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RESPONSE OF SOWS AND LITTERS TO ADDED DIETARY BIOTIN IN ENVIRONMENTALLY REGULATED FACILITIES[1]

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Summary

A 3-yr study was conducted to evaluate the effects of biotin on sow longevity, reproductive performance and piglet performance to weaning utilizing 161 sows and 414 litters. Sows and gilts were fed a basal corn-soybean meal diet (without any antibiotic or chemotherapeutic compounds) during gestation and lactation containing either 0 or .55 ppm added biotin. The basal diet contained .17 ppm total dietary biotin based on microbiological assay. Results indicated sow culling rates and weight gains, number of live pigs at birth, pig weights at birth and weaning, and the interval from weaning to rebreeding were similar for both treatment groups. However, sows fed the diet with added biotin weaned more (P<.05) pigs/litter overall and at gestation-lactation period 1 than did sows fed the basal diet without added biotin, although biotin did not increase (P>.10) the number of pigs weaned at gestation-lactation periods 2 through 5. The incidence of dermatitis, hair loss and soundness of feet and legs did not appear to be affected by adding biotin to the diet. Thus, the addition of .55 ppm biotin to a corn-soybean meal diet fed during gestation and lactation did not improve any of the criteria measured except number of pigs weaned overall.

(Key Words: Sows, Biotin, Gestation, Lactation, Reproductive Performance, Litter Performance.)

Introduction

Swine production has changed from outdoor rearing systems to various types of partially or fully enclosed facilities. As a result, the nutritional status of some vitamins previously considered adequate in swine diets has been questioned. Biotin, essential for normal carbohydrate and fat metabolism, is one such vitamin.

The synthesis of biotin by enteric microflora along with greater access of pigs to bedding, soil and(or) forage in decades past suggested that the addition of biotin to the diet was unnecessary (Lindley and Cunha, 1946). However, biotin deficiency symptoms such as dermatitis, alopecia, depressed growth, foot lesions and heel and toe cracks have been reported in swine units in the United States and Europe (Cunha et al., 1968; Tagwerker, 1973). Biotin has been associated with the maintenance of hoof tissue integrity in swine (Brooks and Simmins, 1981).

Rat and chick reproduction are retarded by biotin deprivation (Balnave, 1977). Sow reproductive performance and foot soundness may also be improved by biotin status (Brooks et al., 1977; Penny et al., 1980), although Grandhi and Strain (1980) did not obtain any improvement (P>.05) in these criteria when biotin was added to barley-wheat-soybean meal-type gestation and lactation diets.

The purpose of this experiment, conducted over a 3 yr period, was to evaluate the effects of adding biotin to corn-soybean meal gestation and lactation diets. Sow reproductive performance, sow longevity and piglet performance to weaning were response criteria.

Materials and Methods

Sows within farrowing groups (16 to 20 sows/group) were stratified into two subgroups based on age, ancestry and postweaning weight as they returned to the gestation facility during the summer of 1978. Subgroups were assigned randomly to one of two dietary treatments: either 0 or .55 ppm added biotin. The average initial weight and age of all sows was 154 ± 5 kg and 1.9 ± .1 yr. The biotin addition of

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.55 ppm was selected to be well above the amount suggested for swine by the NRC (1979) because no requirement has been established. Females remained in their respective treatment group for the entire study unless culled for severe structural unsoundness or breeding failure, as determined by failure to conceive within three consecutive postweaning estrous periods. Replacement gilts were allotted to treatment according to ancestry. During this study, conducted over a 3 yr period, data were obtained from 161 sows and 414 litters.

The basal corn-soybean meal diet (table 1), without any antibiotic or chemotheropeutic compounds, contained an average of 14.7% crude protein and 3,741 kcal of gross energy/kg for the 16 samples analyzed. Vitamins (except biotin) and minerals were added to exceed minimum NRC (1979) requirements. Premixes were formulated to provide either 0 or .55 ppm biotin to the final diet. Microbiological growth assays[3] of the diets with 0 (basal) or .55 ppm added biotin, based on eight samples of each diet, were .17 and .54, respectively. The low biotin level obtained in the microbiological assay for the .55 ppm added biotin treatment may be attributed to the poor biotin recovery associated with the digestion and extraction of biotin from mixed feeds (Tagwerker, 1973). Sows were individually fed 1.8 kg once daily at 0800 h during gestation. An additional .45 kg was fed/day for each suckling pig during the 28 d lactation period. Wheat bran (IFN 4-05-190) replaced 20% of the ground shelled corn by weight from 5 d pre- to 5 d postfarrowing.

