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Animal Feed Science and Technology
127 (2006) 187–199
ANIMAL FEED SCIENCE AND TECHNOLOGY
www.elsevier.com/locate/anifeedsci

Effects of high feed intake during early gestation on sow performance and offspring growth and carcass characteristics[☆]

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Received 15 June 2004; received in revised form 5 July 2005; accepted 29 August 2005

Abstract

A total of 715 sows and their 4193 offspring were used to evaluate effects of increasing feed intake during gestation on sow performance and carcass characteristics of offspring. Two experiments were conducted in southwestern Minnesota on a commercial 3000 sow (PIC, C22 sows × line 337 boars) farrow-to-wean facility, with offspring followed through offsite nursery and finishing complexes. In Exp. 1, sows ($n = 321$) were allotted to one of three treatments: 1.81 kg/d of complete (145 g CP/kg, 7 g/kg lysine, 10 g P/kg, and 9 g Ca/kg) feed (control), 1.81 kg/d complete feed plus 1.81 kg/d of ground maize (added maize), or 3.63 kg/d of complete feed (extra feed) from days 30 to 50 of gestation. Sows were fed 1.81 kg/d of the same diet from breeding until day 30 and between days 50 and 100. All sows were fed 2.72 kg/d after day 100 of gestation until farrowing (day 114). Sows fed increased complete diet from days 30 to 50 of gestation had fewer ($P < 0.05$) pigs born alive than control sows; however, this decrease was not observed for sows fed added maize. Increased complete diet fed from days 30 to 50 of gestation resulted in heavier ($P < 0.05$) offspring at slaughter than controls with offspring from sows fed additional maize being intermediate. Gilt offspring from sows that were provided extra feed

[☆] Contribution no. 02-482-J of the Kansas Agricultural Experimental Station, Manhattan 66506-0210, KS, USA.

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doi:10.1016/j.anifeedsci.2005.08.017

or maize had increased ($P < 0.05$) percentage lean and fat free lean index. In Exp. 2, sows ($n = 394$) were fed 3.63 kg/d of complete diet for one of three periods; days 10–30 (embryonic), 30–50 (early fetal), or 10–50 (embryonic + early fetal) of gestation, versus a control level of 1.81 kg/d from days 10 to 50. Contrary to Exp. 1, increased complete diet treatments did not affect the number of pigs farrowed, and sows fed 3.63 kg/d of feed from days 30 to 50 produced offspring with greater backfat and lower percentage lean than other treatments. It is not known why the positive treatment effects on offspring carcass characteristics in Exp. 1 were not repeated in Exp. 2. Possible explanations are differences in the weight of offspring at harvest, sow parity, and differences in number of pigs born alive. Additional research is needed to identify and evaluate these factors which are influencing this variation.

Keywords: Gestation; Leanness; Offspring; Sow

1. Introduction

Improvements in fetal muscle fibre growth in fetal-pigs have been observed when maternal feed is increased during gestation (Dwyer et al., 1994), or the sows are treated with added somatatropin (Rehfeldt et al., 1993; Kelly et al., 1995), or supplemental L-carnitine (Musser et al., 2001). The increased fetal muscle fibre development may result from improvements in glucose utilization and homeostasis, leading to stimulated fetal growth through increased production of IGF-I by the fetuses (Bassett et al., 1990; Magri et al., 1991).

Muscle fibre number is determined prenatally and, if hypertrophy is not limited after birth, increasing the number of muscle fibres would result in a larger total muscle volume (Luff and Goldspink, 1970; Miller et al., 1975). Development is based on the formation of primary muscle fibres in the early embryonic period (Wigmore and Stickland, 1983). These primary fibres are surrounded by secondary muscle fibres (fast-twitch, white) by day 90 of gestation to form several individual fibre bundles (Kelly and Zacks, 1969; Wigmore and Stickland, 1983; Duxson and Usson, 1989). After secondary muscle fibres form, a steady rate of transformation between muscle fibre types occurs throughout life to a muscle with the appropriate fibre phenotypes, specific to muscle load and function.

