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Mortality among young pigs prior to weaning is extremely high, with swine producers frequently realizing a death loss of 25% of the pigs farrowed. The majority of these deaths occur within three days post-farrowing and can be attributed to pigs being born weak, crushed by the dam, starvation and chilling. Generally these causes are the result of the inability of the baby pig, during the first few days of life, to adequately meet its metabolic energy requirements for sustaining vital body functions. The baby pig, until about three to four days of age, has a difficult time adjusting to those environmental stresses which require high levels of energy. The pig is born with limited body stores of metabolizable fat, and can make only limited use of dietary fat, due to an immature enzyme system. Considerable research interest has been shown in recent years in the development of methods by which increased adipose tissue would be deposited in the fetal pig, and with stimulating the enzyme system of the fetal pig to allow for the enhanced utilization of dietary fat in the sow's milk shortly after farrowing.

The purpose of this study was to alter the dietary energy intake of the gestating sow/gilt in an attempt to cause a conversion from the utilization of carbohydrates for energy to the catabolism of fat, of either a dietary or physiological nature. This conversion could potentially cause a switch from the placental transfer of glucose to ketones and free fatty acids. The utilization of these compounds for energy, in utero, could potentially result in increased fat deposition and the enhanced ability to utilize dietary fat as an energy source at the time of farrowing.

Experimental Procedure

Sixty-two crossbred sows and gilts were used in two experiments involving three different farrowing periods. In experiment 1 (March/April) 15 sows and gilts were allotted to four experimental treatments as follows:

1. Control - fed four pounds of a standard 12% protein corn-soybean meal gestation diet per day.
2. Solka Floc - fed four pounds of solka floc per day, with free access to trace mineralized salt.
3. Solka Floc + Fat - fed four pounds of solka floc with 15% added fat (yellow grease) per day, with free access to trace mineralized salt.
4. Fasted - free access to trace mineralized salt only.

The experimental period for experiment 1 ran from day 96 to day 110 of gestation. Experiment 2 consisted of two separate trials. Trial 1 (May/June) involved 26 gestating sows and gilts, trial 2 (October/November) involved 21 gestating sows and gilts. They were allotted to three experimental treatments as follows:

1. Control - fed four pounds of a standard 12% protein corn-soybean meal gestation diet per day.
2. Control + Fat - fed four pounds of standard 12% protein corn-soybean meal gestation diet with 7.5% added fat (yellow grease) per day, with free access to trace mineralized salt.
3. Solka Floc + Fat - fed four pounds of solka floc with 33.33% added fat (yellow grease) per day, with free access to trace mineralized salt.

The experimental period for both trials of experiment 2 was from day 101 to day 110 of gestation. Composition of the diets are shown in Table 1.

The solka floc used in these experiments was a commercial product manufactured from purified, bleached wood pulp. As defined by the pulp, paper and cellulose derivatives field it is pure cellulose and when used in specialized diets the assumption is made that it is non-caloric.

Prior to the experimental period, the gestating sows/gilts were housed in small groups, based upon parity, on dirt lots with non-insulated shelters, and were fed four pounds per day of the 12% corn-soybean meal gestation diet used as the experimental control. During the experimental period the gestating sows/gilts were penned according to treatment within a barn with an outside concrete feeding floor. The sows/gilts were fed daily at 8:00 a.m. in individual feeding stalls. Throughout the remainder of the day the sows/gilts had free access to fresh water and trace mineralized salt blocks. All inside pens were bedded with sawdust throughout the experimental period.

