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Supplemental Biotin for Swine. II. Influence of Supplementation to Corn- and Wheat-Based Diets on Reproductive Performance and Various Biochemical Criteria of Sows during Four Parities

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SUPPLEMENTAL BIOTIN FOR SWINE. II. INFLUENCE OF SUPPLEMENTATION TO CORN- AND WHEAT-BASED DIETS ON REPRODUCTIVE PERFORMANCE AND VARIOUS BIOCHEMICAL CRITERIA OF SOWS DURING FOUR PARITIES[1]

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Summary

Data from 116 females previously fed a corn-soybean basal diet with 0 or 220 μg supplemental biotin/kg during growth and development were used to study the influence of 0 (NB) or 440 (SB) μg of supplemental biotin/kg to corn-(C) or wheat- (W) based diets for gilts and sows housed in total confinement. Reproductive performance through four parities (total of 245 litters) and various sow and pig biochemical criteria were evaluated. Females fed W diets were older ($P<.07$) at first estrus, farrowed litters that were lighter weight ($P<.01$) at birth and that contained fewer ($P<.05$) total and live pigs compared with females fed C diets. Biotin supplementation did not significantly influence ($P>.10$) farrowing and lactation performance; however, after the first parity, total and live pigs/litter at farrowing tended to be larger for SB females. Conception rate at first estrus postpartum was increased ($P<.07$) by 9% and the average weaning to estrus interval was reduced ($P<.05$) from 14.5 to 10.2 d with SB. Biotin supplementation increased ($P<.001$) the biotin content of sow plasma, milk and liver, while sow liver pyruvate carboxylase activity was not altered ($P>.10$). Pigs farrowed by SB females had three- and fivefold higher ($P<.001$) levels of plasma biotin at birth and 14 d of age, respectively; however, liver biotin levels at birth were not different ($P>.10$) for pigs from NB and SB females. The response to biotin supplementation was similar for C- and W-based diets. The improvements in conception rate and weaning to first estrus and the trend for larger litters after the first parity suggest that biotin supplementation of diets for gilts and sows housed in total confinement may contribute to an improvement in reproductive performance.

(Key Words: Sows, Biotin, Reproduction, Plasma Biotin, Milk Biotin, Grain.)

Introduction

Interest concerning the role of biotin in swine nutrition was rekindled in the mid-1970's with the observation from field trials that biotin supplementation resulted in an improvement in reproductive performance (Cunha, 1971). During the last 7 yr, numerous reports have suggested a beneficial effect of supplemental biotin on litter size, conception rate and the weaning to first estrus interval in sows (Brooks et al., 1977; Halama, 1979; Brooks and Simmins, 1981; Penny et al., 1981; Brooks, 1982); however, other reports (Easter et al., 1979; Grandhi and Strain, 1980; Hamilton et al., 1982) failed to show an improvement from supplemental biotin levels. The supplemental levels reported ranged from 100 to 2,000 μg/kg diet and included basal diets containing varying feedstuffs.

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The biotin present in feedstuffs is not totally available to nonruminants (Wagstaff et al., 1961; Scott, 1968; Anderson and Warnick, 1970). Using chick growth assays, higher biotin bioavailability values have been reported for corn compared with milo, barley, sorghum, oats and wheat, with wheat having the lowest value (Frigg, 1976; Anderson et al., 1978; Baker, 1978).

The effects of biotin supplementation on swine body stores, placental biotin transfer and milk biotin levels are not known. An understanding of their relationship to swine reproductive performance could be useful in ascertaining the need for biotin in sow diets.

The objective of this research was to study the influence of biotin supplementation to corn- and wheat-based diets on reproductive performance and various biochemical criteria in gilts and sows housed in total confinement for four parities.