Studies have identified two gestational periods for that influence muscle fibre number (Rehfeldt et al., 1993; Dwyer et al., 1994). These are the embryonic period (days 10–30), when differentiation of germ layers provides the development of tissues and organs of the fetus, and the early fetal period (days 30–50), which immediately precedes secondary muscle fibre differentiation. Therefore, our objective was to determine if manipulation of feed intake during gestation could alter fetal muscle development and carcass characteristics.

2. Materials and methods

2.1. General

The experimental protocols used in these studies were approved by the Kansas State University Animal Care and Use Committee. Both experiments were conducted on a 3000-

sow (C22 sows bred to line 337 boars, PIC USA, Franklin, KY) farrow-to-wean operation in southwestern Minnesota. During gestation, sows were individually fed and housed in crates (2.13 m × 0.61 m) in a totally slatted, double curtain sided gestation facility. This facility operated on natural ventilation during the summer months and mechanical ventilation during the winter. In Exp. 1, sows were bred in August 1996 and their offspring were harvested in May the following year. Sows were bred and started on test over a 3-wk period. In Exp. 2, sows were bred in August 1997 and their offspring harvested in May the following year. Sows were bred and started on test over a 4-wk period. On approximately day 110 of gestation, sows were moved into an environmentally controlled farrowing facility (20–21 °C). Sows were housed in crates (2.13 m × 0.61 m) with an area (2.13 m × 0.46 m) on either side for the pigs. At birth, pigs were ear notched to identify sow gestation treatment, cross fostered among the three previous gestation treatments, and weaned at 18 ± 3 d. All sows were fed three times each day during lactation to attempt to provide feed ad libitum. The lactation diet contained 11.5 g lysine/kg, 9 g Ca/kg, and 8 g total P/kg. At weaning pigs were moved to 1250 head environmentally controlled nurseries within this commercial production system. Pigs were housed in pens with plastic or woven-wire flooring with 25–28 pigs per pen providing a minimum of 0.28 m^2/pig. After approximately 8 wk, pigs were moved to 1200 head double curtain sided naturally ventilated finishing barns with total concrete slat flooring. On average there were 26 pigs per pen with 0.70 m^2/pig.

After weaning, all pigs were phase fed the same diets formulated to exceed nutrient requirement estimates for their specific weights (NRC, 1998). Farrowing and litter data included the number of pigs born alive, stillborn, and mummified per litter. For carcass data collection, individual pig was considered the experimental unit.

2.2. Experiment 1

2.2.1. Animals

A total of 321 sows with an average parity of 3.2 were used. Sows were fed 1.81 kg/d of a gestation diet from days 0 to 30 of gestation and again after day 50 of gestation until day 100, after which the sows were fed 2.72 kg/d until farrowing. On day 30 of gestation, groups of five sows were randomly assigned to one of three gestation treatments.

2.2.2. Diets

Experimental treatments were fed from days 30 to 50 of gestation and consisted of feeding either: 1.81 kg/d of gestation diet (control), 1.81 kg/d of gestation diet plus 1.81 kg/d of additional ground maize (added maize) or 3.63 kg/d of gestation diet (extra feed). The gestation diet contained 145 g CP/kg, 7 g total lysine/kg, 10 g Ca/kg, and 9 g P/kg (Table 1). The control sows and sows fed increased amount of gestation diet were fed once per day with a feed drop systems (Chore-Time; Milford, IN) that dropped feed into a trough. Sows fed the additional ground maize received the gestation diet (1.81 kg/d) fed by the feed drops and the additional ground maize (1.81 kg/d) as a topdressing provided by hand at the same time as the diet. Studies that have observed improved offspring growth performance via altered gestation feeding regimens have predominantly increased the total amount of complete feed given to the sow. The objective of providing sows only extra maize was to

Table 1
Gestation diet composition (as-fed basis)

Ingredient	g/kg[a]
Maize	746.3
Soybean meal, 46.5 g CP/kg	156.0
Alfalfa meal	50.0
Monocalcium phosphate	25.1
Limestone	11.1
Salt	5.0
Sow premix[b]	2.5
Vitamin premix[c]	2.5
Trace mineral premix[d]	1.5