Backfat thickness was measured at approximately the tenth rib at the start of the experimental period to aid in the allotment of animals between treatments based upon physical condition. Sows/gilts were further allotted to treatments based upon weight, parity, genetic background and service sire. Weights and blood samples were taken on days 95, 100, 105 and 110 of

Table 1. Ingredient Composition of Diets (%)

Ingredient	Gestation					Lactation
	Control	Control + Fat	Solka Floc	Solka Floc + Fat (15%)	Solka Floc + Fat (33.33%)	
Ground yellow corn	77.60	69.22				70.15
Alfalfa meal, 17%	10.00	8.93				
Soybean meal, 44%	9.00	11.25				16.10
Beet pulp						10.00
Solka Floc			100.00	85.00	66.67	
Yellow grease		7.50		15.00	33.33	
Dicalcium phosphate	2.30	2.05				2.35
Ground limestone	.50	.45				.55
Trace mineral salt[a]	.50	.50				.50
Vitamin premix[b]	.10	.10				.10
ASP 250[c]						.25

[a] .8% zinc.

[b] Supplied per lb of diet: vitamin E, 5 IU; riboflavin, 1.5 mg; niacin, 8 mg; vitamin B_{12}, 6 mcg; menadione, 1 mg; d-pantothenic acid, 6 mg; vitamin A, 1500 IU; vitamin D, 150 IU.

[c] Supplied per lb of diet: aureomycin, 50 mg; sulfamethazine, 50 mg; penicillin, 25 mg.

gestation in experiment 1 and on days 100, 105 and 110 of gestation in experiment 2. Blood samples were obtained by vena puncture and were analyzed for serum glucose and serum free fatty acid (FFA) levels. Weights and blood samples were taken approximately five hours post-feeding.

At the end of the experimental period, on day 110 of gestation, the sows/gilts were brought into the farrowing facility. All animals received four pounds of a 14% protein corn-soybean meal lactation diet per day prior to farrowing, and the same diet on a gradually increasing level post-farrowing. Sows/gilts were confined in crates through three days post-farrowing, afterwhich some litters remained in the crates and others were moved to single litter pens. The crates and pens were situated on solid concrete floors that were bedded with sawdust and had solid dividers between adjacent pens/crates. Supplemental zone heat was provided for the baby pigs within the creep area. No cross-fostering of pigs between litters was allowed. The baby pigs received no creep feed but did have free access to the dam's feed and water. Following farrowing the baby pigs were weighed, ear-notched, had their needle teeth and tails clipped and received antibiotic and iron dextran injections. Pigs were weighed again three days post-farrowing and records were maintained concerning litter survivability.

All of the farrowings during trial 1 of experiment 2 were attended. Blood samples of newborn pigs were obtained by vena puncture immediately following birth and were analyzed for serum glucose, serum free fatty acids, and plasma fructose levels.

Results

The data for experiment 1 is summarized in Table 2. There was no significant difference among treatments for backfat thickness or for sow weight at allotment. There was a difference ($P<.01$) in gestation weight change from day 95 to day 110 of gestation, with sows from the solka floc and solka floc + fat treatments experiencing the largest reduction in weight, 56.3 and 53.0 pounds respectively. The fasted animals had a weight loss of 34.3 pounds and the control animals gained 2.0 pounds. There were no significant differences among treatments for serum glucose. Although serum FFA levels did not vary significantly among treatments at days 95 and 100 of gestation, there was a difference at days 105 and 110. Serum FFA change from day 95 to day 110 of gestation was 25.8 uEg/l for control animals and +1769.8, +1714.2 and +1724.8 uEg/l for the solka floc, solka floc + fat and fasted animals, respectively. There were no significant differences among treatments in experiment 1 for any of the parameters measured at farrowing or 3-days post-farrowing.

