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R. Dean Boyd
University of Nebraska-Lincoln

B. D. Moser
University of Nebraska-Lincoln

E. R. Peo, Jr.
University of Nebraska-Lincoln

P. J. Cunningham
University of Nebraska-Lincoln

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EFFECT OF ENERGY SOURCE PRIOR TO PARTURITION AND DURING LACTATION ON TISSUE LIPID, LIVER GLYCOGEN AND PLASMA LEVELS OF SOME METABOLITES IN THE NEWBORN PIG[1,2]

R. Dean Boyd, B. D. Moser, E. R. Peo, Jr. and P. J. Cunningham

University of Nebraska, Lincoln 68583

SUMMARY

Two experiments were conducted to determine the effect of energy source (carbohydrate or fat), fed to sows prior to parturition and during lactation, on energy storage and some metabolite levels in the neonatal pig which may exert an influence on rate of survival.

The first experiment, which involved 12 gravid gilts, consisted of three diets and involved a comparison between energy level and source. The control diet, providing 5,750 kcal of metabolizable energy (ME)/gilt daily, was supplemented with either stabilized tallow or cornstarch to provide 9,300 kcal of ME/gilt daily. Treatments were initiated on the 100th day of pregnancy and continued until parturition. Blood samples were obtained, from the dams on day 110. Those fed tallow had a higher ($P<.05$) free fatty acid concentration when compared to dams receiving cornstarch. At birth, piglets in the tallow group had approximately 2.0% carcass lipid and 188 mg of glycogen/g of wet liver, which was higher but not significantly different from piglets in the cornstarch group (1.9%, 175 mg/g, respectively). While glycogen was highly concentrated in the liver of piglets at birth, it was rapidly depleted postnatally. At 6 hr, 49% of the glycogen remained, and at 24 hr only 14% remained.

A second experiment was conducted to study the effect of additional energy in the form of tallow administered to sows from the 109th day of pregnancy through lactation on the concentration of glucose, FFA and β-hydroxybutyric acid in the plasma of piglets whose birth weights ranged from 680 to 1,090 grams. Piglets from dams fed tallow had a higher ($P<.10$) glucose concentration (54.1 *vs* 37.2 mg/100 ml) at birth than piglets in the control group. Piglets in the tallow group also had a higher ($P<.05$) glucose concentration 6 hr after birth (89.4 *vs* 69.2) and at 24 hr (86.4 *vs* 67.2) compared to piglets in the control group.
(Key Words: Lipid, Glycogen, Glucose, FFA, β-Hydroxybutyric Acid, Piglet.)

INTRODUCTION

While the rate of piglet survival appears to be enhanced when tallow is added to the diet of the lactating dam (Boyd *et al.*, 1978), the physiological factor(s) that influenced survival remain obscure. It is postulated that increased fat content of the dam's milk and content of stored energy (i.e., glycogen and adipose tissue) in the piglet play a vital role.

A number of researchers have demonstrated that the newborn piglet becomes hypoglycemic when fasted for a relatively short period of time (Grahman *et al.*, 1941; Sampson *et al.*, 1942; Morrill, 1952; Goodwin, 1955; Schaffer *et al.*, 1965), whereas it becomes relatively refractory to fasting hypoglycemia by approximately 120 to 140 hr of age (Sampson *et al.*, 1942). Although the piglet is born with a high concentration of liver glycogen, it is rapidly depleted during the period of transition between birth and establishment of regular and adequate suckling. Thus the piglet must be able to effectively compete with littermates for nourishment from the dam. The unusual susceptibility of the newborn to hypoglycemia may be due, in part, to a quantitative deficiency of the mobilizable fat stores. This leads to a progressive decrease in the free fatty acids, and, in turn, results in a failure of the rate of gluconeogenesis to keep

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pace with glucose demands (Swiatek *et al.*, 1968).

