Effect of dietary biotin supplementation on sow reproductive performance and soundness and pig growth and mortality.

K L Watkins, L L Southern and J E Miller

J ANIM SCI 1991, 69:201-206.

EFFECT OF DIETARY BIOTIN SUPPLEMENTATION ON SOW REPRODUCTIVE PERFORMANCE AND SOUNDNESS AND PIG GROWTH AND MORTALITY[1,2,3]

K. L. Watkins[4], L. L. Southern[5] and J. E. Miller[6]

Louisiana State University Agricultural Center, Baton Rouge 70803

ABSTRACT

A 3-yr study was conducted to evaluate the effect of dietary biotin supplementation on the reproductive performance of 90 sows and gilts, and on the pre-weaning growth and mortality of 223 litters. Corn-soybean meal-based diets supplemented with either 0 or 440 μg/kg d-biotin were fed to sows throughout their reproductive cycle. Biotin supplementation had no beneficial effect ($P > .10$) on 107-d sow weight, sow weight at weaning, weaning to estrus interval, foot lesion score, hair loss score, structural soundness score, number of pigs born, number and percentage of pigs born alive or number and percentage of pigs alive at 21 d of age. Biotin supplementation had no effect ($P > .10$) on pig growth or mortality to 21 d of age. These data do not support the concept that biotin supplementation of sow diets is needed.

Key Words: Sows, Pigs, Biotin, Reproduction

J. Anim. Sci. 1991. 69:201–206

Introduction

Biotin is required for CO_2 transfer and activation in carbohydrate metabolism and is a cofactor in other processes involved in protein and lipid metabolism (Balnave, 1977; McDowell, 1989). Experimentally produced biotin deficiencies in swine (Cunha et al., 1946; Hamilton et al., 1982; Misir et al., 1986) as well as in other species (Kratzer et al., 1988; Watanabe and Endo, 1989) have demonstrated that biotin is essential as a B vitamin. Recently, researchers have noted a similarity between the symptoms of experimentally produced biotin deficiency (dermatitis, alopecia, spasticity and edema of the feet, foot lesions, fatty livers and impaired reproductive performance) and clinical abnormalities in sows (Brooks et al., 1977; Grandhi and Strain, 1980; Penny et al., 1981). These symptoms historically have been attributed to poor management and to environmental and breeding stress.

Biotin supplementation of sow diets has been reported to improve (Brooks et al., 1977; Penny et al., 1981; Tribble et al., 1984; Webb et al., 1984; Bryant et al., 1985a,b,c) or to have no effect (Easter et al., 1979; Grandhi and Strain, 1980; Hamilton and Veum, 1984) on sow reproductive performance. Therefore, this study was conducted to investigate the effects of supplemental dietary biotin on sow reproductive performance and soundness and pig growth and mortality to 21 d of age.

Materials and Methods

Ninety crossbred sows fed corn-soybean meal-based, gestation-lactation diets, supplemented with either 0 or 440 μg/kg d-biotin (Table 1), were used in a 3-yr study. Initially, sows were allotted randomly to treatment

[1]Approved for publication by the Director of the Louisiana Agric. Exp. Sta. as manuscript No. 89-11-3368.

[2]Conducted as part of an objective of the S-145 Committee on Nutritional Systems for Swine to Increase Reproductive Efficiency.

[3]Supported in part by Hoffmann-La Roche Inc., Nutley, NJ.

[4]Present address: Lilly Res. Labs., Eli Lilly and Co., P.O. Box 708, Greenfield, IN 46140.

[5]Address reprint requests to L. Lee Southern, Dept. of Anim. Sci., Louisiana State Univ., Baton Rouge 70803.

[6]Dept. of Epidem. and Comm. Health, Louisiana State Univ. School of Vet. Med.

Received January 25, 1990.

Accepted May 9, 1990.

TABLE 1. PERCENTAGE COMPOSITION OF DIETS[a]

	Dietary treatment	
Ingredient	Basal	Basal + biotin
Ground corn	81.28	81.08
Soybean meal (44% CP)	15.93	15.93
Defluorinated rock phosphate	1.67	1.67
Oyster shell flour	.57	.57
Salt	.25	.25
Trace mineral mix[b]	.05	.05
Vitamin mix[c]	.25	.25
Biotin premix[de]		.20

[a]Formulated to contain the following: 14% CP, .66% lysine, .8% Ca, .6% P and 3,202 kcal ME/kg.