Materials and Methods

Gilts previously fed the corn diets from the three growing-finishing trials (groups in sow study) reported by Bryant et al. (1985) were utilized in this study. After completion of the growing-finishing trials, 116 crossbred gilts (36, 40 and 40 gilts from a total of 80, 80 and 80 gilts in trials 1, 2 and 3, respectively) weighing approximately 100 kg were selected based on routine (e.g., underlines, growth rate, soundness, et cetera) gilt selection criteria for the reproductive study. Gilts from within each of the previous biotin levels were randomly assigned (based on weight and ancestory) to either a corn-soybean meal (C) or a wheat-soybean meal (W) diet as outlined below. Supplemental biotin (SB) was added at a level of 440 μg/kg diet to both C and W diets.

Unsupplemented gilts (C)
29 gilts / \ 29 gilts
C W

Supplemented gilts (C+SB)
29 gilts / \ 29 gilts
C+SB W+SB

Diet composition and analyses are presented in table 1. The four diets were initially formulated to be isonitrogenous and isocaloric; however, chemical analysis indicated the W diets were higher in crude protein (2.2% units) than were the C diets. Each gilt received 2.3 kg of feed daily from selection (100 kg) to 21 d after the initial breeding period. Through the remaining part of the first gestation period, 1.8 kg were fed daily. During all subsequent breeding and gestation periods, 1.8 kg were fed from March 1 until November 30 and 2.3 kg were fed from December 1 until February 28 of each year. During lactation, 10% ground (9.5 mm screen) oats were added to each diet. After farrowing, feed intake was increased gradually to a maximum daily intake of 1.36 kg plus .45 kg for each pig being nursed at 7 d post-farrowing.

During breeding and gestation, females (gilts and sows) were housed in total confinement facilities containing partially slatted concrete and solid concrete floors. On d 109 ± 1 of gestation, females were washed, disinfected and randomly assigned to partially slatted farrowing crates that were cleaned and disinfected before each farrowing.

After selection and assignment to dietary treatments at approximately 100 kg (180 d of age), all gilts were checked for estrus once daily using intact boars. Gilts were not bred until they had exhibited at least one normal estrous cycle (18 to 22 d). During specified breeding periods, estrous checks were conducted twice daily at approximately 12-h intervals. Females were bred 12, 24 and 36 h after initial detection of estrus by artificial insemination. Semen from boars was collected daily and fresh semen was used for at least one of the three breedings.

All females were weighed at d 109 ± 1 of gestation and at weaning during each parity, and sow weight loss was calculated. At 12 ± 4 h of age, pigs were weighed. The total number of pigs/litter was determined from the number of live, stillborn and mummified fetuses at parturition. At 21 d post-farrowing, number of pigs/litter, pig body weight, total litter weight and survival rate of pigs born alive were determined for each litter.

Plasma was recovered from blood samples (20 ml) taken via anterior vena cava puncture in each female at selection, at d 109 ± 1 of gestation and at weaning during each parity. From the last 30 litters farrowed, plasma samples were obtained from two male and two female pigs selected at random. Samples were taken via vena cava puncture before nursing and at 14 d of age. Replacement pigs were selected at random for those pigs dying before d 14 of age.

TABLE 1. DIET INGREDIENT AND CHEMICAL COMPOSITION[a]

Item	Diet	
	Corn	Wheat
Ingredient, T		
Yellow corn (IFN 4-02-931)	81.56	
Soft winter wheat (IFN 4-05-284)		84.53
Soybean meal (IFN 5-04-604)	15.51	12.61
Limestone (IFN 6-02-532)	.68	.75
Defluorinated phosphate (IFN 6-01-780)	1.50	1.36
Salt (IFN 6-14-013)	.40	.40
Trace mineral premix[b]	.10	.10
Vitamin-selenium premix[c]	.25	.25
Total	100.00	100.00
Chemical analysis (as-fed basis)		
Crude protein, %	14.0	16.2
Calcium, %	.92	.87
Phosphorus, % (total)	.58	.63
Gross energy, kcal/kg	3,880	3,844
Biotin, μg/kg[d]	105	131

[a]Biotin premix (220 mg/kg) added to obtain a supplemental level of 440 μg biotin/kg diet.