The objectives of the present study were to determine (1) the effect of level (5,750 *vs* 9,300 kcal ME) and source (tallow *vs* cornstarch) of energy in the gestation diet on tissue lipid and liver glycogen content at birth, and rate of liver glycogen disappearance postnatally, and (2) the effect of energy source administered in the gestation-lactation diet of the dam on the concentration of plasma glucose, free fatty acids (FFA) and β-hydroxybutyric acid (BHA) in piglets weighing between 680 to 1,090 g at birth.

EXPERIMENTAL PROCEDURE

Trial 1. Twelve crossbred (Hampshire × Yorkshire × Duroc) gilts were bred to farrow during June. They were involved in a completely randomized design consisting of three gestation diets. All females received 1.82 kg of a corn-soybean meal diet daily until day 100 of gestation, when they were placed in farrowing crates and dietary treatments imposed until parturition. The feeding regime and diet composition, during the experimental part of the gestation period, was described earlier (Boyd *et al.*, 1978). During lactation, the gilts received a lactation control diet which was also previously described (Boyd *et al.*, 1978).

A blood sample was obtained from each of the 12 gilts, 7 hr post-feeding, on day 110 of gestation. Venous blood was obtained from the brachial region for glucose and FFA analysis. Blood for glucose analysis was collected into a separate evacuated glass tube[3] containing sodium fluoride to inhibit glycolysis and potassium oxalate as an anticoagulant. Blood for FFA analysis was collected into an evacuated glass tube containing sodium heparin. After centrifugation, aliquots of plasma were transferred to sterile plastic culture tubes, sealed, and frozen (−10 C) until analyzed. Plasma glucose was determined by the glucostat method[4], while plasma FFA concentration was determined by the method of Laurell and Tibbling (1967).

At birth, piglets were ear notched for identification, weighed and the time of birth was recorded. Litter size was standardized to seven pigs/litter. Piglets weighing ≥772 g at birth were sacrificed at four time periods (birth, 6, 12, and 24 hr after birth). Four pigs represented each gestation treatment, in each time period. The first male piglet born alive in each litter was sacrificed immediate at birth (t_0), prior to nursing, while the first female piglet was sacrificed 6 hr following birth (t_6). At 12 hr (t_{12}) the second male piglet born was sacrificed and at 24 hr (t_{24}) the second female piglet born was sacrificed. Piglets in t_6, t_{12} and t_{24} groups had access to the sow until sacrifice. In only one instance was the opposite sex required to substitute in a time period. In each hour of sacrifice, either one sex or the other was used to assure balance for sex. The method of sacrifice was suffocation by placing the pig into a sealed container while infusing carbon dioxide. Body weight was recorded following sacrifice and the head removed. The gastrointestinal tract, liver and bladder were removed and the carcass of t_0 and t_6 piglets frozen at −10 C until analyzed for total lipid content. The liver was blotted to remove blood (i.e., superficial and internal), placed in polyethylene bags and frozen between two pieces of dry ice. Livers from piglets representing each of the four periods were maintained at −10 C until analyzed for glycogen content.

Piglet carcasses representing t_0 and t_6 periods were thawed, ground twice in a meat grinder and then placed in a Waring blender to homogenize and reduce particle size prior to sampling for analysis. Aliquots were taken and analyzed for total lipid content by the method of Folch *et al.* (1957). Moisture of the ground carcass was determined by drying the tissue at 105 C for 18 hr in a forced air oven. Approximately 1 g of liver tissue was homogenized in a Potter-Elvehjem homogenizer and aliquots were taken for glycogen determination by the colorimetric micro method of Kemp and Heijningen (1954).

Plasma metabolite and liver glycogen data were analyzed by an appropriate application of the one-way analysis of variance while lipid data were analyzed by two-way cross-classification analysis of variance (Snedecor and Cochran, 1967).