Sows were housed in fully enclosed, environmentally regulated gestation and lactation buildings. The flooring in the front one-half of the individual gestation stalls (.61 × 1.98 m) was solid concrete while the rear one-half was concrete slats (12.7 cm wide with 2.54 cm spacings). On d 109 of gestation, the sows were moved to stalls (.61 × 2.13 m) in the farrowing building that had a piglet area (.61 × 2.13 m) on each side of the stall. The flooring was 100% concrete slats (12.7 cm) with 1.27 cm spacing, except for the wider spacings (3.8 cm) directly behind the sow. The two 20-stall farrowing rooms were thermostatically maintained at a minimum temperature of 20 C during the winter months. Radiant heaters provided supplemental heat for the baby pigs. Snout cooling was used for the sows during the summer months.

Litters (inidividual pigs) were weighed at birth and weaning at 28 d of age. Injectable Fe dextran (100 mg Fe) was administered at birth and 14 d of age. Cross-fostering was practiced within treatment groups to equalize litter size. A 20% crude protein starter diet was offered at 3 wk of age.

Response criteria included the following: sow weights and visual evaluation at breeding, d 30, 60, 90 and 107 of gestation, farrowing and weaning; interval between weaning and first estrus, culling rate, number of live and dead pigs at birth, survival to weaning and pig weights at birth and weaning. The visual evaluation for dermatitis, hair loss, foot soundness

[3]Conducted by Hoffman-La Roche, Inc., Nutley, NJ 00710.

TABLE 1. BASAL DIET COMPOSITION

Item	Amount in diet
Ingredients, %	
Ground shelled corn (IFN 4-01-935)	78.3
Soybean meal (44%; IFN 5-04-604)	15.3
Stabilized fat (IFN 4-00-409)	2.0
Dicalcium phosphate (IFN 6-01-080)	2.2
Ground limestone (IFN 6-02-632)	1.2
Trace mineral salt[a]	.50
Vitamin premix[bc]	.50
Actual analysis	
Protein, %	14.7
Gross energy, kcal/kg	3,741.0

[a]Mineral mix provided per kg of diet: 1.70 g Na and 2.63 g Cl as NaCl, 100 mg Fe as $FeSO_4$, 100 mg Zn as ZnO, 50 mg Mn as $MnSO_4 \cdot 3H_2O$, 15 mg Cu as CuO, .95 mg I as Ca $(IO_3)_2$ and .10 mg Se as Na_2SeO_3.

[b]Vitamin mix provided per kg of diet: 5,500 IU vitamin A as vitamin A acetate, 550 IU vitamin D_3 as D-activated animal sterol, 22 IU vitamin E as α-tocopherol acetate, 661.7 mg choline as choline chloride, 33.0 mg D-pantothenic acid as D-Ca-pantothenate, 33.0 mg niacin, 5.5 mg riboflavin, 2.2 mg menadione as menadione-$NaHSO_3 \cdot 3H_2O$, 2.2 mg pyridoxine as pyridoxine-HCl, 2.2 mg thiamine as thiamine-HCl, 1.1 mg folic acid, 33.0 μg vitamin B_{12} and 55 mg ethoxyquin.

[c]Either with or without .55 ppm added biotin. Microbiological growth assays (Hoffman-La Roche, Inc., Nutley, NJ) on eight samples of each diet found average biotin levels of .17 and .54 ppm in the basal and supplemented diets, respectively.

and toe cracks was conducted by a committee of three at each weighing.

Herein, period refers to the number of consecutive gestation-lactation cycles that the sows had completed on their respective experimental diet. Thus, criterion comparisons were made between sows fed their diets for the same length of time. The sow and litter performance data were analyzed by period in a 2 × 4 factorial analysis of variance arrangement. The statistical model contained treatment (0 and .55 ppm added dietary biotin) and year (1978 through 1981) main effects and the treatment × year interaction (Snedecor and Cochran, 1967; SAS, 1979). Discrete data are not normally distributed but tend to follow a Poisson distribution, thus data on number of pigs born alive, stillbirths, mummified fetuses and pigs weaned were subjected to a square root transformation and analyzed as described for the performance data (Snedecor and Cochran, 1967). Pig weights and the number of pigs per litter at weaning were analyzed using birth weights and the number of live pigs farrowed per litter as the respective covariate. Mean differences were detected using the least significant difference test. Least significant means (SAS, 1979) were adjusted for missing observations resulting from management practices (across treatment removal of baby pigs for other research or early weaning of some sows as a result of combining small litters within treatments).