[b]Trace mineralized salt provided the following per kilogram of diet: Zn, 75 mg; Fe, 87.5 mg; Mn, 30 mg; Cu, 8.75 mg; I, 1 mg; Ca, 9 mg and salt, 2.5 g.

[c]Vitamin premix provided the following per kilogram of diet: vitamin A, 4,400 IU; vitamin D_3, 440 IU; vitamin E, 11 IU; riboflavin, 4.4 mg; d-pantothenic acid, 22.0 mg; niacin, 22.0 mg; vitamin B_{12}, 22 μg and choline chloride, 440 mg.

[d]Biotin premix provided 440 μg d-biotin/kg diet.

[e]Biotin content of feed was monitored (Hoffmann-La Roche, Inc., Nutley, NJ) using a microbiological growth assay. Overall mean biotin levels were approximately 160 ± 22 and 443 ± 32 μg/kg for basal and basal + biotin diets, respectively.

groups on the basis of parity and weight. However, when sows were removed from the study for failure to return to estrus or because of injury, they were replaced randomly with gilts. The basal diet was provided to 45 females (112 litters) whereas the basal + biotin diet was provided to 45 females (111 litters). Of the 45 females in each treatment, 28 gilts were used in the basal group and 29 gilts were used in the basal + biotin group. A second data set was derived from the original data set. This second data set contained data from sows that completed at least four farrowings on their respective diets; it included 44 (basal) and 48 litters (basal + biotin) and 11 and 12 sows, respectively. Of the 11 sows in the basal group, 5 were gilts; of the 12 sows in the basal + biotin group, 7 were gilts.

During gestation, sows were penned in groups of six or less in an open-sided building in 2.4-m × 4.9-m pens with partially slatted concrete floors. At d 107 of gestation, sows were moved into farrowing crates with vinyl-coated, expanded-metal floors. The farrowing house was a completely closed facility with underslat waste storage. Fans and air inlets provided ventilation; no artificial cooling or heating was used.

All litters in a contemporary farrowing group were weaned when the youngest litter was 28 d of age. Age at weaning never exceeded 42 d. Cross-fostering of pigs was not practiced and litters were not equalized. Sows were rebred on the first estrus after weaning. The breeding period ended 10 d after weaning or after 23 females were bred. Days to estrus was recorded regardless of whether estrus was detected after the breeding period ended. Sows were culled if they failed to return to estrus during the immediate postweaning breeding period or if they did not exhibit estrus during two subsequent breeding periods.

The diet (Table 1) was supplemented with either 0 or 440 μg/kg d-biotin. Diets were adequate in all nutrients for gestating and lactating swine (NRC, 1988) and were fed throughout the complete reproductive cycle. From d 107 of gestation to 7 d postfarrowing, 20% of each diet was replaced with wheat bran. Sows were fed 1.8 kg/d during gestation and 1.4 kg/d plus .45 kg/pig during each day of lactation. The complete diets were analyzed for biotin content[7] and found to contain 160 ± 22 and 443 ± 32 μg/kg biotin for the basal and basal + biotin diets, respectively. The basal and basal + biotin diet means ± standard deviations were obtained from 35 and 39 diet samples, respectively. We have no explanation for the difference in calculated (600 μg/kg) vs analyzed (443 μg/kg) biotin content of the basal + biotin diet.

[7]Hoffmann-La Roche, Inc., Nutley, NJ.

TABLE 2. NUMBER OF LITTERS PER FARROWING GROUP

	Dietary treatment	
Farrowing number	Basal	Basal + biotin
First	45	45
Second	29	32
Third	20	18
Fourth	11	12
Fifth	7	4
Average ± SD	2.5 ± 1.5	2.5 ± 1.3

Sows were weighed on d 107 of gestation and at the time pigs were weaned. After weaning, sows were evaluated and scored independently by three individuals for incidence and severity of foot lesions, hair loss and structural soundness. Foot lesions were scored according to the system adopted by Brooks et al. (1977). Each foot lesion was given a score from 1 to 5, with a score of 1 indicating small minor lesions and a score of 5 indicating large severe lesions. Hair loss was assigned a score from 1 to 5, with a score of 1 representing no hair loss and a score of 5 representing extensive hair loss. Structural soundness was given a value between 1 and 15, with a score of 1 indicating the sow was structurally correct, sound and free-moving, and a score of 15 indicating severe lameness inhibiting her ability to walk.

