c]	0.31	<0.0001
160 d	81.7[a]	85.3[b]	89.7[c]	0.32	<0.0001
200 d	115.5[a]	120.8[b]	127.7[c]	0.32	<0.0001
ADG, kg/d					
100–142 d	0.61[a]	0.68[b]	0.75[c]	0.008	<0.0001
143–160 d	0.79[a]	0.82[b]	0.90[c]	0.008	0.0003
161–200 d	0.82[a]	0.86[b]	0.91[c]	0.008	<0.0001
Flank to flank, cm					
142 d	67.9[a]	68.6[b]	69.6[c]	0.13	<0.0001
160 d	73.3[a]	74.4[b]	75.7[c]	0.13	<0.0001
200 d	84.1[a]	85.5[b]	87.3[c]	0.13	<0.0001
Caliper, °					
142 d	5.9[a]	6.6[b]	7.3[c]	0.07	<0.0001
160 d	8.0[a]	9.0[b]	9.9[c]	0.07	<0.0001
200 d	12.3[a]	13.4[b]	14.7[c]	0.07	<0.0001
Backfat, mm					
142 d	8.2[a]	8.6[b]	9.0[c]	0.10	<0.0001
160 d	10.1[a]	10.5[b]	11.1[c]	0.10	<0.0001
200 d	15.2[a]	15.7[b]	16.6[c]	0.11	<0.0001
Loin depth, cm					
142 d	3.5[a]	3.7[b]	3.9[c]	0.02	<0.0001
160 d	3.8[a]	4.1[b]	4.4[c]	0.02	<0.0001
200 d	4.7[a]	5.1[b]	5.5[c]	0.02	<0.0001
Fat-to-lean ratio[3]					
142 d	2.43[a]	2.39[b]	2.35[c]	0.03	<0.0001
160 d	2.68[a]	2.58[b]	2.55[c]	0.03	<0.0001
200 d	3.26[a]	3.09[b]	3.06[c]	0.03	<0.0001
Fat-free-lean meat, kg					
142 d	33.4[a]	35.6[b]	37.4[c]	0.20	0.003
160 d	36.9[a]	39.8[b]	42.2[c]	0.20	<0.0001
200 d	45.0[a]	48.8[b]	52.0[c]	0.20	<0.0001

[a–c]Values within rows with different superscripts are significantly different among dietary treatments ($P < 0.01$).

[1]Body weight at 100 d of age was included in the statistical model as a covariate ($P < 0.05$).

[2]Treatment defined by SID lysine:ME ratio (g/Mcal): low = grower diet, 2.3; finisher diet, 1.7; medium = grower diet, 2.6; finisher diet, 1.9; high = grower diet, 2.8; finisher diet, 2.1. The grower diet was fed from 100 to 142 d of age; the finisher diet was fed from 142 to 201 d of age.

[3]Fat-to-lean ratio calculated as backfat divided by loin depth.

ment cycled within 7 d after transfer (Figure 1). Overall, more of the gilts fed the diet with a high SID lysine–to–ME ratio had a natural spontaneous first estrus and fewer required P.G.600 to induce a first estrus than gilts fed the diets with medium and low SID lysine–to–ME ratios ($P < 0.05$; Table 6). Age at first estrus (heat-no-serve) increased as the SID lysine–to–ME ratio in the diet decreased ($P < 0.001$). These data are consistent with the previous report in which gilts fed the diet with a high SID lysine–to–ME ratio reached puberty 10 d earlier than gilts fed the low diet (Calderón Díaz et al., 2017) and reinforces the supposition that gilts with greater lifetime growth rates (**LGR**) generally reach puberty sooner (Beltranena et al., 1991; Lents et al., 2013). Gilts fed the diet with a high SID lysine–to–ME ratio had LGR of 0.6 kg/d at first spontaneous estrus, and LGR was reduced as the SID ly-

Table 5. Least squares means and SEM for traits at first estrus of maternal-line gilts (Large White × Landrace) fed diets (ad libitum) with different standardized ileal digestible (SID) lysine–to–ME ratios from 100 to 200 d of age