Results and Discussion

Treatment effects on sow breeding, gestation and lactation weights are presented in table 2. Due to the small number of observations in periods 5, 6 and 7, those data were pooled and reported as period 5. Biotin supplementation had no effect ($P>.10$) on sow breeding weights when analyzed by period or overall. Gestation weight gain was similar for both treatment groups during periods 1, 2 and 5 and overall. Greater ($P<.05$) gains were obtained for gestating sows fed 0 added biotin during period 3, but less ($P<.05$) during period 4 than for sows fed .55 ppm added biotin. The treatment × year interaction ($P<.05$) obtained for gestation weight gains in periods 4 and 5 may be attributed primarily to environmental variation. Weight loss during lactation was not affected ($P>.10$) by treatment. Easter et al. (1979) and Grandhi and Strain (1980) have also reported that sow gestation and lactation weights were not affected by adding biotin to either corn-soybean meal or wheat-barley-soybean meal diets, respectively.

The interval from weaning to rebreeding and culling level (table 3) were similar ($P>.10$) for both treatment groups. These results are consistent with other reports (Grandhi and Strain, 1980; Penny et al., 1981). However, Brooks et al. (1977) reported that added dietary biotin reduced the rebreeding interval for sows exhibiting biotin deficiency-like symptoms when fed wheat-based diets. Biotin repletion may reduce the weaning to rebreeding interval as a result of improved energy utilization (Tagwerker, 1973).

Farrowing and litter performance to weaning are summarized in table 4. The number of pigs born alive or dead/litter was similar ($P>.10$) for both treatment groups. Because the incidence of stillborn pigs and mummified fetuses were similar for both treatments, the combined total is reported as pigs born dead. Average birth weights were similar ($P>.10$) for both sow treatment groups at all periods and overall, except in period 3, where the birth weight of pigs from sows fed 0 added biotin was greater ($P<.05$) than that of sows fed .55 ppm added biotin. The average number of pigs weaned per litter at 4 wk was greater ($P<.05$) for sows fed .55 ppm added biotin than for sows fed the basal diet without added biotin during period 1 and overall, while the number of pigs weaned was similar ($P>.10$) for both sow treatment groups for periods 2, 3, 4 and 5. The average weaning weight/pig was similar for both treatment groups at all periods and overall. These results are in agreement with Easter et al. (1979) and Grandhi and Strain (1980), who reported that .2 or .3 ppm added dietary biotin did not improve reproductive performance of gilts and primiparous sows fed either corn-soybean meal or barley-wheat-soybean meal diets, respectively. Conversely, Brooks et al. (1977) and Penny et al. (1981) found that biotin supplementation of small grain-based diets fed to sows and gilts with biotin deficiency-like symptoms had favorable effects on litter size at farrowing. Bryant et al. (1981b) also suggested that added dietary biotin tended to improve reproductive performance in sows fed corn-soybean meal and wheat-soybean meal diets. The increase in the number of pigs weaned per litter obtained with added biotin in our experiment has not been reported in the literature. Such a response would more likely

TABLE 2. SOW WEIGHT BY TREATMENT AND GESTATION-LACTATION PERIOD

	Sows/period		Breeding wt/sow (kg)			Gestation wt gain/sow (kg)[a]			Lactation wt loss/sow (kg)[b]		
	Treatment		Treatment			Treatment			Treatment		
Period[c]	0 added biotin	.55 ppm added biotin	0 added biotin	.55 ppm added biotin	SD[d]	0 added biotin	.55 ppm added biotin	SD	0 added biotin	.55 ppm added biotin	SD
1	75	87	144.2	143.2	22.4	55.4	55.9	16.1	25.8	28.8	14.3
2	47	61	175.3	171.6	21.3	51.0	52.3	13.8	33.1	31.2	11.9
3	28	43	185.9	192.4	18.4	59.4[f]	52.3[f]	12.7	38.5	35.5	10.9
4[e]	15	22	200.2	202.8	16.0	47.0[f]	52.6[f]	8.3	36.8	41.4	12.8
5[eg]	16	21	213.5	214.9	17.4	44.1	42.3	8.4	29.4	28.6	11.7
Overall mean	181	234	169.2	171.4	31.5	53.5	52.9	14.7	30.6	31.6	13.3

[a]Gestation wt gain = 107-d gestation wt − breeding wt.

