Effect of Restricted Feed Intake on Early Reproductive Development in Large White Gilts**

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ABSTRACT : Forty-five Large White gilts were used to study the effect of energy intake from 28 to 176 d of age on body composition and reproductive development. From 28 to 60 d, the gilts were fed *ad libitum* a 16.6 MJ DE/kg, 24% crude protein and 1.3% total lysine diet. From 61 d of age three dietary treatments were used; 1) *ad libitum* access to feed (15.6 MJ DE/kg, 21% crude protein and 1.07% total lysine) (H), 2) feed offered at 75% (M) of the previous days intake of H, and 3) feed offered at 60% (L) of the previous days intake of H. ADG from 61 to 176 d of age was ($p<0.05$) affected by treatment. Although live weight at 176 d of age did not differ ($p>0.1$) the H gilts had higher ($p<0.08$) carcass weights than the M or L gilts. Back fat depths were similar ($p>0.1$) for all treatments at 115 d of age, however by 176 d of age M and H gilts were fatter ($p<0.1$) than L gilts. The mean lipid deposition (LD) from 115 to 176 d of age for L gilts (78.9 g/d) was less ($p<0.05$) than for M gilts (143.6 g/d) and H gilts (135.6 g/d). There were no differences between treatments for protein deposition (PD) over the same period. More ($p<0.05$) H gilts (n=8) attained puberty (first observed estrus) than either M gilts or L gilts (n=4 for both). Follicle numbers were similar ($p>0.1$) across treatments. For gilts that attained puberty, H gilts had fewer ($p<0.05$) follicles (13.5) than M gilts (19.7) and L gilts (21.3). For gilts with follicular development, H gilts had the heaviest (458.7 g) reproductive tract weight (RTW). However, for those that attained puberty, L gilts had the heaviest RTW. RTW were lowest for those with no follicular development. Energy restriction had a negative impact on puberty attainment, i.e. it took longer to reach puberty. However, for gilts that attained puberty, the number of follicles was greater for those on lower feed intakes. It would appear that rate of fat deposition, but not necessarily the total amount of fat, plays an important role in puberty attainment. *(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 11 : 1534-1541)*

Key Words : Protein Deposition, Reproductive Development, Pigs

INTRODUCTION

Nutrition is one of many factors which influence reproductive efficiency in pigs (Aherne et al., 1991). The influence of energy intake on puberty attainment in gilts shows considerable variation. While, Pay and Davies (1973) and Friend (1977) reported that energy intake had no effect on puberty attainment, most researchers have reported a restriction in energy intake at some point during the growth phase could delay puberty attainment (Van Lunen and Aherne, 1987; King, 1989; Newton and Mahan, 1992). Feed intake is influenced by many factors. These include physiological factors (neural and hormonal mechanisms, sensory), animal factors (live weight, sex, genotype, health status), the feed (form, quality and ingredients), water (quality and availability), the environment (ambient temperature, air movement, pig space, feeder design) as well as interactions between them (NRC, 1986; Forbes, 1986).

A major objective of pig breeding has been to increase lean (protein deposition) and to limit fat gain (Quiniou et al., 1996a). There is evidence that selection for improved rates of lean deposition and fast body weight growth has resulted in decreased feed intake (Cole and Chadd, 1989). Under many commercial conditions where future breeding females are selected from within the herd, there is little or no difference in feeding management between gilts destined for selection as breeding stock or those destined to be sold for meat production. Nutritional management which optimises protein deposition (PD) and limits lipid deposition (LD) in pigs grown for market may not be a suitable strategy for pigs destined for the breeding herd. Gaughan et al. (1997) concluded that PD and LD might be important determinants of puberty attainment. The objective of this study was to investigate the influence of various energy intakes during the growing phase followed by a short-term *ad libitum* feeding regime on body composition and early reproductive development in Large White gilts.

