Effect of Gestation Dietary Crude Protein Level on the Gestation and Lactation Performance of Primiparous Sows

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Introduction

Gestation is an especially demanding phase of production for the gilt because of the dual energy demands of body maturation (growth of muscle and fat reserves) and growth of the components of pregnancy (Pettigrew and Yang, 1997). Modern sow genotypes have an increased potential for lean gain and large litter size, and this makes an adequate supply of dietary amino acids critical for maximum reproductive efficiency. Currently, it is common to feed one 12 to 13% crude protein (CP) gestation diet, often at the same level of feed intake for the entire duration of gestation. This may prove adequate for gestating sows, but it does not appear to be adequate for gestating gilts to express their reproductive potential.

Recent research has confirmed the benefits of dietary CP levels in excess of NRC (1988) recommendations. Gilts fed higher levels of CP during gestation (16 vs. 13%) had increased litter weight gains and litter weaning weights (Mahan, 1998). Increased CP (16 g/day lysine) improved primiparous sow milk production and litter weight gain (Kusina et al., 1995). Dietary protein level during gestation can also affect sow body fat content at term and feed intake during the subsequent lactation. Energy demands are greatest during the last 2 to 3 weeks of gestation, and gilts are often forced to mobilize body reserves at this time to meet their increasing energy demands.

The objectives of this study were to 1) determine the effect of a two step increase in CP and a single step increase in CP and energy on gilt growth during gestation and reproductive performance during the subsequent lactation. We also wanted to 2) measure the levels of circulating metabolites and metabolic hormones to determine the impact of our dietary treatments on energy balance and body reserve mobilization during gestation and lactation in the gilt.

Materials and Methods

Seventy-five European gilts (1/2 Landrace, 1/4 Large White, 1/4 Duroc) were housed in an open-front unit in 8’x 44’ pens (22’ outside and 22’ under roof) in groups of 7 to 8 with fence line contact to a mature boar. Gilts were checked for heat twice daily and were bred via AI at their second or third estrus in the presence of a mature boar. Gilts were approximately 250 days old and weighed 330 lb at breeding. All gilts initially received 4.4 lb/day of a 13.3% CP, 0.6% lysine diet until day 40 of gestation. Gilts were then allotted by weight to one of 3 dietary treatments at approximately day 40 of gestation. Treatment 1 (Control) remained on the basal diet (13.3% CP, 0.6% lysine) and feeding level (4.4 lb/day) throughout gestation. Treatment 2 (2-Step CP) was stepped up in dietary CP at day 40 to a 14.6% CP, 0.7% lysine diet, and at day 80 to a 16% CP, 0.8% lysine diet, both fed at 4.4 lb/day. Treatment 3 (1-Step CP+E) was stepped up at day 80 of gestation in both CP and energy by increasing the feed intake of the basal diet from 4.4 to 6.0 lb/day. All diets were formulated to meet or exceed NRC (1988) nutrient requirements for breeding gilts. Nutrients provided by the diets and feeding levels used are listed in Table 1. Each gilt's gestation dietary treatment was continued until farrowing. Gilt weight and 10th rib backfat depth were measured on days 10, 40, 80 and 110 of gestation. Twelve gilts per treatment were bled via jugular venipuncture 2 hours postprandial (after feeding), between 9:30 and 10:30 a.m., on days 40, 80 and 110 of gestation to obtain samples for analysis of circulating blood metabolite and hormone levels.

Gilts were then given ad-libitum access to a 16.0% CP, 0.8% lysine lactation diet the day after farrowing, and feed intake was recorded weekly. Sows and their litters were weighed and sows' 10th rib backfat depth was measured on days 2 and 14 and at weaning. Lactation blood samples were drawn 2 hours after feeding 4.4 lb of the lactation diet between 8:30 and 9:30 a.m. on days 14 and 28.