Trial 2. Seventeen Nebraska Gene Pool (Zimmerman and Cunningham, 1975) second parity sows were bred to farrow during January and used in a study involving two dietary gestation-lactation treatments (table 1). Nine sows were

[3] Vacutainer tube, Becton-Dickinson, Rutherford, NJ.

[4] Worthington Biochemical Corp., Freehold, NJ.

TABLE 1. COMPOSITION OF THE GESTATION-LACTATION DIETS, TRIAL 2

Ingredient, %	Internat'l Ref. No.	Diet	
		Control	Control + tallow
Ground yellow corn	4-02-931	65.05	44.33
Soybean meal	5-04-612	15.95	19.34
Tallow, bl., fancy	4-07-880	...	15.00
Beet pulp	4-00-669	10.00	11.11
Wheat bran	4-05-991	2.50	2.78
Dehydrated alfalfa	1-00-023	2.50	2.78
Dicalcium phosphate	6-01-080	2.02	2.25
Calcium carbonate	6-01-069	.43	.48
Monosodium phosphate		...	.20
Trace mineral premix[a]		.05	.06
Sodium chloride (iodized)		.50	.56
Vitamin premix[b]		1.00	1.11
		100.00	100.00

[a]Contributed the following in mg/kg of control/control + tallow diets respectively: Zn, 100/120; Fe, 50/60; Mn, 27.5/33.0; Cu, 5.0/6.0; Co, .5/0.6; I, .75/.95.

[b]Contributed the following per kg of control/control + tallow diets respectively: vitamin A, 5,500/6,105 IU; vitamin D_3, 440/488 ICU: vitamin E, 22.00/24.42 IU: riboflavin, 2.86/3.17 mg; pantothenic acid, 22.00/24.42 mg; niacin, 22.0/24.42 mg; choline chloride, 220.02/244.22 mg; vitamin B_{12}, 22.00/24.42 μg, menadione sodium bisulfite, 2.20/2.44 mg, in a ground corn carrier.

assigned to the control diet and eight to a diet with 15% added stabilized tallow. Sows were individually fed 1.82 kg/day of a 14% corn-soybean meal diet following breeding until the last trimester, when they received 2.73 kg/day. At day 109, sows were placed in farrowing pens and the dietary treatments imposed, with sows receiving 2.27 kg of their respective experimental diets until parturition, when sows were fed *ad libitum* for 14 days. The tallow diet was formulated to provide approximately equal nutrient intake as compared to sows consuming the control diet with the exception of tallow. This trial was initiated to compare the levels of plasma glucose, FFA and BHA, as affected by the dam's diet, in piglets weighing between 680 and 1,090 grams. BHA was used as an index of the ketone body concentration.

Blood samples were obtained from piglets via anterior vena cava (Carle and Dewhirst, 1942) at three time periods within 24 hr of birth. Piglets (both sexes) were either bled immediately at birth (t_0) prior to nursing or at 6 and again at 24 hr (t_6 and t_{24}, respectively) post-birth using a 22 gauge needle, 1 inch in length. Blood samples were not obtained from piglets assigned to be bled at t_0 unless the sample could be collected within 30 sec of birth. Piglets not collected within this interval were assigned to the t_6 and t_{24} treatments. Randomization to hour of bleeding was as follows: the first pig born alive that qualified (i.e., weight: 680 to 1,090 g) was bled immediately, while the rest of the pigs that qualified were bled at t_6 and again at t_{24}. Approximately 1 ml of blood was obtained for glucose analysis and approximately 2 ml of blood were obtained for FFA and BHA determinations. Handling and procedure of analysis of blood were previously described in trial 1 with the addition of the method of Gibbard and Watkins (1968) for the analysis of BHA.

