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The Effect of Maternal Fasting During Late Gestation on Subsequent Growth Performance of Pigs[1]

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ABSTRACT

Three groups of cross-bred (Yorkshire x Duroc x Hampshire) gilts were used to determine the influence of 7-d and 14-d prepartum fasting of gestating gilts on serum glucose and free fatty acids (FFA) levels of the gilts and on body composition and subsequent growth of the progenies. The 7-d and 14-d fasted gilts were taken off feed on days 107 and 100 of gestation, respectively, while the control gilts were maintained on 1.8 kg daily of a gestation diet containing 14% protein. Gestation length, total and number of pigs born alive, hourly milk yield, progeny birth weight, mortality at birth and at weaning were not altered ($P > 0.05$) by 7-d and 14-d feed deprivation. Maternal serum free fatty acids (FFA) were elevated ($P < 0.05$) in the 7-d and 14-d fasted dams while serum glucose remained unchanged ($P > 0.05$). Protein and lipid portions of the piglet body decreased quadratically ($p < 0.05$) with fasting. Fasting and stage of growth increased ($P < 0.05$ and $P < 0.01$, respectively) the subsequent growth of the progenies of the fasted gilts. Fasting level by growth stage interaction ($P < 0.05$) was noted among the experimental groups. The data indicated a strong compensatory growth response by the progeny of fasted gilts which resulted in heavier ($p < 0.05$) pigs at 21 weeks of age.

Key Words: Gestation, Fasting, Progeny, Growth.

INTRODUCTION

Inadequate energy stores in newborn pigs contribute to the high mortality rate in piglets in the swine industry. Efforts to increase the energy reserves of newborn pigs through alteration of the maternal nutrient supply to the fetus have been reported (Elliot and Lodge, 1977; Ezekwe and Martin, 1978; Kasser *et al.*, 1981). A 20-d prepartum maternal fasting increased maternal serum concentration of FFA and the subcutaneous adipose tissue in fetal pigs without alteration of their body weight (Kasser *et al.*, 1981). Furthermore, a similar 20-d fasting was shown to increase the number lipid-containing adiposites in fetal adipose tissue (Hausman

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et al., 1982). Other reports showed that maternal fasting improved a 3-d survival of piglets subjected to fasting stress after birth (Ezekwe, 1981; Kasser *et al.*, 1982).

Although these early changes in subcutaneous fat depot suggest improvement in physiological maturity of the pigs and therefore in factors related to energy reserves and survival, little information is available on growth response of progenies of prepartum fasted dams. Complete nutrient deprivation of gilts for 40 d prepartum in gilts showed reduced early growth of the progenies, but these recovered and were able to reach mature bodyweight faster than the control progenies (Hard and Anderson, 1982). The purpose of this study is therefore to determine the influence of prepartum nutrient deprivation of gilts produced by maternal fasting on subsequent growth of the progeny.

MATERIALS AND METHODS

The pigs used in this study were from gilts utilized for a larger experiment designed to assess the postnatal response of liver and skeletal muscle of piglets to maternal fasting (Ezekwe and Opoku, 1988). Fifteen pregnant cross-bred gilts (Yorkshire x Duroc x Hampshire) were randomly assigned according to body weight to three experimental treatments: control, 7-d fast, and 14-d fast before expected parturition. All the gilts were fed a corn-soybean diet containing 14% protein at a rate of 1.82 kg/day before the initiation of treatments. The 7-d and 14-d fasted groups were taken off feed on days 107 and 100 of gestation, respectively. The control group was maintained on 1.82 kg/day throughout gestation. The diet, described by Ezekwe *et al.*, (1984) was adequately fortified with vitamins and minerals to meet or exceed the NRC-1979 nutrient requirement for gestating swine.

Water and trace mineral salt, provided in form of dry salt, were offered *ad libitum* to the two fasted groups to reduce the possibility of a micronutrient mineral salt deficiency. All the experimental animals were housed in concrete floor pens at a density of 2-4 animals per pen during gestation and provided with adequate bedding material. The gilts were separated and placed in a single, well-bedded pens before farrowing and during lactation.The barn temperature of about 25°C was maintained by means of a fuel gas heating system during the winter. There were no observable health problems associated with the animals during the experiment.

Blood was taken from the anterior vena cava of all the gilts 3 to 4 hours after feeding at the beginning of the study and at weekly intervals thereafter for serum glucose and FFA analyses. All farrowings were attended. Pigs were weighed at birth and the number of live and dead pigs were recorded. One or two pigs from each litter at birth, each near the average body weight of the litter, were mechanically stunned and sacrificed by exsanguination for tissue biochemical determination. Litter size was then equalized to 7 or 8 pigs at birth, and each pig was allowed to suckle the dams until weaning at 7 wk of age. All lactating gilts were fed about 4.9 kg/day, scaled to an additional 0.45 kg of diet per pig nursed. Creep feed was not provided to the pigs before weaning, although the sow feeder was accessible to the pigs. Milk yield was estimated by the weigh-suckle-weigh method (Speer and Cox, 1984) on d 14 of lactation. Pigs were weaned at 7 wk of age and were continued on the study until 21 weeks of age. The pigs were weighed at 7, 14, and 21 weeks of age.