Results and Discussion

Gilt gestation weight gain (WG) from days 80 to 110 was significantly increased by the 2-Step CP and 1-Step CP+E treatments (38.2 and 42.1 vs. 24.0 lb, P<.01) compared to the control treatment (Table 2). This increase in WG during the last 30 days (trimester) of gestation resulted in a greater total gestation weight gain (TGWG) for the 2-Step CP and 1-Step CP+E treatments (115.6 and 115.5 vs. 98.4 lb, P<.02). The 2-Step CP and 1-Step CP+E treatment gilts tended to be approximately 20 lb heavier at day 110 (461.2 and 460.5 vs. 439.9 lb, P<.07). Diet did not significantly affect 10th rib backfat depth (P>.40) or 10th rib backfat change (P>.34) during any trimester of gestation, and did not affect total gestation backfat gain (TGBFG; P>.58). However, gilts from the 1-Step CP+E treatment tended to gain slightly more backfat than the control and 2-Step CP treatments (0.33 vs. 0.30 and 0.28 in.).

Litter birth weight (BW) tended to be greater for the control treatment as compared to the 2-Step CP and 1-Step CP+E treatments (42.8 vs. 39.6 and 40.9 lb, P<.09). This is somewhat surprising, because litter BW was adjusted for litter size, and control gilts gained less weight during gestation. Logically, the 1-Step CP+E treatment should have resulted in an increased pig birth weight due to the extra energy provided during the last 30 days of gestation. Dietary treatment did not influence the total number of pigs born (TB) or the number of pigs born alive (BA). However, TB was numerically greater for the 2-Step CP treatment compared to the control and 1-Step CP+E treatments (11.6 vs. 10.4 and 10.8). The 2-Step CP treatment also had a significantly increased number of stillborn pigs (P<.01). Litter weights at days 14 and 18 and LWG were not different between dietary treatments. Sows from the 1-Step CP+E treatment tended to lose less weight during lactation than sows from the 2-Step CP treatment (17.8 vs. 31.3 lb, P<.07). Sow 10th rib backfat depth at weaning was also significantly greater for the 1-Step CP+E treatment as compared to the Control and 2-Step CP treatments (1.00 vs. 0.88 and 0.81 in., P<.05). This may be the result of the greater gestation WG and development of body reserves of the gilts in the 1-Step CP+E treatment. The increased level of feed intake (4.4 to 6.0 lb) during the last 30 days of gestation did not reduce lactation feed intake of the 1-Step CP+E treatment.

Levels of glucose, insulin, plasma urea nitrogen (PUN), creatinine and non-esterified fatty acids (NEFA) were not affected by dietary treatment (Table 3). However, levels of all of these compounds were changing over time (P<.01). Creatinine and NEFA levels are two indicators of catabolism (i.e., a negative energy balance). Creatinine is an indicator of muscle catabolism, and levels were highest at day 110. This suggests that muscle breakdown was highest during the last trimester of gestation. NEFA levels were highest during early lactation (day 14), indicating lipolysis (fat breakdown) was greatest at this time. Thus, peak creatinine and NEFA levels were reached at times when energy demands on the sow were greatest, and they reflect mobilization of body reserves (muscle and fat, respectively).

Applications

These data suggest that a 260 g/day CP, 12 g/day lysine diet is adequate to support gestating gilt reproduction; however, increased protein levels (260 to 340 g/day CP, 12 to 16 g/day lysine) do increase gilt weight gain during gestation. This extra weight gain could potentially help sows avoid depletion of body reserves and improve sow longevity. This was particularly evident in the reduced weight and backfat loss during lactation for the gilts that received extra CP and energy during the last 30 days of gestation. These data confirm that feeding 260 g/day CP and 12 g/day lysine restricts gilt growth and development of body reserves, and may limit other reproductive parameters. Gestating gilt nutrition should receive special attention, since gilt requirements for protein and energy are greater than those of sows. Increased reproductive performance of gilts over several parities may be realized by increasing levels of crude protein and energy during gestation. These benefits may be realized by increasing nutrient intake during specific stages of gestation rather than for the entire duration.