Data were analyzed by least squares analysis of variance within each hour. Since random differences, due to sampling, in mean treatment, pig weight could not be controlled adequately, piglet birth weight was included in the analysis of variance. For piglets in the t_6 group, differences in birth weight accounted for much of the variation observed in plasma glucose values but was not significant ($P = .10$). By 24 hr, however, weight was a highly significant ($P<.005$) source of variation. The correlation coefficient between birth weight and plasma glucose, at 24 hr, was .44 ($P<.05$). Therefore, plasma glucose values for piglets in the t_6 and t_{24} groups (table 5) represent least square means adjusted for piglet birth weight (i.e., weight as covariable). Other values appearing in table 5 for plasma glucose, FFA and BHA are

TABLE 2. EFFECT OF DIETARY ENERGY LEVEL AND SOURCE ON PLASMA GLUCOSE AND FREE FATTY ACID CONCENTRATION IN THE DAM ON THE 110th DAY OF GESTATION[a], TRIAL 1

Item	Diet			
	Control	Control + tallow	Control + cornstarch	SEM
Number gilts	4	4	4	
Plasma glucose, mg/100 ml	53.6	55.6	56.5	2.7
Plasma FFA, mEq./L.[b]	.12	.15	.11	.01

[a]Diets fed from 100th day of gestation to parturition.

[b]Energy source: tallow *vs* cornstarch ($P<.05$).

unadjusted least square means.

RESULTS AND DISCUSSION

The concentration of plasma glucose and FFA in the dam on the 110th day of gestation is given in table 2. Plasma glucose averaged approximately 55 mg/100 ml and was similar among treatments. Dams receiving the tallow diet had a higher ($P<.05$) FFA concentration (.15 *vs* 11 mEq./L.) than dams fed cornstarch, indicating a source effect on this criterion. No effect due to level of energy was observed. It has been shown repeatedly that fatty acids are transported from mother to fetus in rats (Koren and Shafrin, 1964), rabbits (Van Duyne *et al.*, 1962), guinea pigs (Hershfield and Nemeth, 1968), sheep (van Duyne *et al.*, 1960), man (Van Duyne *et al.*, 1962; Szabo *et al.*, 1969) and monkeys (Portman *et al.*, 1969). In contrast to glucose, the fatty acid level in the mother's blood is usually not reflected in that of the fetus (Hanson and Ballard, 1968) but the rate of transport can be raised by increasing the FFA level in the maternal blood (Sabata *et al.*, 1968). This may play a role in energy storage of the newborn piglet.

The effect of the dam's gestation diet on moisture and lipid content of the carcass and glycogen concentration of the liver in the newborn piglet is shown in table 3. Mean values for tissue lipid and moisture content represent data from piglets sacrificed at t_0 and t_6 since variation due to hour (hour and sex being confounded) and hour x treatment interaction was not significant ($P>.05$). While methods of sampling piglets from each litter failed to equalize weight, means for carcass lipid were not adjusted since weight and lipid content were not highly correlated ($r = .075$).

Piglets in the tallow group had 1.99% tissue lipid while piglets from the control and corn-

TABLE 3. EFFECT OF DAM'S GESTATION DIET ON CARCASS MOISTURE, CARCASS LIPID AND LIVER GLYCOGEN CONCENTRATION IN THE NEWBORN PIGLET, TRIAL 1[a,b]

Item	Diet			
	Control	Control + tallow	Control + cornstarch	SEM
Mean piglet weight, g (8)	1063	1172	1260	...
Moisture, %[c]	80.7	80.7	80.1	1.8
Lipid, %[c]	1.86	1.99	1.88	.10
Mean piglet weight, g (4)	1121	1153	1218	...
Liver glycogen at birth mg/g	170.95	187.74	174.95	9.55

[a]Diets imposed on 100th day of pregnancy.

[b]Number in parenthesis represents number of piglets per treatment.