	Dietary treatment[1]			Pooled	
Trait	Low	Medium	High	SEM	*P*-value
Natural first estrus					
Natural first estrus, %	53.8	56.3	54.5	—	—
Age, d	206	205	204	1.0	0.10
BW, kg	130.6[a]	132.7[b]	135.3[b]	0.8	0.05
Caliper, °	11.6[a]	12.5[b]	13.2[c]	0.2	0.001
Flank to flank, cm	86.4[a]	87.4[a]	88.4[b]	0.5	0.001
Backfat, mm	14.7[a]	15.1[b]	15.8[b]	0.2	0.001
Loin depth, cm	5.1[a]	5.3[b]	5.5[c]	0.04	0.001
Fat-free lean, kg	50.1[a]	51.8[b]	53.6[c]	0.5	0.002
Fat-to-lean ratio[2]	2.9	2.9	3.0	0.1	0.11
Lifetime growth rate,[3] kg/d	0.55[a]	0.56[b]	0.60[c]	0.003	0.008
First estrus induced with P.G.600[4]					
First estrus induced with P.G.600, %	46.2	43.7	45.5	—	—
Age, d	229	230	228	1.1	0.25
BW, kg	135.8[a]	135.7[a]	140.6[b]	1.0	0.002
Caliper, °	12.3[a]	12.0[a]	13.0[b]	0.3	0.04
Flank to flank, cm	86.4	85.6	86.4	0.5	0.57
Backfat, mm	13.0	13.1	13.4	0.4	0.53
Loin depth, cm	4.7[a]	4.9[b]	5.2[c]	0.09	0.003
Fat-free lean, kg	47.3[a]	48.8[b]	51.9[c]	0.9	0.002
Fat-to-lean ratio[2]	2.8	2.8	2.7	0.1	0.19
Lifetime growth rate, kg/d	0.51[a]	0.51[a]	0.54[b]	0.004	0.001

[a–c]Values within rows with different superscripts are significantly different among SID lysine:ME ratios ($P < 0.05$).

[1]Treatment defined by SID lysine:ME ratio (g/Mcal): low = grower diet, 2.3; finisher diet, 1.7; medium = grower diet, 2.6; finisher diet, 1.9; high = grower diet, 2.8; finisher diet, 2.1. The grower diet was fed from 100 to 142 d of age; the finisher diet was fed from 142 to 201 d of age.

[2]Fat-to-lean ratio was calculated as backfat divided by loin depth.

[3]Lifetime growth rate = ADG from birth to first estrus.

[4]P.G.600 (Merck Animal Health, Kenilworth, NJ) = pregnant mare's serum gonadotropin (400 IU) and human chorionic gonadotropin (200 IU).

sine–to–ME ratio of the diet decreased (Table 5). Lifetime growth rates below 0.6 kg/d are expected to delay onset of puberty (Beltranena et al., 1991; Bortolozzo et al., 2009; Patterson et al., 2016) and likely explains the early differences in pubertal response observed among treatments at the onset of boar stimulation.

Serum concentrations of progesterone were used to determine whether gilts that failed to be detected in estrus by 220 d of age had cycled or not. Concentrations of progesterone ≥1 ng/mL in serum indicate gilts had ovulated. Gilts that had failed to be detected in estrus by 220 d of age and had serum concentrations indicating ovulation were defined as behaviorally anestrus. The incidence of behavioral anestrus was 12.8% and did not differ between dietary treatments (13.4, 12.9, and 12.3% for high, medium, and low SID lysine diets, respectively). Consistent with our previous report (Calderón Díaz et al., 2017), most gilts that fail to display estrus are truly prepubertal. A significant portion of the gilts in this study required P.G.600 to induce a first estrus to fit into the management system and to meet weekly breeding needs. Early age at puberty has been linked to greater lifetime productivity (Flowers et al., 2015; Wijesena et al., 2017). This illustrates that getting more gilts to cycle earlier and reducing the use of P.G.600 should be a focal area when trying to improve productivity.