[a] The gestation diet contained 13.81 MJ/kg, 145 g CP/kg, 7.0 g lysine/kg, 10 g Ca/kg, and 9.0 g P kg.
[b] Supplied per kilogram of diet: 386 mg of choline, 0.22 mg of D-biotin, and 1.65 mg of folic acid.
[c] Supplied per kilogram of diet: 11,025 IU of Vitamin A, 1654 IU of Vitamin D_3, 44.1 IU of Vitamin E, 4.4 mg of menadione sodium bisulfite, 8.3 mg of riboflavin, 28.7 mg D-pantothenic acid (as D-calcium pantothenate), 49.6 mg of niacin, 165.4 mg of choline, and 0.03 mg of Vitamin B_{12}.
[d] Supplied per kilogram of diet: 39.7 mg of Mn (oxide), 165.4 mg of Fe (sulfate), 165 mg Zn (oxide), 16.5 mg of Cu (sulfate), 0.30 mg of I (as Ca iodate), and 0.30 mg of Se (as Na selenite).

make a preliminary determination if responses were a result of added energy (maize) or complete diet.

2.2.3. Production measurements

In addition to the sow and litter data described above, pigs in a sub-sample of approximately 24 litters/treatment (randomly sampled from 1 wk's farrowing) were weighed individually to determine the effects of treatments on pig birth weight and the pig-to-pig variation in birth weight within the litters. Pigs were weaned on day 18 and the length from weaning until return to estrus was recorded.

2.2.4. Blood sampling

On day 95 of gestation, blood was collected from randomly selected sows (14/treatment) from 1 wk's breeding. Blood (5 mL) was collected into tubes containing heparin by vena puncture 2 h after feeding. Blood was centrifuged (4000×*g* for 20 min) for plasma extraction. Plasma samples were analyzed for total IGF-I concentrations.

Concentrations of IGF-I in the plasma were determined in a single assay which is a two-sided immunoradiometric assay (IRMA) provided in a coated-tube kit (ActiveTM IGF-I with Extraction, DSL-5600, Webster, TX). Results are calculated using a log–log curve fit, and net counts per minute (CPM) for the control and standards are used to calculate the IGF-I concentration (ng/mL) of the unknown samples from their respective CPMs. Assay sensitivity was 0.024 ng/mL, and the intra-assay coefficient of variation was 3.01%.

2.2.5. Offspring marketing and performance

Pigs were ear notched at birth according to the maternal treatment in gestation. Within 72 h after farrowing, littersize was equalized by cross fostering pigs across all maternal gestation treatments. At weaning, all pigs were sorted based on gender, then litters were mixed, and moved to offsite nurseries. At 10 wk of age, pigs were moved to finishing facilities, and at marketing, pigs were sorted and transported separately by treatment and gender (i.e., castrates or gilts from each individual treatment) into separate compartments of the trailer. Pigs were marketed over a 7-d period and pigs from all treatments were included in each slaughter day. Pigs averaged approximately 161 d of age and 125 kg at marketing. Individual carcass measurements were obtained on 2358 pigs.

2.3. Experiment 2

2.3.1. Animals

A total of 394 sows with an average parity of 3.9 from the same 3000 sow commercial farm used in Exp. 1 were assigned randomly in groups of five to one of four treatments. Treatments were based on the feed intake level during periods of fetal development during gestation.

2.3.2. Diets

The diet composition was the same as Exp. 1 (Table 1). Sows were allotted to treatment at breeding and fed 1.81 kg/d of a complete gestation diet until day 10 (day 0 defined as the onset of estrus). Control sows were fed 1.81 kg/d from days 10 to 50 of gestation. Treated sows received increased amount of feed (3.63 kg/d) of the complete diet for one of three different periods during gestation: days 10–30, 30–50, or 10–50 of gestation. The objective of selecting the three feeding periods was to attempt to define the optimal period of gestation which extra feed would impact fetal development. Sows were allotted to treatment at breeding and fed 1.81 kg/d of a complete gestation diet until day 10 (day 0 defined as the onset of estrus). All sows were provided 1.81 kg/d from days 50 to 100 and 2.72 kg/d from days 100 to 114 of gestation.