[c]Mean values for lipid and moisture content represent piglets sacrificed at birth and 6 hr following birth. Variation due to hour (birth, 6)of sacrifice and hour X treatment interaction not significant ($P>.05$).

starch groups had 1.86% and 1.88%, respectively. No difference in tissue lipid content was observed for piglets within energy level or source comparisons but piglets in the tallow group tended to have a higher concentration than those from the corn-starch group. Seerley *et al.* (1974) observed a difference ($P<.05$) in tissue lipid concentration as a result of corn oil administration (2.44%) in comparison to corn starch (2.04%) when the treatments were initiated on day 109 of gestation, whereas, Friend (1974) reported that feeding corn oil during late gestation did not increase percent fat in carcasses of newborn piglets.

Energy level did not appear to affect liver glycogen concentration in piglets at birth. Piglets in the tallow group had 187.7 mg/g in comparison to 175.0 mg/g for piglets in the cornstarch group, however, the numerical difference between energy sources were not significant. Further investigation using more piglets is warranted to determine, with confidence, the effect of energy source on liver glycogen concentration at birth. Seerley *et al.* (1974) reported that piglets from dams fed cornstarch or corn oil had more ($P<.05$) glycogen per unit of weight in the *longissimus* muscle than those from the control group. Both groups had more glycogen in the liver but only piglets in the cornstarch group were significantly higher.

The rapidity with which glycogen is removed from the liver of piglets from birth though 24 hr of age is shown in table 4. The first 24 hr were considered to be a period of transition when liver glycogen reserves would be hydrolyzed to help maintain blood glucose concentration until regular and adequate suckling was established. Shelley (1961) has shown that large glycogen reserves are accumulated late in fetal life in a number of species and these reserves have an important function as sources of metabolic fuel when the neonate is separated from its placental source of glucose at birth. She demonstrated that after birth glycogen reserves decrease rapidly, reaching their minimal point the first day. A number of researchers have shown that glycogen is rapidly removed from the liver of the piglet postnatally (Sampson *et al.*, 1942; Morrill, 1952; Swiatek *et al.*, 1968; Anderson and Wahlstrom, 1970; Elliot and Lodge, 1977) but Anderson and Wahlstrom (1970) and more recently Elliot and Lodge (1977) measured liver glycogen concentration close enough to the time of birth to demonstrate how soon thereafter glycogen was being

TABLE 4. EFFECT OF DAM'S DIETARY TREATMENT PRIOR TO PARTURITION ON THE RATE OF LIVER GLYCOGEN DISAPPEARANCE IN THE PIGLET FROM BIRTH THROUGH 24 HOURS, TRIAL 1[a]

Hour of sacrifice	Treatment comparison					Pooled comparison[b]		
	No. pigs per treatment	Control	Control + tallow	Control + cornstarch	SEM	No. pigs per treatment	Glycogen concentration	% of 0 hr.
0 (birth)	4	170.95	187.74	174.95	9.55	12	177.88	...
6	4	73.76	94.10	93.89	24.64	12	87.25	49.05
12	4	61.92	97.80	59.39	14.13	12	73.04	41.06
24	4	18.96	22.18	35.02	7.02	12	25/30	14.27

[a]Diets fed from 100th day of pregnancy to parturition.

[b]Means for dietary treatments were pooled within hour of sacrifice.

depleted. The concentration of liver glycogen at birth has been shown to be 40 to 100 mg/g of wet tissue in a number of species (Shelley, 1961) but the piglet has been reported to be considerably higher (Swiatek *et al.*, 1968; Anderson and Wahlstrom, 1970; Mersmann, 1971; Seerley *et al.*, 1974). Piglets sacrificed immediately at birth in this study had 177.9 mg of glycogen per g of liver tissue, which compares well with data by Mersmann (1971) and Seerley *et al.* (1974). Six hours after birth 49.1% of the glycogen remained. Twenty-four hours after birth only 14.3% remained. Since tissue lipid storage is extremely low and liver glycogen is rapidly removed, it is absolutely essential for piglets to obtain regular and adequate nourishment from the dam in order to survive.