Each pig was weighed at farrowing and at 21 d of age; number of pigs born, number born alive and number alive at 21 d of age were recorded to evaluate sow reproductive performance.

Data were analyzed using ANOVA procedures appropriate for repeated measure design (Steel and Torrie, 1980). Independent effects in the model were dietary treatment, sow, farrowing number, sow within treatment and treatment by farrowing interaction. Treatment mean differences were tested using sow within treatment mean square as the error term. Using the same model, pig growth and mortality to 21 d were analyzed with litter as the experimental unit. The variable, number of pigs born, was used as a covariate in the model to test the effects of biotin on percentage of pigs born alive, number of pigs at 21 d, percentage of pigs alive at 21 d, and pig weight at 21 d. The covariate was significant ($P < .05$) for each trait.

Results and Discussion

The sows in both treatment groups were on the study for various lengths of time and for a different number of farrowings (Table 2). Therefore, the results presented here are divided into two data sets. One set contains data from all sows and litters irrespective of the number of farrowings they contributed to the study (Table 3). The second data set contains only sows that completed at least four farrowings during the experimental period (Table 4). Although no farrowing × treatment interactions were detected ($P > .10$) in the data

TABLE 3. EFFECT OF DIETARY BIOTIN ON THE REPRODUCTIVE PERFORMANCE OF ALL SOWS[a]

	Dietary treatments		
Item	Basal	Basal + biotin	SE
107-d sow wt, kg	214.7	207.1	7.6
Sow wt at weaning, kg	193.0	186.5	6.8
Foot score	3.91	3.06	1.52
Hair score	1.74	1.56	.12
Soundness score	2.34	2.43	.19
Rebreeding interval, d	6.35	5.80	.74
No. of pigs born	11.19	11.35	.57
Percentage born alive	77.98	80.49	3.18
Pig birth wt, kg	1.47	1.49	.06
No. of pigs at 21 d	6.85	7.74	.49
Percentage alive at 21 d[b]	80.53	86.62	3.72
Pig 21-d wt, kg	5.05	4.97	.16

[a]Data are least square means of 112 litters (basal) or 111 litters (basal + biotin). No differences were observed due to biotin supplementation ($P > .10$).

[b]As a percentage of pigs born alive.

TABLE 4. EFFECT OF DIETARY BIOTIN ON THE REPRODUCTIVE PERFORMANCE OF SOWS COMPLETING FOUR FARROWINGS[a]

Item	Dietary treatments		SE
	Basal	Basal + biotin	
107-d sow wt, kg	219.6	199.7	9.2
Sow wt at weaning, kg	196.7	185.2	7.7
Foot score	7.16	6.48	1.38
Hair score	1.68	1.58	.11
Soundness score	2.38	2.23	.22
Rebreeding interval, d	4.98	5.25	.42
No. of pigs born	11.41	10.66	.58
Percentage born alive	78.82	81.91	2.13
Pig birth wt, kg	1.58	1.45	.08
No. of pigs at 21 d	7.42	7.56	.34
Percentage alive at 21 d[b]	89.00	85.82	2.38
Pig 21-d wt, kg[c]	5.15	4.73	.13

[a]Data are least square means of 44 (basal) or 48 (basal + biotin) litters representing 11 and 12 sows, respectively.

[b]As a percentage of pigs born alive.

[c]Biotin effect, $P < .03$.

of our experiment, we felt it necessary to equalize farrowing number across treatments and to present this second data set. In addition, Brooks et al. (1977) and Bryant et al. (1985b) have reported that biotin supplementation increased the number of total and live pigs farrowed only after the first parity. Therefore, all first farrowing data were removed from the second data set and the remaining data were reanalyzed. No significant differences ($P > .10$) in this analysis deviated from either of the previously described statistical analyses. Thus, this final data set is not presented.

Feeding sows a corn-soybean meal-based diet supplemented with 440 μg/kg d-biotin had no effect ($P > .10$) on reproductive performance, soundness, foot lesions, hair loss or subsequent pig growth and mortality (Table 3). Grandhi and Strain (1980) reported that biotin supplementation (200 or 300 μg/kg) had no effect on gestation weight gain, lactation weight loss, number of pigs born, birth weight, number of pigs at 21 d and 21-d pig weight. However, they reported that biotin supplementation slightly (but nonsignificantly) decreased the severity of foot lesions. Hamilton and Veum (1984) also reported that biotin supplementation (550 μg/kg) did not affect reproductive performance, soundness of feet and legs or hair score of sows. Easter et al. (1979) reported that biotin supplementation (200 μg/kg) of a corn-soybean meal sow gestation diet was not warranted.