[b]Contained: 20% Zn, 10% Fe, 5.5% Mn, 1.1% Cu and .15% I.

[c]Supplied (per kilogram of premix): 1.76 g riboflavin, 8.8 g pantothenic acid, 8.8 g niacin, 8.8 mg vitamin B_{12}, 176 g choline chloride, 176,000 IU vitamin A, 176,000 IU vitamin D_3, 4,400 IU vitamin E, 440 mg menadione dimethylprimidinol bisulfite (MPB) and 40 mg Se.

[d]Determined by microbiological assay. Corn + biotin and wheat + biotin diets contained 470 and 490 μg total biotin/kg diet, respectively.

The four pig samples were composited by litters (1-ml aliquot/pig) within sampling times and assayed for plasma biotin (PB) concentration. During parities 3 and 4, one pig was killed immediately after birth from each of 41 litters and the liver removed and frozen at −20 C until assayed for biotin content. Fifty-three sows (parities 3 and 4) were given 3 ml oxytocin intramuscularly (d 14 of lactation) and a milk sample obtained by manual expression of all milk from one side of the udder. Biotin determinations were made on milk samples after the fat was removed by centrifugation (10,000 x g) for 15 min under refrigeration. Five to seven days after weaning at parity 4, sows were slaughtered and liver samples obtained for determination of biotin and pyruvate carboxylase activity. Pyruvate carboxylase activity was determined on fresh liver tissue according to the procedure of Deodhar and Mistry (1969) and activity was expressed as nmol $^{14}CO_2$ converted$\cdot$min$^{-1}\cdot$mg protein^{-1}. Protein concentrations were determined on homogenized liver samples by the procedure of Lowry et al. (1951). Liver samples were lyophilized and ground (Wiley mill, .5-mm screen) before biotin assays. All biotin determinations were performed using the microbiological procedure outlined by Bryant et al. (1984).

Females were removed from the experiment if they (1) failed to conceive after two successive breeding periods, (2) failed to express estrus by 400 d of age, (3) failed to return to estrus within 60 d after weaning, (4) encountered farrowing problems (i.e., small birth canal, prolapsed uterus, et cetera) that would significantly affect the sow's performance during the next parity and that were believed unrelated to dietary treatments and(or) (5) developed unsoundness that prevented them from rising and walking to obtain food and water. The number of females removed from the study is summarized in table 2.

Statistical Analysis. Conception rate and biochemical criteria were analyzed as a 3 x 2 x 2 factorial using analysis of variance procedures. Animal group (trial from growing-finishing studies), level of biotin and type of grain were fixed main effects. Breeding period means were the experimental unit for conception rate, while females and(or) pigs were the experimental unit for the biochemical data. Reproductive data were analyzed as a split-plot design with Harvey's (1977) mixed-model least-squares analysis procedure. Fixed main plot effects included biotin, grain, group (trial from growing-finishing studies) and all possible two-way interactions. A preliminary analysis indicated no three-or fourway interactions ($P<.50$) of biotin, grain, group or parity; therefore, all three- and fourway interactions were omitted from the model. The mean square for random effects of female within biotin, grain and group was used to test fixed main plot effects. Fixed sub-plot effects of parity and all twoway interactions of parity with biotin, grain and group were tested with the residual error mean square. The parity effect was also partitioned into linear, quadratic and cubic orthogonal components.