Effect of the dam's gestation diet on the rate of liver glycogen disappearance in the piglet from birth through 24 hr of age is shown in table 4. Differences between energy level and source within each hour were not significant. It was postulated that administration of a fat source prior to parturition and/or during lactation would have a liver glycogen sparing effect on the piglets. While piglets in the tallow group appeared to have more liver glycogen at birth through 12 hr, in comparison to piglets in the other groups, there were no statistical differences observed.

The next approach was to test the postulate that administration of a fat source, to the dam, would have a glycogen sparing effect on the piglets when tallow was administered prior to and during the lactation period. Trial 2 was designed to concentrate on smaller piglets, which appeared to benefit considerably from tallow addition as indicated by increased survival rate (Boyd *et al.*, 1978). The data indicated that piglets whose birth weight was ≤1,000 g tended to have a higher rate of survival on days 1, 2, 3, and 14 when their dams received tallow in the

TABLE 5. EFFECT OF THE DAM'S GESTATION-LACTATION DIET ON THE CONCENTRATION OF GLUCOSE, FREE FATTY ACIDS AND β-HYDROXYBUTYRIC ACID IN PLASMA OF PIGLETS WEIGHING 680 TO 1,090 G AT BIRTH, TRIAL 2[a,b,c]

Time/Metabolite	Diet: Control	Diet: Control + tallow
	4 Pigs	5 Pigs
Birth		
Glucose, mg/100 ml[d]	37.18 ± 5.84	54.06 ± 5.23
Free fatty acids, mEq./L.	.07 ± .01	.07 ± .01
β-hydroxybutyric acid, mEq./L.	.01 ± .00	.01 ± .00
	15 Pigs	
6 hr after birth		
Glucose, mg/100 ml[e]	69.19 ± 6.07	89.35 ± 6.07
Free fatty acids, mEq./L.	.15 ± .02	.15 ± .04
β-hydroxybutyric acid, mEq./L.	.03 ± .00	.03 ± .00
24 hr after birth		
Glucose, mg/100/100 ml[e,f]	67.18 ± 4.87	86.37 ± 4.87
Free fatty acids, mEq./L.	.23 ± .02	.21 ± .02
β-hydroxybutyric acid, mEq./L.	.04 ± .00	.03 ± .00

[a]Diets fed from 109th day of pregnancy through 14-day lactation.

[b]Number of litters with pigs weighing 680 to 1,090 g/number of litters allotted to study for control and tallow diets, respectively, 7/9, 6/8.

[c]Least square means. Plasma glucose values at 6 and 24 hr adjusted for birth weight of the piglets utilized in study. Mean birth weights for control and tallow piglets, respectively: 953 g and 867 g. Unadjusted values for control and tallow piglets at 6 and 24 hr, respectively: 71.05, 88.17; 72.61, 79.82.

[d]Control *vs* tallow ($P<.10$).

[e]Control *vs* tallow ($P<.05$).

[f]Diet × sex interaction ($P<.01$). Treatment × sex means for control and tallow treatments (female and male) respectively: 80.4, 54.0 *vs* 76.1, 96.7.

lactation diet. Piglets whose birth weight was between 680 and 1,090 g were used in this study. It was felt that blood glucose concentration would be indicative of the persistence of liver glycogen concentration and that it would represent the sum of the benefits derived from ingestion of dietary carbohydrates, glycogenolysis and gluconeogenesis. The effect of the dam's gestation-lactation diet on the concentration of plasma glucose, FFA and BHA is shown in table 5. Piglets from dams fed tallow had a higher ($P<.10$) glucose concentration (54.1 *vs* 37.2 mg/100 ml) at birth than piglets from dams on the control diet. This advantage was maintained through 24 hours. Piglets in the tallow group had a higher ($P<.05$) glucose concentration at t_6 (89.4 *vs* 69.2) and at t_{24} (86.4 *vs* 67.2) compared to piglets in the control group. At t_{24}, a highly significant ($P<.01$) diet × sex interaction existed. (table 5, footnote f). This indicates that variation in plasma glucose at t_{24} was due to large differences within males between treatments. A biological explanation for this is not known. Seerley *et al.* (1974) reported a similar finding to that observed in the t_0 group. Addition of corn oil to a basal diet, fed to gravid sows, caused increased ($P<.05$) blood glucose concentration in piglets at birth as compared to energy added from cornstarch (55.2 *vs* 43.4 mg/100 ml, respectively).