2.3.3. Production measurements

Similar to Exp. 1, sow farrowing data included number of pigs born alive, stillborn, and mummified per litter.

2.3.4. Blood sampling

Maternal plasma samples were collected from approximately 20 sows per treatment (randomly sampled from 1 wk's breeding group) on day 50 of gestation (3 h after the meal) then divided into four aliquots and frozen for later determination of plasma total and free IGF-I and insulin concentrations. Procedures used were the same as described in Exp. 1, with the addition of the free IGF-I assay.

Plasma-free IGF-I concentrations were determined using a two-sided IRMA provided in a coated-tube kit (ActiveTM Free IGF-I with Extraction, DSL-9400, Webster, TX). Assay sensitivity was 0.03 ng/mL, and intra-assay coefficient of variation was 6.78%.

Concentration of insulin in plasma was determined in a single assay using a coated-tube kit (Coat-A-Count® Insulin, DPC, Los Angeles, CA). The quantity of insulin in the sample was then determined by comparing the counts to a standard curve. When 0.104, 0.312, 1.04, 2.08, and 4.16 ng/mL insulin were added to 100 μL of zero calibrator, recovery averaged 107%. To determine parallelism of the analysis, various volumes of pig serum (100, 150, and 200 μL) were assayed providing estimates of insulin concentration of 1.93, 1.98, and

1.05 ng/mL, respectively. Sensitivity of the assay was 2 μIU/mL and intra-assay variation was 4.9%.

2.3.5. Offspring marketing and performance

A sub-sample of litters (approximately 20 per treatment) from 1 wk's farrowing group was weighed at birth, and within litter variation of pig birth weight was also evaluated. Pigs were ear notched at birth according to the maternal treatment in gestation and littersize was then equalized across treatments. At weaning (day 18), pigs were sorted by gender, mixed among the maternal gestation treatments, and moved to offsite nurseries. Pigs were moved to finishing buildings at approximately 63 d of age. At the time of marketing, pigs were sorted and loaded by treatment and gender (i.e., castrates or gilts from each individual treatment). Pigs were sold over a 14-d period, with pigs from all treatments being represented each harvest day (Swift, Inc., Worthing, MN). Pigs averaged approximately 150 d of age and 112 kg at marketing. Individual carcass measurements were obtained on 1835 pigs.

2.3.6. Statistical analysis

Data were analyzed using the GLM procedure of SAS (SAS Institute Inc., Cary, NC). Sow was considered as the experimental unit in the analysis of farrowing data with parity as the covariate. In the analysis of carcass data, pig was used as the experimental unit. Hot carcass weight was used as a covariate for the analysis of 10th rib fat depth, loin depth, percentage lean, and fat free lean index. Analysis of interactions between gender of offspring and treatment was determined, due to gilts expressing more lean at slaughter. When F-tests were significant ($P<0.05$), separation of means was completed with the LSD procedure of SAS. Variation in birth weight was evaluated using Levene's test, which measures the absolute difference between the mean birth weight and individual pig weight (Milliken and Johnson, 1984). This analysis reports values in which lower values correspond to less variation within the litter. Sow was used as the experimental unit in the analysis. Values reported are least square means with or without the specified covariates.

3. Results

3.1. Experiment 1

Sows fed increased amount of gestation diet from days 30 to 50 of gestation had fewer ($P<0.05$) total pigs born and tended to have fewer ($P<0.058$) pigs born live than either control sows or sows fed added maize; this decrease was not observed for sows fed additional ground maize (Table 2). No differences were observed for the number of pigs stillborn or mummified per litter ($P>0.10$). Length of return to estrus was unaffected ($P>0.10$) by treatments. No differences ($P>0.05$) were observed for concentrations of total IGF-I in plasma (20.64, 29.06, and 20.08 ng/mL IGF-I; S.E. 4.94, for control, 1.81 kg complete diet and 1.81 kg of added maize, and 3.63 kg of complete diet, respectively).