Results

Only 40 females (34.5%) of the 116 gilts that started the study completed four parities (table 2). Eight gilts failed to complete four parities before the study was terminated; however, if the study had been continued, a portion of these eight gilts would certainly have reached four parities. Anestrous behavior was high, with 27 females (23.3%) culled for this reason. Eight of these 27 anestrous females failed to reach puberty, while the remaining 19 became anestrus after puberty (four) or weaning (15). Examination of the ovaries from 23 females culled for anestrus and so classified revealed small ovaries containing no follicles > 3 mm, no corpora hemorrhagica and no corpora lutea. Ovaries from four females contained corpora lutea and corpora albicantia, indicating cyclic activity but lack of estrous expression (silent heat). Anestrous activity was evenly distributed across dietary treatments. Seventeen females (14.7%) were culled for failure to conceive after two successive breeding periods, with 12 and 5 females coming from NB and SB diets, respectively. Twelve females (five from NB and seven from SB) were culled for unsoundness.

There was a biotin × parity interaction ($P<.03$) for sow weight loss from d 109 ± 1 of gestation to 21 d post-farrowing. During parity 1, SB sows lost less weight than did NB sows; however, during parity 4, NB sows lost more

TABLE 2. NUMBER OF FEMALES REMOVED FROM THE EXPERIMENT BY REASON

	Supplemental biotin, μg/kg	
Reason	0	440
Completed four parities	18	22
Anestrus		
Never cycled[a]	4	4
Postpuberty[b]	1	3
Postpartum[c]	9	6
Failure to conceive	12	5
Unsoundness[d]	5	7
Died	3	1
Rectal prolapse	2	1
Farrowing problems	1	1
Failed to complete four parities before termination of study	4	4
Miscellaneous	1	2
Total	60	56

[a]Defined as failure to express estrus before 400 d of age.

[b]Defined as failure to continue to exhibit estrous cycles after puberty.

[c]Defined as failure to return to estrus with 40 d postweaning.

[d]Defined as unable to rise, walk and obtain food and water.

weight. Weight loss during parities 2 and 3 was similar for NB and SB sows. There were no other twoway interactions of biotin, grain, group or parity; therefore, the data were summarized by main effects of biotin and type of grain.

Breeding Performance. Age at first estrus was greater (P<.07) for W-fed gilts compared with C-fed gilts (table 3). The biotin × grain interaction was significant, with C + SB gilts exhibiting estrus at the youngest age (260 d) and W + SB gilts exhibiting estrus at the oldest age (284 d). The mean age at first expressed estrus (puberty) was 272 d. These results are much higher than those reported by Mavrogenis and Robison (1976); however, the incidence of gilts with delayed puberty has been reported to range from 10 to 50% under modern production systems (Christenson and Ford, 1979; Rampacek et al., 1981). Group effect was significant (P<.001), with gilts in group 3 averaging 358 d to puberty as compared with 231 and 236 d for group 1 and 2, respectively. There were no biotin × group and grain × group interactions (P>.10); therefore, the data for group 3 was included in the analysis. Some undiagnosed condition is believed responsible for this dramatic effect on group 3 and based

TABLE 3. LEAST-SQUARES MEANS FOR THE REPRODUCTIVE PERFORMANCE OF GILTS AND SOWS FED TWO LEVELS OF BIOTIN AND TWO TYPES OF GRAIN

	Grain		Supplemental biotin, μg/kg		
Item	Corn	Wheat	0	440	SE[a]
No. of litters	119	126	118	127	
Breeding performance					
Age first estrus, d[bc]	269	281	278	272	3.2
Conception rate, %[de]	80.2	79.4	75.3	83.9	2.4
Weaning to estrus interval, d[fg]	13.0	11.7	14.5	10.2	1.1
Farrowing performance					
Total pigs born/litter[ghi]	11.8	10.6	11.1	11.3	.24
Live pigs born/litter[ghi]	10.7	9.7	10.1	10.4	.22
Pig birth wt, kg	1.38	1.31	1.35	1.34	.02
Total litter birth wt, kg[gj]	14.7	12.7	13.5	13.9	.33
Lactation performance to 21 d					
No. of pigs/litter	8.9	8.5	8.5	8.9	.20
Pig body wt, kg	5.14	5.09	5.10	5.12	.07
Total litter wt, kg	45.4	42.6	42.9	45.1	.96
Pig survival rate, %[gk]	83.8	88.8	85.6	87.0	1.3
Sow wt loss, g[il]	26.5	24.1	26.3	24.3	1.0
Daily feed intake/sow, kg[glm]	4.2	4.1	4.2	4.2	.05

[a]Standard error of the treatment mean.