MATERIALS AND METHODS

Animals and management

The pigs were taken from The University of Queensland, Gatton Large White herd. After weaning at 28 d of age the pigs were group-housed (15 pigs/pen) by sex in 50% wire mesh floored weaner pens (1.9 m × 2.25 m). From 28 d of age until 60 d of age the pigs were given *ad libitum* access to a weaner diet (17.3 MJ DE/kg, 24% crude protein and 1.3% lysine on a dry matter basis). Forty-five gilts (15 littermate triads; three gilts from a litter, 15 litters used)

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were randomly selected at 61 d of age (16.4±4.8 kg). Each litter was sired by a different boar. Following selection, the gilts were individually housed in 2.3 × 1.2 m pens with fully slatted floors, and were randomly allocated within a litter to one of three dietary treatments. The dietary treatments were; 1) H - *ad libitum* access from 61 d of age until 176 d of age; 2) M - feed offered was restricted to 75% of the previous days intake of H, from 61 d of age until 170 d of age and then given *ad libitum* access, and 3) L - feed offered was restricted to 60% of the previous days intake of H, from 61 d of age until 170 d of age and then offered *ad libitum* access from 170 d of age; The diet used in all treatments contained 15.6 MJ DE/kg, 21% crude protein and 1.0% lysine (dry matter basis). Feed offered to the H gilts was based on the relationship between live weight (W) and feed intake (MJ/d) using the asymptotic equation, DE = $2.621 \times W^{0.63}$ (ARC, 1981). A previous study (Gaughan unpublished) found that the ARC (1981) equation underestimated feed intake for the genotype used in this study by approximately 6%, therefore 10% more feed was offered each day than suggested by the equation to ensure pigs always had access to feed. The restricted feeding regimes were designed to ensure that the L group reached 100 kg live weight by 176 d of age. At 176 d of age gilts from all treatments were slaughtered. The 176 d was based on a previous study which indicated that puberty attainment in the UQ herd was between 166 and 180 days of age (Gaughan et al., 1995, 1997). During the study mean ambient temperature (t_a) was 23±6°C. Electric heaters were used when t_a was less than 20°C. Fans and sprinklers were used when t_a exceeded 28°C. Lights were turned on at 06:00 h and turned off at 18:00 h daily.

The pigs were weighed every 7 d from 61 d of age and BF was measured every 7 d from 115±4.6 d of age using a Renco Lean-Meater (Renco Corporation, Minneapolis, MN). The P_2 position was taken as the depth of fat and skin at a position 65 mm lateral to the junction of the last rib and the vertebrae. Prior to the first measurement of BF a tattoo was used to mark the sites. At 145 d of age, the gilts were vaccinated against Erysipelas, Leptospirosis and Parvovirus.

Diets and feeding

The gilts were given two thirds of their daily feed allocation between 08:00 h and 08:30 h. The remainder was fed out between 15:00 h and 15:30 h each day. The feed was placed in an individual feeder (capable of holding about 3.5 kg) at the front of each pen. Uneaten feed from the previous day was removed and weighed each morning. The diets were formulated to exceed NRC (1988) recommendations for growing pigs (20 to 110 kg)(table 1). The nutrient composition of the diets were analyzed by Agrifoods Technology P/L, Toowoomba, Queensland using the methods of AOAC (1990).

Table 1. Ingredients and nutrient composition of weaner diet fed from 28 to 60 d of age, and grower diet fed from 61 to 176 d of age

Item	Weaner diet	Grower diet
Ingredients, kg		
Barley	-	160.00
Wheat	647.00	620.00
Meat meal (50% CP)	138.00	90.00
Soybean meal (solvent)	158.00	110.00
Lysine	0.18	2.00
Salt	2.50	2.50
Vitamins and minerals[A]	2.00	2.00
Methionine	-	0.04
Sunflower oil	52.00	15.00
Analyzed composition[B] (As fed)		
Energy, MJ DE/kg	15.0	14.1
Total lysine, %	1.31	1.07
Crude protein, %	22.0	19.2
Crude fibre, %	2.5	3.5
Ca, %	0.95	1.05
Available P, %	0.55	0.60