Table 2. Experimental Data For Experiment 1

Item	Treatments			
	Control	Solka Floc	Solka Floc + Fat	Fasted
Gestation				
95 d wt, lb	456.5	443.5	462.3	457.0
110 d wt, lb	458.0	387.3	409.3	422.8
95-110 d wt change, lb[a]	+2.0	-56.3	-53.0	-34.3
95 d serum glucose mg/dl	97.8	98.8	99.0	90.0
100 d serum glucose mg/dl	82.8	86.5	80.5	80.8
105 d serum glucose mg/dl	86.0	74.3	89.0	67.5
110 d serum glucose mg/dl	75.3	58.3	92.5	70.8
95-110 d serum glucose change mg/dl	-22.5	-41.0	-6.5	-19.5
95 d serum FFA uEg/l	333.5	264.5	542.2	402.3
100 d serum FFA uEg/l	272.0	1237.5	1298.7	1290.8
105 d serum FFA uEg/l[a]	207.5	1912.8	1422.5	2150.5
110 d serum FFA uEg/l[b]	307.8	2034.3	2256.3	2127.0
95-110 d serum FFA change uEg/l[b]	-25.8	+1769.8	+1714.2	+1724.8
Farrowing				
No. of sows/gilts	4	3	4	4
Gestation length, d	114.8	113.8	112.7	113.0
No. of live pigs/litter	11.0	11.3	11.8	12.5
Total litter wt, lb	33.7	31.8	32.5	36.0
Avg pig wt, lb	3.0	2.8	2.8	2.8
3-days post-farrowing				
No. of live pigs/litter	7.5	7.3	7.8	7.8
Total litter wt, lb	28.8	26.7	28.2	26.9
Avg pig wt, lb	3.6	3.7	3.5	3.3
Percent pig survival, %	68.0	65.8	68.8	61.0

[a] $P<.01$.

[b] $P<.05$.

The data for experiment 2 are summarized by trial in Table 3. Weight change from day 100 to day 110 of gestation varied for both trial 1 ($P<.05$) and trial 2 ($P<.01$). In both trials the control and control + fat animals gained weight during this period while the solka floc + fat animals lost weight. Serum glucose levels did not differ significantly for either trial at days 100 or 105 of gestation, however, there was a significant difference in serum glucose levels at day 110 of gestation for both trials 1 and 2. Serum glucose level change from days 100

to 110 of gestation varied significantly among treatments only in trial 1. In both trials, however, there was a net increase in serum glucose levels for the control and control + fat treatments and a net decrease in serum glucose level in the solka floc + fat treatment. There were no significant differences among treatments for serum FFA level at day 100 of gestation, however, there were differences at 105 and 110 days of gestation for both trial 1 and trial 2. Serum FFA change from day 100 to day 110 of gestation varied significantly among treatments in both trials. Again, as in experiment 1, there were no significant differences among treatments for any of the farrowing or 3-day post-farrowing variables.

The data for trials 1 and 2 of experiment 2 were also analyzed collectively. There were differences among treatments for 100 to 110 day gestation weight change ($P<.001$), 110 day gestation serum glucose level ($P<.001$), 100 to 110 day gestation serum glucose level change ($P<.01$), 105 and 110 day gestation serum FFA levels ($P<.001$) and 100 to 110 day gestation serum-FFA change ($P<.001$).

The blood analysis data for the baby pigs in trial 1 of experiment 2 are summarized in Table 4. There were no significant differences among treatments for serum glucose, plasma fructose, or serum FFA levels.