Hot carcass weights of offspring (castrates and gilts) from sows fed increased amount of gestation diet and gilts from sows fed added maize from days 30 to 50 of gestation were heavier ($P<0.05$) at slaughter than offspring of controls (Table 3). Differences were

Table 2
Effects of feed intake from days 30 to 50 of gestation on sow and litter performance, Exp. 1

Item	Complete diet, 1.81 kg/d[a]	Complete diet, 1.81 kg/d plus 1.81 kg/d of ground maize	Complete diet, 3.63 kg/d	P[b]	S.E.M.
No. of sows	111	108	102	–	–
Lactation length (d)	16.79	16.06	16.49	<0.225	0.31
Average parity[c]	3.41	3.12	3.32	<0.538	0.20
No. of pigs per litter					
Total born	11.01d	10.67d	9.80e	<0.05	0.36
Born live	10.14d	10.03d	9.14e	<0.058	0.33
Stillborn	0.59	0.42	0.52	<0.414	0.09
Mummies	0.28	0.22	0.14	<0.309	0.06
Length of return to estrus (d)	5.85	6.02	6.43	<0.555	0.39
Litter birth weight (kg)[d]	15.78	15.77	14.95	<0.540	0.70
Pig birth weight (kg)[d]	1.42	1.47	1.34	<0.262	0.06
Residual variation in birth weight (kg)[d]	0.28	0.25	0.30	<0.293	0.03

Within a row, means without a common letter differ ($P<0.05$).
[a] The gestation diet was formulated to contain 145 g CP/kg, 7.0 g lysine/kg, 10 g Ca/kg, and 9.0 g P/kg.
[b] Overall model probability value.
[c] Used as a covariate in the analysis of farrowing performance.
[d] A sample of litters, selected at random ($n=24$, 26, and 22 litters per treatment, respectively) were weighed.

not observed in castrate offspring for 10th rib fat depth; however, gilts from sows fed added maize or increased complete diet had less ($P<0.01$) 10th rib fat depth at slaughter than controls. No differences were observed for loin depth in gilts from various maternal treatments. Castrates from sows fed additional maize had greater ($P<0.01$) loin depth than offspring from sows fed either control levels or increased amount of diet. Gilts from sows fed either additional maize or increased complete diet had a greater ($P<0.01$) percentage lean and fat free lean index than gilts from control sows. No differences were observed ($P>0.10$) in either percentage lean or fat free lean index of castrates from the various maternal treatments.

3.2. Experiment 2

Sows provided increased feed during any treatment phase of gestation had similar number of pigs born compared to control sows (Table 4). No differences ($P>0.10$) were observed for the number of pigs born alive, stillborn, or mummified per litter. No differences were observed ($P>0.10$) in either pig or litter birth weight or variation in pig birth weight.

Free IGF-I (not bound by binding proteins) was elevated ($P<0.05$; Table 5) on d 50 in plasma of sows fed increased feed from days 30 to 50 and 10 to 50 of gestation but not for sows fed increased feed from days 10 to 30. Total IGF-I did not differ for the various treatments, nor did the percentage of IGF-I that was in the bound form (approximately 98% bound). Insulin was elevated ($P<0.01$) on day 50 of gestation, with sows fed 3.63 kg/d from days 30 to 50 having the highest values.

Table 3
Effects of feed intake from days 30 to 50 of gestation on carcass characteristics of offspring, Exp. 1