[A] Contributed the following per kg of diet: Weaner diet, vitamin A, 16,000 IU; vitamin D_3, 4,400 IU; α-tocopheryl, 100 mg; menadione dimethyl-pyrimidinole, 8.8 mg; thiamine, 2.8 mg; riboflavine, 6 mg; pyridoxine, 4 mg; vitamin B_{12}, 0.04 mg; calcium pantothenate, 24 mg; niacin, 40 mg; folic acid, 1 mg; biotin, 0.2 mg; cobalt, 1 mg; iodine, 2 mg; iron, 250 mg; magnesium, 100 mg; zinc, 250 mg, copper, 40 mg; selenium, 200 mg. Grower diet, vitamin A, 7,000 IU; vitamin D_3, 3,000 IU; α-tocopheryl, 60 mg; menadione dimethyl-pyrimidinole, 8.8 mg; riboflavine, 6 mg; pyridoxine, 2 mg; vitamin B_{12}, 0.02 mg; calcium pantothenate, 20 mg; niacin, 30 mg; biotin, 0.2 mg; cobalt, 0.4 mg; iodine, 2 mg; iron, 120 mg; magnesium, 80 mg; zinc, 200 mg, copper, 20 mg; selenium, 200 mg. Rhone-Poulenc, Brisbane, Australia.

[B] Proximate analysis (Agrifood Technology P/L., Toowoomba, Australia).

Oestrus detection

Oestrus activity was monitored for 20 to 30 min twice daily at 09:00 h and 16:00 h, from 145 d of age (no boar exposure until 165 days of age) until puberty attainment. The gilts were examined for behavioural (standing response to back pressure) and visual changes (reddening and swelling of the vulva) associated with estrus. From 165 d of age, the gilts were moved from their pens at 10:00 h each day to an adjacent shed (14 m away) and placed in a pen next to a mature (>12 months old) boar. The gilts were then allowed to enter the boar pen, under stockperson supervision. After 3 to 5 minutes the gilt was removed. The gilts were then returned to their individual pen. This procedure was carried out again at 14:00 h. Observations of oestrus (back pressure test) were then made firstly with the gilts in the adjacent pen, and then with the gilt and boar in

the same pen. Ovarian activity was further assessed by examination after slaughter.

Measurements at slaughter

The gilts were slaughtered at a commercial abattoir at 176 d of age. The reproductive tracts were removed immediately following exsanguination. The vulva was removed from the reproductive tract at the external urethral orifice. The following parameters were measured: (i) total reproductive tract weight (ovaries, uterine tubes, uterus and vagina). (ii) number and size (mm) of corpora lutea (CL) and follicles (>3 mm). Carcass weight (hot carcass, head on) and BF (using a Hennessy probe) were determined within 10 min of slaughter.

Lipid and protein deposition

LD and PD were calculated using the method of Gaughan et al. (1997). LD and PD were calculated for the periods from 115 d to 176 d of age, and 145 d to 176 d of age.

Statistical analysis

Data were analysed as a randomised complete block design by least squares analysis of variance in the general linear models procedure of SAS (1988) in which the treatment group was the class variable. The model used was occurrence of oestrus, feed intake, feed:gain ratio, growth rate, live weight at slaughter, backfat depth at slaughter, PD, LD, weight of carcass, weight of reproductive tract, number of follicles (>3 mm) and number of corpus luteum. Treatment groups were further subdivided for statistical analysis according to their degree of reproductive development, and the same analysis carried out. The sub groups were: pu = puberty attained, fd = follicular development or nd = no follicular development.

RESULTS

One L pig died shortly after the trial commenced, and one H gilt was removed from the study due to leg problems. No other health related concerns were noted.

Feed intake and growth performance

Feed intake (FI) (as-fed), DE intake (dry matter basis) and feed to gain ratio (FGR) are presented in table 2. The mean daily DE intake for the H gilts was about 15% lower than expected (38.7 MJ/d actual; 44.5 MJ/d expected). FGR decreased ($p<0.001$) as the level of restriction increased (3.4, 2.6, and 2.1 for H, M and L respectively).

Overall, the H gilts had the greatest weight gain and highest ADG irrespective of ovarian development. Live weight at slaughter was affected ($p<0.05$) by treatment, but not stage of reproductive development. Live weight, weight gain, dressed weight, ADG from selection to slaughter, and BF at slaughter are presented in table 3.