Serum glucose was determined by the glucose oxidase procedure[1] and serum FFA was assayed according to the methods of Dunocombe, (1963, 1964).

Analysis of carcass dry matter, protein, lipid, and water was done on the pigs sacrificed at birth. The carcasses were frozen and later thawed and ground with the aid of a meat grinder. Sampling techniques and analyses used were those as described by Hartsook and Hershberger (1963). Gilt farrowing characteristics, blood data, and progeny chemical composition data were analyzed by one-way analysis of variance (Steel and Torrie, 1960). Differences between means were determined by Newman Keul's procedures. Orthogonal polynomial contrasts were used to evaluate the effect of level of fasting. For progeny postnatal growth data of body weight and four different growth periods, a 3 x 4 factorial analysis of variance was used to assess treatment by growth period interactions. Treatment means were separated by the least significant difference technique (LSD).

RESULTS AND DISCUSSION

Gestation length, total pigs born, percent born alive, piglet weight at birth and at 49 d of age, total pigs born alive, and hourly milk yield were similar ($p > 0.05$) among the control and fasted groups (Table 1). The similarity of birth weight, gestation length, and litter size among the experimental groups was in agreement with my previous report (Ezekwe, 1981). When gilts were restricted to a third of the caloric intake of the control group throughout gestation, or deprived for 40 d at various segments of gestation, birth weight was severely affected (Anderson *et al.*, 1979; Pond *et al.*, 1986). This study showed that gilts possessed the ability to protect the fetuses from short-term nutritional stress during the most rapid period of fetal growth. After farrowing, the adaptive mechanisms were still sufficient to maintain lactation in the fasted gilts as demonstrated by similar hourly milk yield among the treatment groups.

Live weight gain at 49 d of age was comparable among the treatment groups. Although nonsignificant, control pigs showed a 6.2-fold increase in body weight from birth to 49 d of age while 7-d and 14-d progenies had 6.7-fold and 7.7-fold increases within the same period, respectively. Survival at birth and at 49 d of age was not influenced by maternal fasting. Although improved survival has been reported in piglets from fasted dams when subjected further to fasting stress after birth (Ezekwe, 1981, Kasser *et al.*, 1982), pigs in this experiment, reared under practical farm conditions, showed no improvement in survival over the untreated progenies.

Serum FFA concentrations, although more variable within groups than glucose, were elevated in 7 d fasted gilts at 112 d ($P < 0.01$) of gestation and in 14 d fasted gilts at 107 d ($P < 0.05$) and 112 d ($p < 0.01$) of gestation (Table 2). Serum glucose concentration was stabilized within fasting levels. A 4-d total fast in rats resulted in a significant drop in serum glucose level (Girard *et al.*, 1977). The ability of gilts and sows to maintain a stable serum glucose level during the fasting was considered to be a key to the metabolic adaptation responsible for the buffering effect provided

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TABLE 1. Farrowing performance characteristics and milk yield in gestionally fasted gilts[a].

Characteristics	Control	7-d Fasting	14-d Fasting
Gestional length, d	114.6 ± 0.5	113.9 ± 0.6	113.6 ± 0.6
Total pigs born, no	10.6 ± 1.0	11.6 ± 1.2	12.0 ± 1.4
Piglet weight, kg	1.5 ± 0.1	1.4 ± 0.1	1.3 ± 0.1
Percent born alive	89.0 ± 6.5	93.8 ± 3.7	81.4 ± 11.2
Pig weight at 49-d, kg	9.4 ± 1.1	9.4 ± 0.6	10.0 ± 0.8
Pig survival at 49-d, % live pigs[b]	80.8 ± 5.0	77.9 ± 10.5	71.9 ± 11.9
Hourly milk yield, g	219.2 ± 35.7	233.0 ± 30.1	208.5 ± 28.1

[a] mean ± SE for five aninals
[b] % of live pigs after sacrifice at birth

TABLE 2. Serum free fatty acids and glucose concentrations in control and fasted gilts before and during fasting[a].

Item	Gestation	Control	7-d Fasting[b]	14-d Fasting
Glucose, mg/dl	98	59.4 ± 10.0	---	72.5 ± 8.9
	107	66.7 ± 7.6	65.1 ± 4.8	51.1 ± 10.9
	112	59.3 ± 10.2	51.4 ± 6.5	45.8 ± 9.7
Free fatty acids, μEq/l	98	440.0 ± 117.7	---	287.0 ± 101.6*
	107	621.0 ± 250.0	1102.0 ±99.1**	1,030 ± 122.7**

[a] Mean ± SE for five gilts
[b] Treatment initiated at 107 d of gestation
* Differed from pretreatment FFA level ($P < 0.05$)
** Differed from pretreatment FFA level ($p < 0.01$)

to the fetuses. This ability to buffer the offsprings may be regulated by hormones. Glucagon has been shown to be elevated in gilts during maternal fasting (Kasser *et al.*, 1982).