Item	Complete diet, 1.81 kg/d[a]	Complete diet, 1.81 kg/d plus 1.81 kg/d of ground maize	Complete diet, 3.63 kg/d	P[b]	S.E.M.
No. of pigs					
Castrates	404	412	366	–	–
Gilts	403	433	340	–	–
Hot carcass weight (kg)[c]					
Castrates	94.2d	94.9d	95.8e	<0.05	0.26
Gilts	91.7d	93.2e	93.3e	<0.033	0.28
10th rib fat depth (mm)[d]					
Castrates	20.27	20.23	20.44	<0.772	0.13
Gilts	17.28d	16.70e	16.46e	<0.01	0.11
Loin depth (mm)[d]					
Castrates	57.88d	58.93e	57.62d	<0.01	0.17
Gilts	58.97	59.72	59.23	<0.212	0.18
Lean (g/kg)[d,e]					
Castrates	535	536	533	<0.406	0.7
Gilts	555d	558e	559e	<0.01	0.8
Fat free lean index (g/kg)[d,e]					
Castrates	491	491	490	<0.774	0.6
Gilts	504d	506e	508e	<0.01	0.6

Within a row, means without a common letter differ ($P<0.05$).
[a] The gestation diet was formulated to contain 145 g CP/kg, 7.0 g lysine/kg, 10 g Ca/kg, and 9.0 g P/kg. Pigs averaged approximately 161 d of age and 125 kg at marketing.
[b] Overall model probability value.
[c] Means were adjusted for age at market by covariate analysis.
[d] Hot carcass weight was used as a covariate in the analysis.
[e] Represents abattoir calculated values.

Pigs were slaughtered at a heavier hot carcass weight in Exp. 1 than in Exp. 2 (93.9 kg versus 84.1 kg; Table 6). No differences (P>0.22) were observed for hot carcass weight; however, castrate offspring from sows fed increased feed from days 30 to 50 of gestation had decreased ($P<0.05$) loin depth than offspring from other sows. Offspring from sows fed increased feed from days 30 to 50 of gestation also had decreased ($P<0.05$) percentage lean and fat free lean index, and increased ($P<0.05$) 10th rib fat depth. Feeding sows 3.63 kg/d of diet from days 10 to 50 resulted in offspring carcass characteristics similar (P>0.10) to controls.

4. Discussion

Dwyer et al. (1994) investigated the impact of increased feed intake (5 kg/d) during gestation (days 25–50, 50–80, or 25–80) on muscle fibre development and postnatal performance. No differences were found among treatments, but a tendency was reported for

Table 4
Effects of increased feed intake during gestation on sow and litter performance, Exp. 2

Item	Control 1.81 kg/d[a]	3.63 kg/d of feed from days			P[b]	S.E.M.
		10 to 30	30 to 50	10 to 50		
No. of sows	104	97	95	98	–	–
Average parity	3.52c	4.41d	3.87c	3.69c	<0.069	0.26
No. of pigs born[c]	10.28	10.59	9.99	9.81	<0.481	0.60
No. of pigs born alive[c]	8.78	9.16	8.53	8.08	<0.229	0.60
No. of pigs born stillborn[c]	0.92	0.90	0.93	1.08	<0.677	0.16
No. of pigs born mummified[c]	0.58	0.54	0.52	0.65	<0.930	0.23
No. of litters	17	19	14	21	–	–
No. pigs per litter	8.94	9.26	9.29	9.71	<0.822	0.67
Avg. pig birth weight (kg)	1.39	1.56	1.57	1.45	<0.321	0.08
Avg. litter birth weight (kg)	13.99	14.77	14.88	14.32	<0.861	0.86
Residual variation in birth weight (kg)[d]	0.20	0.20	0.29	0.22	<0.157	0.03

Within a row, means without a common letter differ ($P < 0.05$).
[a] The gestation diet was formulated to contain 145 g CP/kg, 7.0 g lysine/kg, 10 g Ca/kg, and 9.0 g P/kg.
[b] Overall model probability value.
[c] Means were adjusted for parity by covariate analysis.
[d] Test measures the absolute difference between the mean birth weight and individual pig weight. Lower values would indicate less variation of weight within the litter.

an increase in muscle fibre number in offspring from sows fed 5 kg/d from either days 25 to 50 (9% improvement) or days 25 to 80 (5% improvement) of gestation compared to controls. Dwyer et al. (1994) also observed an increase in the ratio of secondary to primary fibres, indicating a more glycolytic-type muscle. A positive relationship between fibre number and growth (ADG days 70–130, $r = +0.415$; $P < 0.001$) and feed efficiency ($r = +0.419$; $P < 0.001$; Dwyer et al., 1993) has been reported to support the impact of fibre number on postnatal growth.