Table 2. Least square means (±s.e.) for total feed intake (kg), mean daily feed intake (kg), mean daily DE intake and feed:gain ratio, from 61 to 176 d of age for gilts fed either ad-libitum (H), fed 75% of H (M) or fed at fed 60% of H (L)

	H	M	L
Number of gilts	14	15	14
Total feed intake, kg	296.5	217.5	173.2
	± 4.50[c]	± 4.30[b]	± 4.50[a]
Mean daily feed intake, kg	2.6	1.9	1.5
	± 0.05[c]	± 0.04[b]	± 0.05[a]
Mean daily energy intake, MJ DE	40.7	29.4	23.4
	± 0.30[f]	± 0.30[e]	± 0.30[d]
ADG, kg/d	0.77	0.71	0.71
	± 0.3[b]	± 0.3[a]	± 0.3[a]
Feed:gain, kg/kg	3.38	2.67	2.11
	± 0.11[c]	± 0.10[b]	± 0.11[a]

[a,b,c] Means within a row lacking a common superscript differ ($p<0.001$).

[d,e,f] Means within a row lacking a common superscript differ ($p<0.05$).

When grouped according to follicular development (fd), the H gilts with fd (Hfd) were heavier ($p<0.05$) (table 3). Differences for weight gain, dressed weight and ADG between the treatments were similar ($p>0.1$). However, the ADG of the Mfd and Lfd gilts were lower ($p<0.05$) than for the Hfd gilts. There were no treatment differences for those that attained puberty.

There were no differences ($p>0.1$) between dietary treatments (10.4±0.46) for BF at 115 d of age. However, by slaughter the M and H gilts were fatter ($p=0.07$ and $p=0.06$ respectively) than the L gilts. BF was influenced ($p<0.05$) by treatment for those gilts with follicular development. There were no differences ($p>0.8$) between the M and H gilts. BF at slaughter was 40% lower in the L gilts compared with the M gilts and was 30% lower than for H gilts. Irrespective of treatment, BF at slaughter was lowest for gilts with no follicular development (nd).

Protein and lipid deposition

The relationship between PD and dietary treatment is presented in table 4. Mean PD from 115 to 176 d of age were similar ($p>0.05$) across treatments. Similarly PD from 145 to 176 d of age was not affected ($p>0.05$) by dietary treatment. PD was 18.4% higher in the Lnd and 11.3% higher in the Mnd gilts compared to the Lfd and Mfd gilts respectively. However, PD was 18.8% lower ($p>0.05$) for the Hnd compared to the Hfd gilts. There were no differences in PD for those gilts that attained puberty.

Table 3. Least square means (± s.e.) for live weight at 61 d of age, 145 d of age and at slaughter (176 d of age), weight gain from 61d of age until slaughter, ADG from 61 d of age until slaughter, backfat depth at 115 d of age, 145 d of age and back fat depth at slaughter, for gilts fed either *ad libitum* (H), fed 75% of H (M) or fed at fed 60% of H (L)

		Treatment		
Class	Item	H	M	L
All Gilts				
Number		14	15	14
Live weight at 61 days of age, kg		16.0 ± 3.8	16.3 ± 3.6	17.5 ± 3.4
Live weight at 115 days of age, kg		56.9 ± 8.0	53.4 ± 6.5	51.1± 6.1
Live weight at 145 days of age, kg		80.1± 6.2[b]	75.1 ± 7.3[b,a]	72.7± 6.0[a]
Live weight at 176 days of age, kg		104.7 ± 2.3	100.0 ± 2.3	98.7 ± 2.3
Weight gain (d 61 to d 176), kg		88.7 ± 2.7	83.7 ± 2.6	81.2 ± 2.7
ADG (d 61 to d 176), kg/d		0.77 ± 0.30[b]	0.71 ± 0.30[a]	0.71 ± 0.30[a]
ADG (d 115 to d 176), kg/d		0.78 ± 0.32	0.76 ± 0.31	0.78± 0.31
ADG (d 145 to d 176), kg/d		0.79 ± 0.28	0.80 ± 0.27	0.84 ± 0.28
Backfat at 115 days of age, mm		10.5 ± 0.2	10.4 ± 0.2	10.5 ± 0.2
Backfat at 145 days of age, mm		13.9 ± 0.3[d]	13.5 ± 0.3[d]	12.3 ± 0.2[c]
Backfat at 176 days of age, mm		17.5 ± 0.9[d]	18.0 ± 0.9[d]	14.5 ± 0.9[c]
Dressed wt[A], kg		75.0 ± 1.8[g]	70.4 ± 1.7[e]	71.8 ± 1.8[e,g]
No follicular development (nd)		Hnd	Mnd	Lnd
Number		3	3	3
Live weight, kg		90.6 ± 3.7	96.9 ± 3.7	92.8 ± 3.7
Weight gain, kg		77.4 ± 6.2	89.6 ± 6.2	86.3 ± 6.2
ADG, kg/d		0.68 ± 0.50	0.77 ± 0.50	0.76 ± 0.50
Backfat, mm		14.3 ± 2.1	17.0 ± 2.1	13.3 ± 2.1
Follicular development (fd)		Hfd	Mfd	Lfd
Number		11	12	11
Live weight, kg		104.5 ± 2.4[b]	94.6 ± 2.2[a]	98.2 ± 2.4[a]
Weight gain, kg		91.7 ± 2.7[b]	82.3 ± 2.6[a]	80.0 ± 2.7[a]
ADG, kg/d		0.80 ± 0.30[b]	0.69 ± 0.30[a]	0.69 ± 0.30[a]
Backfat, mm		19.6 ± 1.3[b]	18.6 ± 1.3[b]	15.8 ± 1.3[a]
Attained puberty				
Number		8[a]	4[b]	4[b]
Live weight, kg		106.5 ± 2.2	97.2 ± 3.0	100.9 ± 3.5
Weight gain, kg		92.0 ± 2.8	82.0 ± 3.9	84.6 4 ± 0.5
ADG, kg/d		0.81 ± 0.32	0.69 ± 0.45	0.74 ± 0.52
Backfat, mm		19.6 ± 1.7	19.7 ± 2.4	15.0 ± 2.7