References

Kusina, J., J.E. Pettigrew, A.F. Sower, B.A. Crooker, M.E. White, M.R. Hathaway, and G.D. Dial. 1995. The effect of protein (lysine) intake during gestation and lactation on lactational performance of the primiparous sow. J. Anim. Sci. Abstract 73(Suppl. 1):85.

Mahan, D.C. 1998. Relationship of gestation protein and feed intake level over a five-parity period using a high-producing sow genotype. J. Anim. Sci. 76:533-541.

Pettigrew, J.E., and H. Yang. 1997. Protein nutrition of gestating sows. J. Anim. Sci. 75:2723-2730.

Table 1. Nutrients provided by gestation diets and feeding levels utilized.

% Crude Protein	Amount Fed (lb)	Crude Protein (g)	Lysine (g)	Energy (Kcal)
13.3	4.4	266	12.0	6521
14.6	4.4	292	14.0	6524
16.0	4.4	320	16.0	6545
13.3	6.0	359	16.2	8803

Table 2. Effect of 2-step increase in CP and a 1-step increase in CP and E versus a control CP level on gilt growth and lactation performance.

	1) Control	2) 2-Step CP	3) 1-Step CP+E	Effect of Diet	Contrast
No. Gilts	22	19	22		
Gilt Wt, d14 (lb)	342.1 ± 5.5	344.8 ± 6.0	346.4 ± 5.5	ns	ns
WG, d14-d40 (lb)	33.2 ± 2.0	34.7 ± 2.1	30.4 ± 2.0	ns	ns
WG, d40-d80 (lb)	41.2 ± 2.8	37.5 ± 3.1	41.9 ± 2.8	ns	ns
WG, d80-d110 (lb)	24.0 ± 4.3	38.2 ± 4.7	42.1 ± 4.3	P<.02	1 vs. 2&3, P<.01
TGWG (lb)	98.4 ± 5.4	115.6 ± 5.7	115.5 ± 5.4	P<.05	1 vs. 2&3, P<.02
Gilt Wt, d110 (lb)	439.9 ± 9.1	461.2 ± 9.6	460.5 ± 9.1	ns	1 vs. 2&3, P<.07
TGBFG (in)	0.30 ± 0.03	0.28 ± 0.03	0.33 ± 0.03	ns	ns
Gilt BF, d110 (in)	1.00 ± 0.03	0.99 ± 0.03	1.06 ± 0.03	ns	ns
Wt Loss, d110-d2 (lb)	31.4 ± 6.4	39.0 ± 6.8	42.0 ± 6.7	ns	ns
Litter BW (BA+SB), d2	42.8 ± 1.1	39.6 ± 1.2	40.9 ± 1.2	ns	1 vs. 2&3, P<.09
Total Born (BA+SB)	10.4 ± 0.8	11.6 ± 0.8	10.8 ± 0.8	ns	ns
No. Born Alive	10.0 ± 0.7	10.6 ± 0.8	10.2 ± 0.8	ns	ns
No. Stillborn	0.3 ± 0.2	1.0 ± 0.2	0.4 ± 0.2	P<.03	2 vs. 1&3, P<.01
LW, d14 (lb)	82.8 ± 4.1	73.78 ± 4.4	79.9 ± 4.2	ns	ns
No. Pigs, d14	8.6 ± 0.4	8.4 ± 0.4	9.1 ± 0.4	ns	ns
LW, d28 (lb)	137.8 ± 9.4	130.4 ± 8.9	144.3 ± 8.9	ns	ns
No. Pigs, d28	8.4 ± 0.6	8.3 ± 0.6	9.0 ± 0.6	ns	ns
Sow Lact Wt Loss (lb)	29.4 ± 5.3	31.1 ± 5.3	17.8 ± 5.5	ns	2 vs. 3, P<.07
Sow Wean Wt (lb)	378.2 ± 7.6	383.9 ± 7.7	396.2 ± 7.5	ns	ns
Sow Lact BF Loss (in)	0.10 ± 0.03	0.09 ± 0.03	0.06 ± 0.03	ns	ns
Sow BF, Weaning (in)	0.88 ± 0.07	0.81 ± 0.06	1.00 ± 0.06	ns	1&2 vs. 3, P<.05
Lact ADFI Wk 1 (lb)	8.4 ± 0.6	7.7 ± 0.6	8.6 ± 0.6	ns	ns
Lact ADFI Wk 2 (lb)	11.5 ± 0.7	9.0 ± 0.8	10.6 ± 0.8	ns	ns