Biotin supplementation did not improve ($P > .10$) reproductive performance, soundness, foot lesions, hair loss or pig growth and mortality of sows when only the data from sows that completed at least four farrowings (Table 4) were analyzed. In fact, weight of pigs at 21 d was reduced ($P < .03$) by biotin supplementation.

Several studies have shown that dietary biotin supplementation reduces the incidence and(or) severity of foot lesions and cracks in sows (Brooks et al., 1977; Webb et al., 1984; Bryant et al., 1985a,c). Although in our experiment foot lesion scores of sows fed biotin-supplemented diets tended to be lower than those of sows fed unsupplemented diets (Tables 3 and 4), this difference did not approach significance ($P > .6$) due to the variability of this trait (CV = 77 and 76 for the foot lesion score data in Tables 3 and 4, respectively). Attempting to normalize distribution of foot lesion, hair and soundness score data by performing a log(+1) transformation (Steel and Torrie, 1980) did not change the probability levels for these criteria. However, our results are similar to those of Hamilton and Veum (1984), who found no improvements from added biotin in the overall appearance or soundness of feet and legs in sows.

Brooks et al. (1977) and Bryant et al. (1985a) also have reported that biotin reduced the weaning to rebreeding interval. Our data support those of Grandhi and Strain (1980), Hamilton and Veum (1984) and Tribble et al.

(1984), who were unable to detect any effect from biotin supplementation on rebreeding interval.

Biotin supplementation did not affect the length of time sows remained reproductively viable (Table 2). The sows used in this study farrowed an average of 2.5 litters regardless of biotin supplementation.

The results reported here do not support the concept that supplementation of corn-soybean meal-based sow diets with biotin is beneficial. The discrepancy in the efficacy of biotin supplementation seen in presently available literature most likely reflects the wide range of environmental, nutritional and management practices used in the swine industry today. Grandhi and Strain (1980) reported that biotin supplementation of gestation and lactation diets containing barley and wheat did not improve reproductive performance. However, Misir and Blair (1988a) reported that the biotin in cereal grains was poorly available to the pig and that diets based on wheat or barley would not contain an adequate level of bioavailable biotin. Bryant et al. (1985a,b) observed beneficial effects from supplementing wheat-based sow diets with 440 μg/kg biotin and Brooks et al. (1977) reported that supplementing wheat- and barley-based diets with biotin reduced foot lesions and increased the number of pigs farrowed.

Biotin in corn has been reported to be nearly completely available to poultry (Frigg, 1976; Misir and Blair, 1988b). In our study and in the studies of Easter et al. (1979) and Hamilton and Veum (1984), in which essentially no beneficial effects of biotin supplementation were found, corn was used exclusively as the grain source. Sauer et al. (1988), however, reported that only 4% of the biotin in corn was digested by growing barrows fitted with T-cannulas, and that, although the total biotin content of many feedstuffs was adequate, its availability to the pig was low. Hamilton and Veum (1984) have suggested that overdrying, poor storage conditions and presence of mold may reduce the availability of biotin in corn. This could account for some of the beneficial effects of biotin supplementation reported by those feeding corn-based diets.

Another important factor that should be considered is housing conditions. Type of flooring may affect the incidence and severity of foot lesions and soundness. Access to feces or pasture also will provide the sow with additional biotin. In our study, sows were kept in total confinement pens with partially slatted floors, allowing access to fecal material. Microbial production of biotin in the large intestine may provide a substantial amount of biotin under some conditions. Although we do not know how much, if any, of microbially produced nutrients can be absorbed in the hindgut, through coprophagy sows would obtain microbial biotin to supplement their dietary intake.

Implications

Biotin supplementation of corn-soybean meal diets did not improve reproductive performance of sows or the preweaning performance of their pigs. However, under certain environmental and nutritional conditions biotin supplementation might be warranted.

Literature Cited

Balnave, D. 1977. Clinical symptoms of biotin deficiency in animals. Am. J. Clin. Nutr. 30:1408.