[A] Hot carcass weight, head on, trotters on, kidneys and flare fat in.

[a,b] Means within a row lacking a common superscript differ ($p<0.05$).

[c,d] Means within a row lacking a common superscript differ ($p<0.1$).

[e,f] Means within a row lacking a common superscript differ ($p<0.08$).

Mean LD from 115 to 176 d of age was lowest ($p<0.01$) for the L gilts. There were no differences between H and M gilts. For those gilts with follicular development, LD was lowest ($p<0.05$) for Lfd gilts. The LD was 50% less ($p<0.07$) for the L gilts which attained puberty (Lpu) compared with the M gilts, which attained puberty (Mpu). Overall, the L group had lower LD's than either the M or H group at all stages of development.

The LD:PD ratio for the period 115 to 176 d of age, and for the period 145 to 176 d of age was lowest for L gilts, and highest for M gilts at all stages of reproductive development. For all treatments, the ratio was lowest for those gilts with no follicular development and greatest for those with follicular development (table 4).

Reproductive development

Reproductive development data are presented in table 5. There were no correlations ($p>0.05$) between dietary

Table 4. Least square means ±s.e.m. for protein (PD) and lipid deposition (LD), and LD:PD ratio for gilts grouped by treatment and follicular development, for gilts fed either *ad libitum* (H), fed 75% of H (M) or fed at fed 60% of H (L)

Class Item	Treatment		
	H	M	L
115 d to 176 d of age[A]			
Number	14	15	14
PD g/pig d^{-1}	119.3	120.2	124.9
	±9.3	±8.9	± 9.2
LD g/pig d^{-1}	135.6[a]	143.6[a]	78.9[b]
	±13.1	±12.6	±13.1
LD:PD	1.1	1.2	0.63
145 d to 176 d of age[B]			
Number	14	15	14
PD g/pig d^{-1}	122.9	115.2	125.8
	±8.4	±8.1	±8.4
LD g/pig d^{-1}	112.6[a,b]	130.6[a]	77.8[b]
	±14.6	±14.1	±14.6
LD:PD	0.92	1.10	0.62
No follicular development[B] (nd)	Hnd	Mnd	Lnd
Number	3	3	3
PD g/pig d^{-1}	104.5	126.6	148.2
	±12.9	±12.9	±12.9
LD g/pig d^{-1}	80.9	115.9	61.3
	±32.4	±32.4	±32.4
LD:PD	0.77	0.91	0.41
Follicular development[B,C] (fd)	Hfd	Mfd	Lfd
Number	11	12	11
PD g/pig d^{-1}	128.0	112.3	121.0
	±9.8	±9.4	±9.8
LD g/pig d^{-1}	121.2b	134.2b	82.3a
	±16.7	±15.9	±16.7
LD:PD	0.95	1.20	0.68
Attained puberty[B] (pu)	Hpu	Mpu	Lpu
Number	8[a]	4[b]	4[b]
PD g/pig d^{-1}	128.2	97.6	127.8
	±12.1	±17.1	±17.1
LD g/pig d^{-1}	120.6	155.8	78.8
	±19.4	±27.4	±27.4
LD:PD	0.94	1.61	0.61