[b]Grain effect (P<.07).

[c]Biotin × grain effect (P<.05).

[d]No. of females pregnant ÷ no. of females mated × 100.

[e]Biotin effect (P<.07).

[f]Biotin effect (P<.05).

[g]Linear parity effect (P<.01).

[h]Grain effect (P<.05).

[i]Biotin × parity interaction (P<.10).

[j]Grain effect (P<.01).

[k]No. of pigs alive at 21 d ÷ no. of pigs born alive × 100.

[l]From d 109 ± 1 of gestation to 21 d post-farrowing.

[m]Maximum daily feed intake was 1.36 kg plus .45 kg/pig nursing.

on the symptoms, a viral infection is hypothesized. Simmins and Brooks (1983) reported no effect of biotin supplementation on age at onset of puberty.

Average days to estrus after weaning decreased linearly ($P<.01$) from parity 1 to parity 3. No data were obtained after weaning at parity 4. The weaning to estrus interval was extremely variable (range, 5 to 60 d). Of 19 anestrous females, 12 became anestrus after weaning. The number of anestrous sows was high. However, a recent survey indicated that the incidence of postweaning estrus in sows varied from 4 to 40% among herds (Crabo, 1982). Only the data from females returning to estrus within 40 d after weaning were used to test for differences. The weaning to estrous interval was shorter ($P<.05$) in females that received SB diets (10.2 d) compared with females that received NB diets (14.5 d). However, the percentage of gilts returning to estrus within 7 d was similar (49 vs 45%) for NB and SB females, respectively. More SB females (32 vs 12%) returned to estrus from 7 to 14 d compared with NB females, with this difference primarily responsible for the overall biotin effect. Brooks et al. (1977), Halama (1979) and Simmins and Brooks (1983) have also reported a reduction in the weaning to rebreeding interval with supplemental biotin. To the contrary, Penny et al. (1981) and Grandhi and Strain (1980) noted no response in the weaning to estrous interval with biotin supplementation.

Initially, conception rates were low (73.3 and 70% for parities 1 and 2, respectively) but increased during parities 3 and 4 (82 and 91%, respectively). Females consuming SB diets had a 9% higher ($P<.05$) conception rate compared with NB females. Halama (1979) also reported a 9% improvement in conception rate when biotin was supplemented to diets of sows showing visual signs of hair loss and foot lesions. Grandhi and Strain (1980) failed to obtain a response in conception rate with biotin supplementation.

Farrowing Performance. Females consuming C diets farrowed a greater ($P<.03$) number of total pigs/litter and a greater ($P<.05$) number of live pigs/litter (table 3) compared with females receiving the W diets. The average litter birth weight was 2 kg greater ($P<.01$) for C females as compared with W females. The reason for this reduction in farrowing performance when W diets were fed is unknown. Wheat diets were isocaloric with C diets and contained 2% units higher crude protein; therefore, a lack of dietary crude protein or energy may be eliminated as factors. Dietary amino acid analysis also indicated adequate levels for both types of grain.