Table 3. Experimental Data For Experiment 2 By Trial

Item	Treatments					
	Control		Control + Fat		Solka Floc + Fat	
Trial	1	2	1	2	1	2
100 d wt, lb	429.4	393.1	425.8	399.9	432.5	394.5
105 d wt, lb	435.6	391.7	431.3	406.1	435.5	390.7
110 d wt, lb	440.2	395.3	436.7	412.7	428.3	376.4
100-110 d wt change, lb [a,d]	+10.8	+2.2	+10.8	+12.5	-4.3	-12.1
100 d serum glucose, mg/dl	60.7	66.0	65.8	72.4	73.1	69.8
105 d serum glucose, mg/dl	68.4	70.6	69.8	71.4	62.5	69.3
110 d serum glucose, mg/dl [a,c]	71.8	80.3	71.9	85.4	55.3	64.7
100-110 d serum glucose, mg/dl [a]	+11.1	+14.3	+5.8	+13.2	-17.9	-5.0
100 d serum FFA, uEg/l	192.5	328.9	306.1	251.4	323.1	265.6
105 d serum FFA, uEg/l [b,e]	247.7	300.6	299.5	364.0	1280.9	1342.6
110 d serum FFA, uEg/l [b,e]	310.8	324.2	355.2	548.0	1905.4	2138.0
100-110 d serum FFA change, uEg/l [b,e]	+118.7	-4.4	+48.9	+296.5	+1582.5	+1872.6
Farrowing						
No. of sows/gilts	8	7	10	7	8	7
Gestation length, d	115.2	114.8	114.8	114.4	113.8	113.6
No. of live pigs/litter	10.3	9.2	9.2	9.6	9.1	10.8
Total litter wt, lb	35.3	27.1	28.2	29.8	30.2	29.4
Avg pig wt, lb	3.5	2.9	3.3	3.2	3.4	2.8
3-days post-farrowing						
No. of live pigs in litter	6.8	7.6	6.5	7.8	5.9	6.4
Total litter wt, lb	25.8	28.4	21.1	28.7	22.9	21.4
Avg pig wt, lb	3.9	3.6	3.4	3.7	3.9	3.2
Percent pig survival	66.3	81.0	71.0	83.1	69.9	59.6

[a] Trial 1, $P<.05$.
[b] Trial 1, $P<.001$.
[c] Trial 2, $P<.05$.
[d] Trial 2, $P<.01$.
[e] Trial 2, $P<.001$.

Table 4. Baby Pig Blood Analysis Data
(Experiment 2, Trial 1)

Analysis	Treatments		
	Control	Control + Fat	Solka Floc + Fat
No. of pigs	82	94	73
Serum glucose, mg/dl	58.3	54.2	60.7
Plasm fructose, mg/dl	24.9	23.2	24.5
Serum FFA, uEg/l	423.0	434.3	394.9

Discussion

Serum FFA levels in the gestating sows/gilts were affected by dietary treatments. The serum FFA levels of the control animals in both experiments remained relatively stable, while the control + fat treatments in experiment 2 became slightly elevated, possibly due to the increased digestion of the dietary fat. In both experiments the serum FFA levels were extremely elevated at 110 days of gestation for the animals on the solka floc, solka floc + fat (15% and 33.33%) and the fasted treatments. Due to the poor consumption of the solka floc, with and without added fat in both experiments 1 and 2, these treatments may have been closely related to the fasted treatment of experiment 1. Similar peaks were reached for these treatments in experiment 1 after 15 days of treatment exposure and in experiment 2 after 10 days of treatment exposure. This may suggest that this is the maximum circulating serum FFA level possible.

There was little pattern in the serum glucose levels for any of the treatments in both experiments. Serum glucose levels may have influenced by glycogen breakdown resulting from the stress of animal handling during blood collection.

In the baby pig blood analyses of experiment 2, trial 1, there were no significant differences among treatments for any of the specific blood tests, in spite of the significant differences among treatments in the 110 day gestation levels of serum glucose ($P<.05$) and serum FFA ($P<.001$) in their dams. These baby pig blood levels may have peaked earlier in relation to the blood levels of their dam's, and returned to a normal level by the time of farrowing following the cessation of the dietary treatments of the dams at day 110 of gestation.

Differences were not observed among treatments in either of the experiments for any of the variables that were measured at the time of farrowing or 3-days post-farrowing.

Summary

Two experiments, involving three farrowing periods and 62 crossbred sows and gilts, were conducted to evaluate the dietary alteration of the energy metabolism in the sow/gilt during late gestation. Serum FFA levels of the sow/gilt were repeatedly influenced during gestation by the dietary treatment; however, this was less noticeable with serum glucose levels. The dietary treatment of the gestating sow/gilt during the experimental period had no influence on the litter performance exhibited at farrowing or 3-days post-farrowing.