[A] 54 to 101 kg live weight.
[B] 76 to 101 kg live weight.
[C] These data include those that attained puberty.
[a,b] Means within a row lacking a common superscript differ ($p<0.05$).

treatments and age at puberty, weight of reproductive tract, or number of CL's. The number of follicles increased as the dietary restriction increased (13.5, 19.7 and 21.3 for H, M and L respectively). There was a positive correlation between reproductive tract weight and the number of CL's ($r=0.65$, $p=0.0001$) and number of follicles ($r=0.41$, $p=0.007$).

Table 5. The reproductive tract weight (g), the number of follicles and corpora lutea for gilts which attained puberty by 176 d of age, and those with follicular development (including those which attained puberty) and reproductive tract weight (g) for gilts with no follicular development

Class Item	Treatment[A]		
	H	M	L
Puberty attainment (pu)	Hpu	Mpu	Lpu
Number	8[a]	4[b]	4[b]
Age at puberty, d	162.8	172.2	167.7
	±3.6	±5.1	±5.1
Reproductive tract weight, g	458.7	449.3	483.0
	±79.7	±112.73	±130.17
Number of follicles	13.5	19.7	21.3
	±1.9[a]	±2.7[b]	±3.1[b]
Number of corpora lutea	7.7	5.5	9.3
	±1.8	±2.6	±3.0
Follicular development[1] (fd)	Hfd	Mfd	Lfd
Number	11	12	11
Reproductive tract weight, g	432.8	363.6	316.5
	±60.6	±57.9	±60.6
Number of follicles	14.3	14.2	16.3
	±1.7	±1.6	±1.7
No follicular development (nd)	Hnd	Mnd	Lnd
Number	3	3	3
Reproductive tract weight, g	226.4	167.3	142.4
	±53.0	±53.0	±53.0
Number of follicles	0	0	0

[A] H fed *ad libitum*, M fed 75% of H and L fed at fed 60% of H.
[a,b] Means within a row lacking a common superscript differ ($p<0.05$).
[1] These data include those that attained puberty.

There were differences between L and H ($p<0.05$) and M and H ($p<0.05$) for the number of gilts that attained puberty, but not age at puberty. Sixteen gilts (4 L, 4 M and 8 H) attained puberty by 176 d of age. Four of the H gilts and one of the L gilts with no observed estrus activity were cyclic. This was determined by ovarian inspection (follicle>3 mm and regressing corpora lutea) at slaughter. Eighteen gilts (7 L, 8 M and 3 H) were approaching oestrus at time of slaughter (determined by ovarian inspection). Nine gilts (three per treatment) showed no evidence of ovarian activity by slaughter and were classified as immature.

There were no treatment effects ($p>0.05$) on reproductive tract weight. Within treatment, reproductive tract weights were highest for gilts that attained puberty followed by those with follicular development. There were

no differences ($p>0.05$) between treatment (those with follicular development) for number of follicles or CL ($p>0.05$). For those gilts that attained puberty the mean number of follicles were similar for the L and M groups. The number of follicles was lowest ($p>0.05$) for H gilts. There were no differences between treatments in regard to CL number.

DISCUSSION

Feed intake

The *ad libitum* DE intake (estimated ME, 36.5 MJ/d) of the H gilts was 15% lower than expected. Campbell and Traverner (1988) reported ME intakes of 42 MJ/d, and Quiniou et al. (1996b) reported ME intakes of 38 MJ/d for *ad libitum* fed pigs. The lower intakes in this experiment are due in part to the higher ambient temperatures (18 to 30 °C) compared with the pigs of Campbell and Traverner (1988) which were kept at about 18°C, and Quiniou et al. (1996b) which were kept at 23°C. Genotype may also have influenced intake (Quiniou et al., 1996b). In the present study, mean ME intakes varied from 20.6 MJ/d for L gilts to 36.5 MJ/d for H gilts.