Based on the combined data for four parities, biotin supplementation did not improve ($P>.10$) any of the farrowing responses that were tested. However, there was a biotin × parity interaction for average number of total pigs/litter ($P<.08$) and average number of live pigs/litter ($P<.10$). Females consuming SB diets farrowed fewer total pigs (1.5 pigs) and live pigs (1.2 pigs) per litter during the first parity compared with NB females (figure 1). At parity 2, the response for total pigs/litter was similar for NB and SB females, but number of live pigs/litter was .7 pigs higher for SB females compared with NB females. During parities 3 and 4 the improvements in litter size for SB females were almost identical, with increases of 1.0 and .8 pigs/litter for average number of pigs and average number of live pigs, respectively. Studies from Europe and Mexico, which used basal diets of varying composition, have reported improvements in litter size ranging from 4 to 14% (Brooks et al., 1977; Halama, 1979; Michel and Mastchi, 1981; Penny et al., 1981; Simmins and Brooks, 1983). Three of these studies (Brooks et al., 1977; Penny et al., 1981; Simmins and Brooks, 1983) also noted a greater response in litter size for sows compared with gilts. No improvements in farrowing performance for supplemental biotin have been reported for females consuming corn-soybean meal diets (Easter et al., 1979; Hamilton et al., 1982) and barley-wheat-soybean meal diets (Grandhi and Strain, 1980).

Lactation Performance. Lactation performance was not significant ($P>.10$) for level of biotin or type of grain fed (table 3). All responses favored the females fed SB diets, compared with the NB diets, with the combined lactation responses resulting in SB females having 2.2 kg heavier litters at 21 d of lactation. Other reports on the lactation performance of sows consuming diets containing supplemental biotin have reported slight to no response (Brooks et al., 1977; Easter et al., 1979; Hamilton et al., 1982; Simmins and Brooks, 1983).

The significant advantages in litter size and litter weight obtained at farrowing for females fed C diets were not present ($P>.10$) at 21 d of lactation. But all responses at 21 d of lactation,

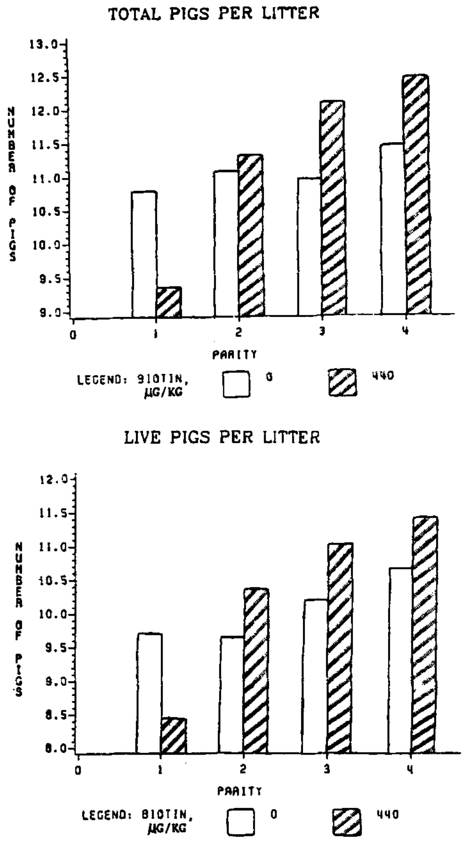

Figure 1. Biotin X parity interaction for total number of pigs and live pigs per litter.

except pig survival rate, favored the females fed C diets compared with W-fed females.

Biochemical Criteria. Other than a reduction (P<.06) in baby pig PB at 14 d of age for W-based diets, the type of grain fed did not influence (P>.10) sow and pig biotin body stores or sow hepatic pyruvate carboxylase activity (table 4). Biotin supplementation elevated (P<.001) sow and pig PB levels and biotin content of sow milk and liver. Pig liver biotin content (at birth) and sow hepatic pyruvate carboxylase activity were not influenced (P>.10) by level of biotin. The initial PB levels shown in table 4 reflect the elevation in PB from biotin supplementation during the growing-finishing period (Bryant et al., 1985). Plasma biotin remained higher (P<.001) at d 109 of gestation and at weaning during each parity for females consuming SB diets. Plasma biotin levels were lower (P<.05) at d 109 of gestation compared with PB levels at weaning. This higher PB at weaning may reflect the elevated daily feed intake during lactation. Simmins and Brooks (1983) also reported elevated plasma biotin levels for biotin supplemented sows, but prefarrowing and weaning levels were similar.