After adjusting for the effects of treatment, gilts that had their first estrus induced with P.G.600 had less BW and backfat at the start of boar exposure and when moved to sow farms than gilts that had a spontaneous natural first estrus ($P < 0.05$; Table 7). As mentioned, gilts with greater LGR generally reach puberty earlier, and it is sug-

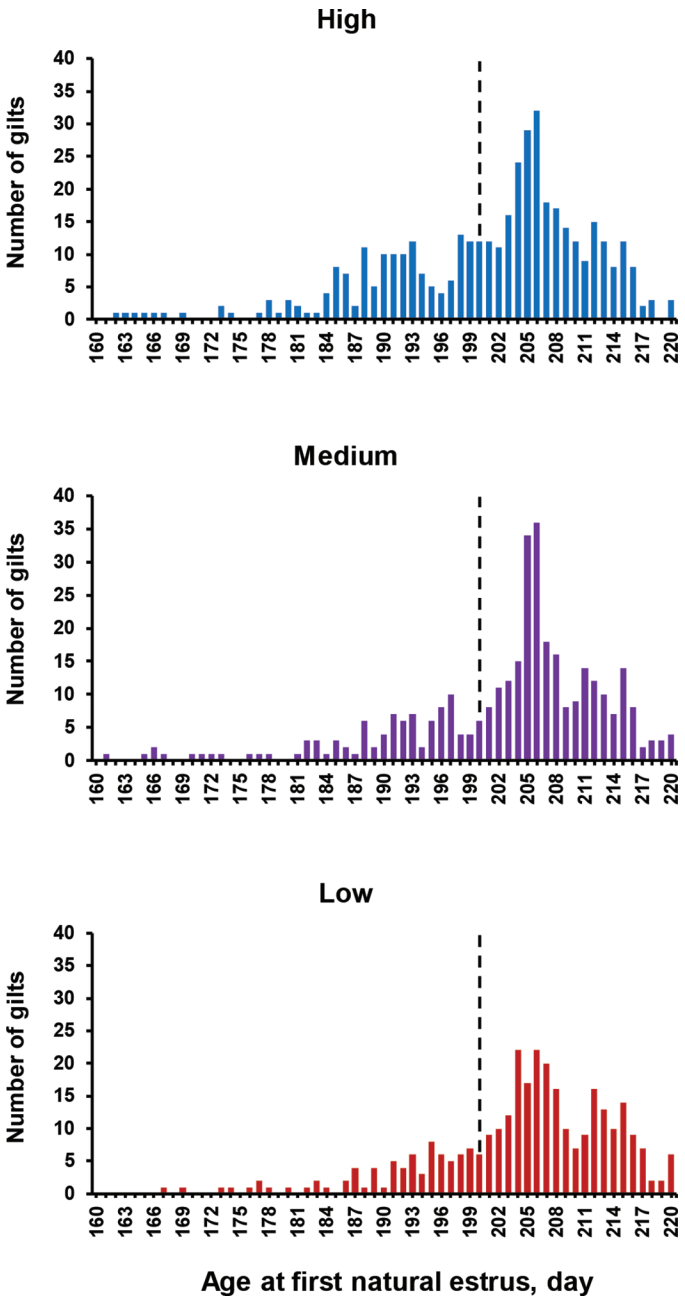

Figure 1. Frequency distribution for age at natural first estrus (first heat-no-serve) for maternal-line gilts (Large White × Landrace) fed diets (ad libitum) from 100 to 200 d of age with different standardized ileal digestible lysine:ME ratios (g/Mcal; low = grower diet, 2.3; finisher diet, 1.7; medium = grower diet, 2.6; finisher diet, 1.9; high = grower diet, 2.8; finisher diet, 2.1. The grower diet was fed from 100 to 142 d of age; the finisher diet was fed from 142 to 201 d of age.) The dashed line denotes the age at which gilts were moved from the gilt developer unit to the sow farms.