Some question could arise about whether a glucose concentration of 86.4 at t_{24} is enough higher than 67.2 mg/100 ml to account for an increased rate of survival. A frequency distribution of the t_{24} plasma glucose concentration is shown in table 6 for each treatment group. Two of the piglets in the control group had glucose concentrations between 0 and 20 mg/100 ml. Both were in coma when sampled. Blood glucose in vigorous, healthy baby pigs usually fluctuates between 60 and 140 mg/100 ml and as long as the concentration remains above 50 mg/100 ml, the piglet may not show any unusual behavior (Sampson, 1964). When the glucose concentration decreases to 20 mg/100 ml or less, convulsions and coma are imminent.

Addition of tallow to the diets of gestating-lactating sows exerted a glucose maintaining effect in smaller, presumably less competitive piglets in the litter (680 to 1,090 g). This is postulated to be a major factor affecting an increase in rate of survival of this group. The observation is possibly due to one or a combination of the following: (1) greater concentration of liver glycogen at birth, (2) a larger proportion of the energy being contributed by fat via the milk, and (3) possibly greater concentration of carcass lipid at birth.

Another important energy source that is present in the blood is FFA. According to Dryer (1970), FFA is that portion of the total fatty acid pool that circulates in immediate readiness for metabolic needs (i.e., satisfaction of energy requirements). This small but important lipid moiety is especially important when an insufficient quantity of glucose limits the usual carbohydrate sources of energy. Under conditions of acute starvation, the FFA concentration in piglets may rise to twice the normal concentration (Swiatek *et al.*, 1968; Gentz *et*

TABLE 6. FREQUENCY DISTRIBUTION OF 24 HR PLASMA GLUCOSE CONCENTRATION OF PIGLETS WEIGHING 680–1,090 g AT BIRTH, TRIAL 2[a]

Glucose concentration interval mg/100 ml	Dietary treatment			
	Control		Control + tallow	
	Frequency	%	Frequency	%
0 – 20	2	13.33	0	.0
20 – 40	0	.0	0	.0
40 – 60	1	6.67	2	13.33
60 – 80	7	46.66	4	26.67
80 – 100	3	20.00	8	53.33
100 – 120	1	6.67	1	6.67
120 +	1	6.67	0	.0
Total	15	100.00	15	100.00

[a]The mean plasma glucose values for control and tallow diets, respectively, are 67.18 and 86.37 mg/100 ml (see table 5).

al., 1970) provided adequate substrate mixture (i.e., tissue lipid) is available. Adequate tissue lipid is apparently not available in newborn pigs. Concentration of plasma FFA in piglets whose birth weights ranged from 680 to 1,090 g are given in table 5. In both treatment groups, the concentration of plasma FFA increased from birth through 24 hours. This has been shown to occur in a number of newborn mammals (Van Duyne and Havel, 1959; Persson and Gentz, 1966) including the pig (Bengtsson *et al.*, 1969). Plasma FFA averaged .07 mEq./L. at t_0, .150 mEq./L. at t_6 and approximately .223 mEq./L. at t_{24} and was similar among treatments.

There was a moderate elevation of plasma BHA (table 5) during the test period and was similar in both treatment groups. It would appear that a ketotic condition would not be a complicating factor acting to limit survival in neonatal piglets. This conclusion is given support by Gentz *et al.* (1970).

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