Females consuming SB diets had a threefold increase in milk biotin concentration and the magnitude of the difference between NB and SB females was similar to the difference observed for PB. A positive correlation (P<.05) was observed between sow milk biotin level and pig PB, with elevations in milk biotin resulting in higher pig PB at 14 d of age (.65). Pig liver biotin content was positively correlated (P<.01) with sow pyruvate carboxylase activity (.72). Plasma biotin was extremely high in newborn pigs, but there was a seven- and fourfold decrease in PB at 14 d of age for pigs from NB and SB females, respectively. Sow PB at weaning was negatively correlated (P<.01) with pig PB at birth (−.71).

Discussion

The results of this study indicate that sow plasma, milk and liver stores and pig plasma concentrations of biotin can be increased by supplementing breeding herd diets with biotin at 440 μg/kg diet. The porcine placenta seems capable of transporting large quantities of biotin to the fetus as evidenced by higher levels in the fetal plasma at birth in pigs from the SB females. Kaminetzky et al. (1974) observed much higher biotin blood levels in human neonates at birth compared with maternal biotin blood levels and hypothesized that the placental transfer mechanism accumulates biotin in fetal circulation against a concentration gradient.

The suggested NRC (1979) biotin requirement for gilts and sows is 100 μg/kg diet. Although not conclusive, results from the present study suggest that this level may be insufficient for optimal reproductive performance in breeding swine housed in total confinement. The mechanism by which biotin might increase conception rate and reduce the weaning to estrus interval is unclear. Penny et al. (1981) suggested an important role for biotin in numerous enzyme reactions that are ultimately involved in energy production and utilization. This role may be a factor in improvement of litter size for second through fourth parity sows supplemented with biotin. This hypothesis may

TABLE 4. LEAST-SQUARES MEANS FOR VARIOUS BIOCHEMICAL CRITERIA AS INFLUENCED BY BIOTIN SUPPLEMENTATION AND TYPE OF GRAIN FED[a]

	Grain				Supplemental biotin, $\mu g/kg$				
Item	Corn		Wheat		0		440		SE[b]
Plasma biotin, ng/dl[c]									
Initial	101	(53)	99	(57)	60	(55)	141	(55)	4.3
Gestation (d 109)[d]	102	(95)	91	(109)	51	(97)	132	(107)	2.9
Weaning[d]	111	(82)	108	(99)	69	(88)	150	(93)	3.1
Milk biotin, μg/liter[ce]	44	(25)	47	(28)	24	(23)	68	(30)	2.8
Liver biotin, μg/g DM[c]	1.10	(38)	1.20	(37)	.96	(39)	1.34	(36)	.06
Liver pyruvate carboxylase activity[f]	10.6	(32)	10.1	(26)	10.2	(30)	10.5	(28)	2.31
Pig									
Plasma biotin, ng/dl[c]									
Day 0	841	(14)	883	(14)	425	(11)	1299	(17)	111
Day 14[g]	229	(14)	146	(15)	62	(11)	313	(18)	22
Liver biotin, μg/g DM	.77	(21)	.75	(20)	.79	(17)	.73	(24)	.04

[a]No. of observations/mean in parentheses.

[b]Standard error of the treatment mean.

[c]Biotin effect ($P<.001$).

[d]Mean for four parities.

[e]Grain × biotin effect ($P<.03$).

[f]Expressed as nmol $^{14}CO_2$ converted·min^{-1}·mg $protein^{-1}$.

[g]Grain effect ($P<.06$).

also be involved in the conception rate and postweaning improvements observed in this study. The present study is the first sow report on biotin supplementation that presents the combined reproductive responses of conception rate, farrowing-lactation performance and the weaning to estrus interval. The results point to an improvement in all three phases of reproduction from biotin supplementation and suggest the need for further study of biotin's role in swine reproduction.

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