gested that the threshold for LGR is 0.6 to 0.7 kg/d (Beltranena et al., 1991; Bortolozzo et al., 2009), but only if boar exposure starts at about 140 d of age. If boar exposure starts at 160 d of age, as was the case in the current experiment, LGR of gilts did not appear to influence age at puberty (Amaral Filha et al., 2009). Gilts in the current study that displayed a spontaneous estrus in the GDU before moving to the sow farm were about 4 kg heavier and had about 1.4 mm more backfat at the start of boar exposure (160 d of age), and at 200 d of age, when movement to the sow farm occurred, gilts that had a spontaneous estrus in the GDU were 8.1 kg heavier and had 3.2 mm more backfat than gilts that required P.G.600 to induce a first estrus at the sow farm ($P < 0.05$; Table 7). Similarly, gilts that had a natural spontaneous estrus at the sow farm were 3.2 kg heavier and had 0.8 mm more backfat at the start of boar exposure when compared with gilts that required P.G.600 to induce first estrus, and the differences were even greater between these gilts at 200 d of age ($P < 0.05$; Table 7). This would suggest that small differences in growth rate can affect the onset of puberty even when boar exposure starts at 160 d of age. This can have important economic implications for the farm, both in the number of nonproductive days that gilts may accumulate and in the amount of P.G.600 that is used. It should be noted that overall LGR of gilts in the current study would be considered low growth when compared with typical studies with commercial gilts (Amaral Filha et al., 2009; Bortolozzo et al., 2009). This is reflective of the fact that SID lysine contents in current diets are 15 to 30% less (high and low SID lysine–to–ME ratio diet, respectively) than in typical diets fed to gilts in finishing (Calderón Díaz et al., 2015b). Lents et al. (2013) showed that gilts with greater LGR at 21 wk of age reached puberty earlier and that this was independent of backfat, which is consistent with previous research (Patterson et al., 2002). However, it has long been believed that gilts require a certain level of physiological maturity, as indicated by backfat, muscle mass, fat-to-lean ratio, and so on, to reach puberty (Kirkwood and Aherne, 1985). Gilts that had a spontaneous natural first estrus indeed had more backfat and LD at the beginning and throughout the current study than gilts that received P.G.600 to induce first estrus. Therefore, the greater LGR, backfat, and muscle in gilts that had a spontaneous first estrus likely reflects a greater physiological maturity than gilts that required P.G.600 for first estrus.

One of the hallmarks of an effective gilt stimulation program is for >80% of gilts to have a recorded estrus before delivery to the sow farm (Williams et al., 2005). The frequency distribution for first estrus in the current study (Figure 1) clearly shows this was not the case. When approximately 1,200 commercial gilts in Iowa were subjected to direct boar contact beginning at 160 d of age, a wide range in age at first estrus (160 to 265 d of age) was observed (Calderón Díaz et al., 2015b) with 3 distinct subpopulations of gilts defined as early responders, mid-responders, and late responders (Vallet, 2015). Gilt stimulation programs often involve remixing gilts every 2 wk to stimulate the onset of estrus in these mid and late responders (Levis, 2000; Soede et al., 2006). Due to a limited

Table 6. Number of maternal-line gilts (Large White × Landrace) fed diets (ad libitum) with different standardized ileal digestible (SID) lysine–to–ME ratios from 100 to 200 d of age, when gilts were in the gilt development unit (GDU), that had a spontaneous naturally occurring puberty in the GDU or the sow farm, or that had puberty induced at the sow farm with P.G.600[1]

	Dietary treatment[2]				
Item	**Low**	**Medium**	**High**	**Total**	***P*-value[3]**
Natural puberty in GDU, no.	93	114	179	386	0.0001
Natural puberty at sow farm, no.	278	278	289	845	
P.G.600 induced puberty, no.	405	358	335	1,098	
Total with puberty, no.	776	750	803	2,329	
Response to P.G.600 for puberty					
P.G.600 to induce puberty, no.	488	455	394	1,330	0.05
Estrus after P.G.600, no.	405	358	335	1,098	
Estrus after P.G.600, %	83.2	79.2	85.7	82.6	
No estrus after P.G.600, no.	83	97	59	239	
Mistimed P.G.600[4]	1	3	3	7	

[1]P.G.600 (Merck Animal Health, Kenilworth, NJ) = pregnant mare's serum gonadotropin (400 IU) and human chorionic gonadotropin (200 IU).

[2]Treatment defined by SID lysine:ME ratio (g/Mcal): low = grower diet, 2.3; finisher diet, 1.7; medium = grower diet, 2.6; finisher diet, 1.9; high = grower diet, 2.8; finisher diet, 2.1. The grower diet was fed from 100 to 142 d of age; the finisher diet was fed from 142 to 201 d of age.