Protein deposition

PD, primarily a function of genotype (Dunkin, 1990), is also affected by energy intake (Black et al., 1986) and protein intake (de Greef and Verstegen, 1995), and the environmental conditions under which the pigs are housed (Williams, 1991). As the gilts were subjected to similar environmental conditions for the duration of the trial and were of similar genotype, any differences reported between treatments would be due to dietary differences.

The lack of any differences between the treatments for PD suggests that protein and energy intakes of all treatments were at levels which could maintain PD, at least for this genotype. The method used to calculate PD in this study does not allow the upper limits of protein retention (PD_{max}) to be determined. The possibility exists that the higher LD in M and H gilts, was due to energy being partitioned away from PD (de Greef and Verstegen, 1995), possibly because PD_{max} for this genotype had been reached.

Lipid deposition

Overall, LD was about 40% lower in the L group compared with the M group and the F group. The lower LD for the L gilts was expected due to their lower energy intakes (Taylor et al., 1992). LD was lower in those gilts with no follicular development compared with those with follicular development. Lower LD may indirectly have an effect on reproductive development in the gilt. The mean BF was lower (2.4 mm) at slaughter for gilts with no follicular development compared with those with follicular development. Although the Lnd gilts were the leanest, the Mnd gilts were fatter than the Lpu gilts and the Lfd gilts. The results from the present study suggesting that body fatness is not a direct precursor for reproductive development are in agreement with de Ridder et al. (1990), and Beltranena et al. (1993). However, the long-term implications for reproductive efficiency are important. Gilts which enter the breeding herd with low body fat reserves are not likely to remain in the herd for any length of time (Gaughan et al., 1995).

Oestrus and puberty attainment

Puberty attainment was influenced by dietary treatment but was not influenced by BF. This agrees with a number of authors who have suggest that body fat reserves are not important for the initiation of puberty in gilts (Young et al., 1990; Aherne et al., 1991; Rozeboom et al., 1995) for those which attained puberty. Age at puberty (166 d) was similar to ages reported by (Gaughan et al., 1997; Rozeboom et al., 1995).

Other factors, therefore, may have influenced the higher degree of sexual development of M and H gilts compared with L gilts. A number of authors have suggested a minimum weight/age threshold and a minimum lean tissue to adipose tissue ratio that gilts need to attain before puberty is initiated (den Hartog and Noordewier, 1984; Kirkwood and Aherne, 1985; Burnett et al., 1988; Paterson, 1989). The evidence from the present study does not support the lean to adipose tissue ratio concept. If the LD:PD ratio was important for sexual development, there should have been clear differences between the L, M and H gilts, because of the differences in the LD:PD ratios. These findings are in agreement with reports from a number of authors (Young et al., 1990; Beltranena et al., 1993; Rozeboom et al., 1993).

Observation of the ovaries at slaughter confirmed (follicles > 3 mm and regressing CL) that four H gilts and one L gilt did reach estrus but without showing overt signs. Newton and Mahan (1992) also found that there was an increased number of silent estrus when gilts were fed *ad libitum*. This may be due to a reduction in circulating steroid levels, especially progesterone, when gilts are on a high plane of nutrition (Lussier-Cacon et al., 1977; Dyke et al., 1980; Pharazyn et al., 1991).

There was no effect of treatment on overall ovulation rate (based on number of CL's). While the number of gilts with CL's were too small to draw conclusive results it is likely that energy intake was not limited in those animals with follicular development. For the gilts that attained puberty, the number of follicles for gilts with at least two standing heats, was two to three times greater than for those which only had one standing heat. Similar results have been reported by Gaughan et al. (1997) using the same genotype.

The fatter gilts had a fewer follicles, which is consistent with lower litter size of fatter gilts (greater BF) reported by Wise et al. (1993) and Gaughan et al. (1995).

IMPLICATIONS

Although limited by numbers it would appear that a restriction in energy intake during the growing period may retard reproductive development (a delay in reaching puberty) in the gilt. The reasons for this are not clear, but it may be that physical development is retarded. In contrast, back fat depth *per se* did not influence puberty attainment. Gilts which enter the breeding herd with low body fat reserves are not likely to remain for long within the herd. There may be benefit in earlier selection of gilts for breeding, and feeding them differently to animals destined for slaughter.

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