In Exp. 1, we observed decreased total number of pigs born alive in sows fed increased amount of gestation diet from days 30 to 50; however, sows fed additional ground maize farrowed litters similar to those of the controls. Nor were there any differences in litter

Table 5
Effects of increased feed intake during gestation on blood metabolites, Exp. 2

Item	Control 1.81 kg/d[a]	3.63 kg/d of feed from days			P[b]	S.E.M.
		10 to 30	30 to 50	10 to 50		
No. of sows[c]	19	21	17	18	–	–
Total IGF-I (ng/mL)	59.5	50.1	74.9	67.5	<0.201	8.85
Free IGF-I (ng/mL)	1.31de	1.18d	1.62e	2.05f	<0.01	0.24
IGF-I bound (%)	98.2	99.3	98.5	98.1	<0.344	0.57
Insulin (ng/mL)	0.78de	0.63d	1.04f	0.84ef	<0.01	0.09

Within a row, means without a common letter differ ($P < 0.05$).
[a] The gestation diet was formulated to contain 145 g CP/kg, 7.0 g lysine/kg, 10 g Ca/kg, and 9.0 g P/kg.
[b] Overall model probability value.
[c] Sows were bled 3 h after feeding on day 50 of gestation.

Table 6
Effects of increased feed intake during gestation on offspring carcass performance, Exp. 2

Item	Control 1.81 kg/d[a]	3.63 kg/d of feed from days			P[b]	S.E.M.
		10 to 30	30 to 50	10 to 50		
No. of pigs						
Castrates	198	246	228	200	–	–
Gilts	188	294	237	244	–	–
Hot carcass weight (kg)[c]						
Castrates	84.0	85.3	83.6	83.8	<0.215	0.69
Gilts	83.6	84.3	85.0	83.0	<0.222	0.70
10th rib fat depth (mm)[d,e]						
Castrates	16.7f	16.4f	17.8g	16.8f	<0.01	0.25
Gilts	12.8f	13.0f	13.8g	13.2f	<0.01	0.21
Loin depth (mm)[d,e]						
Castrates	55.3f	55.8f	54.0g	55.5f	<0.034	0.51
Gilts	57.9	58.3	57.6	57.9	<0.603	0.45
Lean (g/kg)[d,e]						
Castrates	553f	556f	545g	553f	<0.01	1.8
Gilts	579f	578f	573g	577f	<0.022	1.4
Fat free lean index (g/kg)[d,e]						
Castrates	500f	501f	495g	499f	<0.01	1.2
Gilts	518f	518f	514g	517f	<0.01	1.0

Within a row, means without a common letter differ ($P < 0.05$).
[a] The gestation diet was formulated to contain 145 g CP/kg, 7.0 g lysine/kg, 10 g Ca/kg, and 9.0 g P/kg. Pigs averaged approximately 150 d of age and 112 kg at marketing.
[b] Overall model probability value.
[c] Means were adjusted for age at market by covariate analysis.
[d] Means were adjusted for hot carcass weight by covariate analysis.
[e] Represent calculated abattoir values.

size among sows provided increased feed in Exp. 2. High feed intake has been shown to be detrimental to embryo survival, but it would appear that it is most detrimental during the first 72 h immediately after breeding (Jindal et al., 1997). Dwyer et al. (1994) observed no differences in the total number of pigs born with changes in maternal feed intake. Unlike our study, Dwyer et al. (1994) increased feed intake gradually over a 5-d period and then gradually decreased feed intake over a 5-d period, and this possibly may have prevented some embryonic loss. Lodge (1969) observed that feeding up to 2.72 kg/d during gestation had no effect on the number of pigs born alive. A possible explanation for the lower reproductive performance might be that increased feed intake occurred to rapidly and resulted in embryo mortality. Further research is needed to verify if stepping up feed intake prior to and down following the treatment window is necessary to remove this response.