[3]*P*-value is for the 3 × 3 chi-squared table (dietary treatment × puberty location or P.G.600 response, respectively).

[4]P.G.600 given in error at 1 to 16 d after puberty had occurred. For analysis, these animals were coded as having a natural puberty.

number of pens that could be allocated to each dietary treatment within a weekly gilt cohort, gilts in the present study could not be remixed in the GDU. Prepubertal gilts are expected to display estrus within a week after transport (Einarsson et al., 2008), and indeed, a large proportion of gilts in the current study cycled within 7 d of transport to the sow farm (Figure 1). This indicates that gilts were sexually mature enough to cycle but needed the additional stimulation of transportation to reach puberty. Due to constraints in the number of pens available for housing gilts and boars, the gilt-to-boar ratio used in the current study (20 to 24 gilts per boar) was greater than is typically considered optimal (15 to 17 gilts per boar) and may have contributed to the need for additional stimulation such as transportation to induce estrus. A separate study funded by the NPB sow lifetime productivity research initiative, conducted with over 4,000 commercial gilts in Minnesota, showed that an intensive boar stimulation program is critical for delivering a high proportion of breeding-eligible gilts to the sow farm (Patterson et al., 2016). Beginning at 160 d of age, gilts in the study by Patterson et al. (2016) were moved from their home pen to a boar exposure area for daily boar stimulation and estrus detection. The boar exposure area allowed for gilts to interact with a battery of up to 8 boars and included both fence-line and within-pen exposure for 15 min. Nonestrus gilts were remixed within 2 wk of onset of boar stimulation, and after 23 d were treated with P.G.600. Under these conditions, an average of 72% of gilts entering boar stimulation had a recorded heat-no-serve before delivery to the sow farm, with an average of 181 d of age at first heat-no-serve. About 47% of the gilts in the current study required P.G.600 to induce a first estrus to fit into the management system and to meet weekly breeding needs, with an average of 82.6% of gilts displaying estrus after P.G.600 (Table 6). Of gilts that entered intensive boar stimulation in the study by Patterson et al. (2016), an average of 24.5% received P.G.600 (weekly groups ranged from 8.7 to 48.6%), with 76.7% of these gilts displaying estrus. It is expected that using the high SID lysine–to–ME gilt-development diet described herein with the intensive boar stimulation program described in the study by Patterson et al. (2016) could be a highly effective strategy to optimize gilt growth and pubertal development.

Gilts removed during the feeding period represented 12% of total gilts on test (Table 8). This proportion is similar to previous studies (Knauer et al., 2011; Calderón Díaz et al., 2015a). There was no difference among dietary treatments in the total number of gilts removed or reason for removal ($P = 0.35$). The primary reason for removal was mortality (unexplained death, 30.6% of removals; euthanasia, 16.4% of removals) followed by tail injury (19.2% of

Table 7. Estimated differences in effect size for weight and backfat measures of maternal-line gilts (Large White × Landrace) fed diets (ad libitum) with different standardized ileal digestible (SID) lysine–to–ME ratios from 100 to 200 d of age, and that had a first estrus that occurred as a natural spontaneous estrus in the gilt development unit (GDU), that occurred as a natural spontaneous estrus after moving to the sow farm at 201 d of age, or that was induced with P.G.600[1] after 220 d of age

	Occurrence of first estrus[3]				Dietary treatment[4]			
Trait[2]	Never cycled	P.G.600 induced	Natural at sow farm	Natural in GDU	High	Medium	Low	Trait at d 100*
BW age 160 d, kg	0[a]	1.21[b]	4.39[c]	5.07[d]	0[a]	−4.22[b]	−7.57[c]	0.64
SE		0.53	0.56	0.64		0.37	0.37	0.01
BF age 160 d, mm	0[a]	0.26[b]	1.01[c]	1.62[d]	0[a]	−0.47[b]	−0.81[c]	0.95
SE		0.15	0.15	0.17		0.1	0.1	0.03
BW age 200 d, kg	0[a]	2.73[b]	7.36[c]	10.87[d]	0[a]	−6.01[b]	−11.19[c]	0.72
SE		0.76	0.79	0.91		0.52	0.52	0.02
BF age 200 d, mm	0[a]	0.51[b]	1.85[c]	3.78[d]	0[a]	−0.64[b]	−1.01[c]	1.43
SE		0.24	0.25	0.29		0.1	0.16	0.05

[a–d]Estimated effects with different superscripts within occurrence of first estrus or dietary treatment differ ($P < 0.05$).