Table 3. Circulating levels of glucose, insulin, plasma urea nitrogen (PUN), creatinine and non-esterified fatty acids (NEFA) during gestation and lactation.

Metabolite and Day of Gestation or Lactation		1) Control	2) 2-Step CP	3) 1-Step CP+E	Effect of Diet
Glucose (mg/dL)[a]	d 40	47.0 ± 4.2	53.6 ± 4.7	51.9 ± 4.0	ns
	d 80	45.1 ± 4.2	54.0 ± 4.4	54.0 ± 4.0	ns
	d 110	63.5 ± 4.2	64.8 ± 4.4	60.6 ± 4.0	ns
	d 14	69.4 ± 4.2	65.8 ± 4.5	74.8 ± 4.1	ns
	d 28	63.3 ± 5.5	69.3 ± 6.6	62.1 ± 6.0	ns
Insulin (uIU/mL)[a]	d 40	14.2 ± 4.9	18.7 ± 4.8	15.0 ± 4.9	ns
	d 80	20.7 ± 4.9	20.6 ± 5.7	18.6 ± 4.9	ns
	d 110	20.3 ± 4.9	25.4 ± 5.7	23.6 ± 4.9	ns
	d 14	21.1 ± 5.2	25.2 ± 6.1	32.5 ± 5.2	ns
	d 28	14.5 ± 6.8	18.9 ± 8.5	12.2 ± 6.3	ns
PUN (mg/dL)[ab]	d 40	14.0 ± 3.1	16.1 ± 3.0	22.4 ± 3.1	1 vs. 3, P<.07
	d 80	14.3 ± 3.1	15.1 ± 3.6	16.8 ± 3.1	ns
	d 110	11.0 ± 3.1	15.7 ± 3.6	13.9 ± 3.1	ns
	d 14	16.9 ± 3.3	20.0 ± 3.9	18.3 ± 3.2	ns
	d 28	16.6 ± 4.3	19.5 ± 5.4	20.7 ± 3.9	ns
Creatinine (mg/dL)[a]	d 40	1.98 ± 0.20	2.01 ± 0.19	2.06 ± 0.20	ns
	d 80	2.15 ± 0.20	2.02 ± 0.23	2.13 ± 0.20	ns
	d 110	2.48 ± 0.20	2.35 ± 0.23	2.37 ± 0.20	ns
	d 14	1.78 ± 0.21	2.17 ± 0.25	2.12 ± 0.20	ns
	d 28	1.65 ± 0.28	2.01 ± 0.35	1.82 ± 0.25	ns
NEFA (umol/L)[a]	d 40	80.9 ± 32.1	86.0 ± 29.2	87.0 ± 30.1	ns
	d 80	152.9 ± 30.1	145.2 ± 34.7	155.9 ± 30.1	ns
	d 110	125.2 ± 30.1	156.4 ± 34.7	99.1 ± 30.1	ns
	d 14	264.8 ± 32.1	292.4 ± 37.4	269.6 ± 30.7	ns
	d 28	227.0 ± 41.7	169.8 ± 52.2	223.1 ± 38.3	ns

[a] Time effect (P<.01)
[b] Time x Diet effect (P<.04)