Dwyer et al. (1994) also observed no significant differences in litter weight with increased feed intake from days 25 to 50 of gestation. In our experiment, no differences were observed in birth weight variation among treatments, suggesting that neither increased feed intake nor added ground maize (days 30–50) alters normal pig birth weight variation.

Increasing the feed intake from 1.81 to 3.63 kg/d or providing an additional 1.81 kg of ground maize/d from days 30 to 50 of gestation improved most carcass characteristics of gilt offspring in the first experiment, but not in the second. Increases in hot carcass weight of offspring from increasing the amount of gestation diet from days 30 to 50 of gestation were observed, although increases were not as large as the response observed with pST (Kelly et al., 1995). Effects of pST on IGF-I, a significant myogenic factor, could partially explain these differences. Administration of pST during a similar phase of gestation produced much larger increases in maternal IGF-I than observed in our experiment (Rehfeldt et al., 1993; Kelly et al., 1995; Sterle et al., 1995). However, not all experiments have reported improvements in fetal development with pST administration (McLaughlin et al., 1996; Kuhn et al., 2004). Kuhn et al. (2004) also reported no influence in postnatal growth of offspring when gilts were administered pST in early gestation. In our study only sows fed 3.63 kg/d from days 30 to 50 of gestation had higher plasma free IGF-I concentrations; however, sows fed increased feed days 10–30 during gestation had been removed from treatment for several days, as in Exp. 1 where sows were bled on day 95 of gestation. To date, the impact of free versus total IGF-I is unclear due to lack of understanding of the role of binding proteins in myogenesis. The effects on IGF-I and possibly other myogenic factors may help to explain the differences in the magnitude of the response in offspring performance.

The initial experiment revealed that sows fed 3.63 kg/d from days 30 to 50 of gestation produced offspring that were leaner and heavier at slaughter than control offspring. However, this was not observed in the second experiment. In fact, the response was the opposite with increased fat depth and a lower percentage lean observed for offspring from sows fed 3.63 kg/d from days 30 to 50 of gestation. Offspring from sows fed high feed intake from days 30 to 50 had less lean, although the increase in hot carcass weight was similar to the previous experiment. Increased hot carcass weight of the offspring is consistent with pervious research in which an improvement in ADG was observed for offspring of sows provided additional feed during gestation (Dwyer et al., 1994; Penny et al., 2000). No advantage in percentage lean was observed in the offspring of sows fed increased feed from days 10 to 50 of gestation, but a numerical improvement in loin depth was observed in offspring from sows fed 3.63 kg/d from days 10 to 30 of gestation.

There are differences between our two experiments that may explain the differences in response. Differences in parity, weight of offspring at slaughter, overall leanness of the offspring, and the number of pigs born per litter may have important effects. Sows in the second experiment were older and fewer pigs were born alive. Pigs in that study also had lighter hot carcass weight (approximately 9 kg) than in Exp. 1. Because the offspring in the second experiment were considerably lighter than the animals in the first experiment, they were leaner and this might limit the treatments' abilities to enhance lean growth. It will be important to address the unknown effects of parity and marketing age or weight in future research. Additionally, as other experiments have shown, advantages from increased muscle fibre number are often observed in late finishing (Dwyer et al., 1993). It is possible that if muscle fibre number were increased, pigs would reach their growth potential later than controls, extending the lean deposition curve.

There may indeed be a period from days 10 to 50 of gestation when high maternal feed intake could lead to improved muscle development of the fetal pig. However, more research is needed to assure repeatability of this response and to understand the potential factors influencing the response.

5. Conclusion

The response of offspring leanness as influenced by increased feed intake was inconsistent. There were, though, some positive traits observed that might suggest fetal development was influenced by feed intake. The potential to increase postnatal gain and carcass characteristics by increased feed intake might be a tool that producers could utilize to improve the leanness and efficiency of pigs. These experiments show alteration of pig development from changes in maternal nutrition, but are inconsistent and more research may help to resolve differences in results between these experiments.

Acknowledgements

We would like to thank D. Troyer, C. Samland, J. Woodworth, T. Rathbun, and L. McBeth for assistance in data collection.

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