[1]P.G.600 (Merck Animal Health, Kenilworth, NJ) = pregnant mare's serum gonadotropin (400 IU) and human chorionic gonadotropin (200 IU).

[2]Boar exposure began at 160 d of age. BF = backfat.

[3]Within occurrence of first estrus, estimates are adjusted for the effect of dietary treatment and trait at 100 d. Comparisons are relative to the never cycled and high treatment group, respectively.

[4]Treatment defined by SID lysine:ME ratio (g/Mcal): low = grower diet, 2.3; finisher diet, 1.7; medium = grower diet, 2.6; finisher diet, 1.9; high = grower diet, 2.8; finisher diet, 2.1. The grower diet was fed from 100 to 142 d of age; the finisher diet was fed from 142 to 201 d of age.

*Trait at 100 d of age (BW and BF, respectively) was significant ($P < 2.0E-16$).

removals) and poor body condition (18.3% of removals). In the previous report where gilts were fed these diets, poor body condition was the major reason for removal (Calderón Díaz et al., 2017); however, because gilts in that study were infected with porcine epidemic diarrhea virus, definitive conclusions about how SID lysine–to–energy ratios affected body condition during development could not be made. Current results confirm that decreasing SID

Table 8. Number of animals removed between 100 and 200 d of age with removal reason

	Reason for removal							
Dietary treatment[1]	Death	Poor body condition	Lame	Injured tail	Prolapse	Vulva injury	Euthanized	Total
Low	30	19	10	28	5	2	22	116
Medium	37	27	13	24	9	—	24	134
High	44	20	9	17	4	2	13	109
Total	111	66	32	69	18	4	59	359

[1]Treatment defined by standardized ileal digestible lysine:ME ratio (g/Mcal): low = grower diet, 2.3; finisher diet, 1.7; medium = grower diet, 2.6; finisher diet, 1.9; high = grower diet, 2.8; finisher diet, 2.1. The grower diet was fed from 100 to 142 d of age; the finisher diet was fed from 142 to 201 d of age.

lysine–to–ME ratios, within the range described in the present study, are not related to poor body condition as a removal reason. Additionally, leg problems were a major reason for removal (>70%) of gilts in the previous study (Calderón Díaz et al., 2015a); however, lameness accounted for less than 9% of the gilt removal in the current study.

APPLICATIONS

The NPB Sow Lifetime Research Consortium established an objective to formulate gilt-development diets that would slow growth and alter body composition of gilts when fed ad libitum under commercial conditions, with the expectation that such an approach would prove useful for improving sow lifetime productivity. The current results demonstrate that by increasing dietary NDF and reducing SID lysine–to–ME ratios during development, gilt growth can be slowed such that average BW of gilts are within the 115- to 140-kg pubertal weight range that has been proposed as optimal (Bortolozzo et al., 2009). There are, however, important considerations beyond this simple weight statistic. Reducing grams of SID lysine to megacalorie of ME in gilt-development diets decreased growth rate, muscle mass, and backfat, even though all gilts responded normally to typical management strategies (remixing and P.G.600). Reducing SID lysine–to–ME ratios below 2.8 to 2.1 g of SID lysine to megacalorie of ME (high grower and finisher ration, respectively) in gilt diets during development can be expected to increase age at puberty by reducing the number of gilts that have a spontaneous naturally occurring estrus and increasing the number of gilts requiring P.G.600 for puberty. The overall number of breeding-eligible gilts delivered to the sow farms in the current study was less than acceptable, but some of this effect was due to experimental and facility limitations. Gilts fed lower SID lysine–to–ME ratios reached puberty with less total BF and lean tissue, which may have negative consequences for sow productivity. Understanding growth and pubertal development of gilts in response to these diets is the first step in a series of studies. The next step will be to evaluate how these developmental responses affect gilt longevity and productivity from first through third parity.

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