The mean protein, lipid, and ash component of the pigs' body at birth were influenced ($P < 0.05$) by the level of fasting (Table 3). Protein and lipid, fractions decreased ($P < 0.05$) while ash content increased ($P < 0.05$) quadratically with the level of fasting. The proportion of carcass water remained unchanged ($P > 0.05$).

The growth pattern of the progeny of fasted gilts from birth through 21 wk of age is presented in Figure 1. Postnatal growth was influenced by the level of fasting ($p < 0.05$) and stage of growth ($p < 0.01$). There was also a significant ($p < 0.05$) fasting level by growth stage interaction; the mean body weight of the pigs did not differ ($p > 0.05$) at birth, 7 wk, and 14 wk of age. However, body weight at 21-weeks of age was different ($p < 0.05$) among the three experimental groups: 56.9, 64.5, and 68.9 kg for control, 7-d and 14-d fasted progenies, respectively.

The strong compensatory growth from pigs in the present studies agreed well with the previous reports by Donker *et al.*, (1986), who showed that restricting to 4 h of feeding a day or to 72% of *ad libitum* during growing or finishing period elicited

TABLE 3. Percent chemical body composition of pigs at birth from control and fasted gilts[a].

Item	Control	7-d Fasting	14-d Fasting
Dry Matter	20.6 ± 0.4	19.8 ± 0.5	20.1 ± 0.5
Protein[b]	15.4 ± 0.3	14.2 ± 0.5	14.7 ± 0.4
Lipid[b]	1.5 ± 0.1	1.2 ± 0.1	1.3 ± 0.2
Ash[b]	3.7 ± 0.2	4.4 ± 0.2	4.1 ± 0.3
Water	79.4 ± 0.4	80.2 ± 0.4	79.9 ± 0.5

[a] Mean ± SE for six animals
[b] Quadratic effect of fasting (P <0.05)

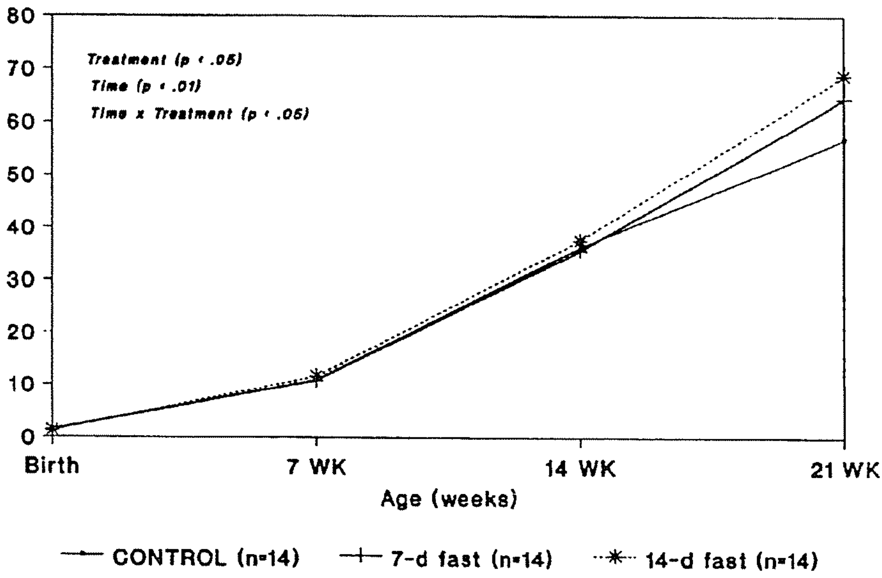

FIGURE 1. Growth patterns of progenies of control, 7-d and 14-d gestionally fasted gilts. Body weight of progeny at 21 weeks of age was different (P < 0.05 among the three groups.

a compensatory growth response proportional to the severity of restriction. Similar studies have shown that pigs from 40-d fasted dams grew faster between 80 to 150 d of age and attained prepubertal estrus earlier than controls (Hard and Anderson, 1982). In this study, most of the compensatory growth response occurred between 14-wk and 21-wk of age. It is not clear why the compensatory growth response was not triggered until 14-wk of age. Previous biochemical results from liver and skeletal muscles from pigs (Ezekwe and Opoku, 1988) showed that cellular development which was depressed at birth was fully reversed by 7 wk of age.

Normal husbandry practices in swine production recommend limited or restricted feeding of pregnant sows/gilts in order to minimize excessive fat deposition by the dam (Ensiminger, 1970). This study indicates that alteration of metabolite status of the dam through feed deprivation may also be beneficial to the progeny postnatally. However, maternal fasting cannot be recommended as a practical alternative for swine production until the sow's subsequent reproductive performance is thoroughly evaluated. More research is needed to understand the mechanism of action of compensatory growth response in swine.

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