Brooks, P. H., D. A. Smith and V.C.R. Irwin. 1977. Biotin-supplementation of diets: the incidence of foot lesions, and the reproductive performance of sows. Vet. Rec. 101:46.

Bryant, K. L., E. T. Kornegay, J. W. Knight, H. P. Veit and D. R. Notter. 1985a. Supplemental biotin for swine. III. Influence of supplementation to corn- and wheat-based diets on the incidence and severity of toe lesions, hair and skin characteristics and structural soundness of sows housed in confinement during four parities. J. Anim. Sci. 60:154.

Bryant, K. L., E. T. Kornegay, J. W. Knight, K. E. Webb, Jr. and D. R. Notter. 1985b. 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. J. Anim. Sci. 60:145.

Bryant, K. L., E. T. Kornegay, J. W. Knight, K. E. Webb, Jr. an D. R. Notter. 1985c. Supplemental biotin for swine. I. Influence on feedlot performance, plasma biotin and toe lesions in developing gilts. J. Anim. Sci. 60:136.

Cunha, T. J., D. C. Lindley and M. E. Ensminger. 1946. Biotin deficiency syndrome in pigs fed desiccated egg white. J. Anim. Sci. 5:219.

Easter, R. A., J. R. Corley, M. W. Esch and D. L. Wende. 1979. Vitamin B-6, biotin, folacin and thiamin supplementation of corn-soybean meal diets for swine. J. Anim. Sci. 49(Suppl. 1):239(Abstr.).

Frigg, M. 1976. Bio-availability of biotin in cereals. Poult. Sci. 55:2310.

Grandhi, R. R. and J. H. Strain. 1980. Effect of biotin supplementation on reproductive performance and foot lesions in swine. Can. J. Anim. Sci. 60:961.

Hamilton, C. R., T. L. Veum, D. E. Jewell and J. A. Siwecki. 1982. The biotin status of weanling pigs fed semipurified diets as evaluated by plasma and hepatic parameters. Int. J. Vitam. Nutr. Res. 53:44.

Hamilton, C. R. and T. L. Veum. 1984. Response of sows and litters to added dietary biotin in environmentally regulated facilities. J. Anim. Sci. 59:151.

Kratzer, F. H., K. Knollman, L. Earl and J. L. Buenrostro. 1988. Availability to chicks of biotin from dried egg products. J. Nutr. 118:604.

McDowell, L. R., 1989. Vitamins in Animal Nutrition, Comparative Aspects to Human Nutrition. Academic Press, San Diego, CA.

Misir, R., R. Blair and C. E. Doige. 1986. Development of a system for clinical evaluation of the biotin status of sows. Can. Vet. J. 27:6.

Misir, R. and R. Blair. 1988a. Biotin bioavailability from protein supplements and cereal grains for weanling pigs. Can. J. Anim. Sci. 68:523.

Misir, R. and R. Blair. 1988b. Biotin bioavailability of protein supplements and cereal grains for starting turkey poults. Poult. Sci. 67:1274.

NRC. 1988. Nutrient Requirements of Swine (9th Ed.). National Academy Press, Washington, DC.

Penny, R.H.C., R.D.A. Cameron, S. Johnson, P. J. Kenyon, H. A. Smith, A.W.P. Bell, J.P.L. and J. Taylor. 1981. Influence of biotin supplementation on sow reproductive efficiency. Vet. Rec. 109:80.

Sauer, W. C., R. Mosenthin and L. Ozimek. 1988. The digestibility of biotin in protein supplements and cereal grains for growing pigs. J. Anim. Sci. 66:2583.

Steel, R.G.D. and J. H. Torrie. 1980. Principles and Procedures of Statistics: A Biometrical Approach (2nd Ed.). McGraw-Hill Book Co., New York.

Tribble, L. F., J. D. Hancock and D. E. Orr. 1984. Value of supplemental biotin on reproductive performance of sows in confinement. J. Anim. Sci. 59(Suppl. 1): 245(Abstr.).

Watanabe, T. and A. Endo. 1989. Species and strain differences in teratogenic effects of biotin deficiency in rodents. J. Nutr. 119:255.

Webb, N. G., R.H.C. Penny and A. M. Johnston. 1984. Effect of a dietary supplement of biotin on pig hoof horn strength and hardness. Vet. Rec. 114:185.