[b]Lactation wt loss = 107-d gestation wt − weaning wt.

[c]Period = the number of consecutive gestation-lactation cycles that sows were maintained on their respective experimental diet.

[d]Standard deviation.

[e]Treatment × year interaction ($P<.05$) for gestation weight gain.

[f]Treatment differences ($P<.05$) within period.

[g]Includes pooled data for periods 5, 6 and 7.

TABLE 3. SOW REBREEDING INTERVAL AND CULLING LEVELS BY TREATMENT AND GESTATION-LACTATION PERIOD[a]

	No. of sows rebred at the end of each period		Interval from weaning to rebreeding (d)			Culling level (%)[bc]	
	Treatment		Treatment			Treatment	
Period[d]	0 added biotin	.55 ppm added biotin	0 added biotion	.55 ppm added biotin	SD[e]	0 added biotin	.55 ppm added biotin
1	4.7	59	7.6	7.7	10.7	24.3	21.6
2	28	43	8.1	6.1	12.4	20.3	9.1
3	15	21	5.3	7.4	8.2	9.5	12.5
4	10	12	5.0	5.5	1.7	0	5.7
5[f]	6	10	4.3	3.9	2.9	5.4	3.4
Overall means	106	145	7.0	6.7	10.0	57.3	53.5

[a]Treatment means did not differ (P>.10).

[b]Percentage of the treatment total within period.

[c]Average sow ages were 3.08 ± .18 and 3.01 ± .15 yr for 0 and .55 ppm added biotin, respectively.

[d]Period = the number of consecutive gestation-lactation cycles that sows were maintained on their respective experimental diets.

[e]Standard deviation.

[f]Includes pooled data from periods 5, 6 and 7.

have been associated with prior increases in the number and(or) weight of pigs at birth. The increases of .38 and .29 pigs weaned by our biotin supplemented sows during period 1 and overall, respectively, are of practical importance. However, because none of the other response criteria measured in this experiment were affected by added biotin, it is questionable if the increased number of pigs weaned per litter should be attributed entirely to biotin, even though we have no alternative explanation, other than a chance effect.

Evaluation of all sows in both treatment groups for biotin deficiency-like symptoms at each weighing did not reveal any improvement from added biotin in overall appearance or soundness of feet and legs, as judged visually by committee. The sows were not scored objectively and, therefore, no mean scores are reported because few biotin-related symptoms were observed in either treatment group. Our results are similar to reports that added dietary biotin had no effect on lesion severity in gilts and first litter sows (Grandhi and Strain, 1980) or on puncture and compression analyses of hoof tissue of growing pigs (Simmins and Brooks, 1980). However, other reports suggest that biotin supplementation may reduce the incidence of foot lesions in sows and gilts (Brooks et al., 1977; Bryant et al., 1981a). Biotin may also be involved in maintaining hoof tissue integrity (Penny et al., 1980; Brooks and Simmins, 1981).

The lack of response to added dietary biotin in this experiment for all criteria measured except number of pigs weaned per litter overall may be because the basal diet contained an analyzed biotin level of .17 ppm. Thus, sows fed the diet without added biotin received .31 mg biotin/d during gestation. This level exceeds the NRC (1979) suggested daily biotin allowance (.18 mg/d) by 72%, although no biotin requirement has been established for swine (NRC, 1979). Little is known about nutrient absorption from the hindgut of pigs, although sows may receive considerable biotin associated with microbial synthesis in the hindgut. Coprophagy may also provide a dietary source of biotin. However, our sows were kept in individual gestation and farrowing stalls and had little or no opportunity to practice coprophagy.

Biotin levels in corn range from .08 to .10 ppm (Scheiner and DeRitter, 1975) as determined by microbiological growth assay, and are

TABLE 4. LITTER PERFORMANCE BY TREATMENT AND GESTATION-LACTATION PERIOD

Period[c]	Litters/period		No. of live pigs born/litter			Dead pigs born/litter[a]			Average birth wt/pig (kg)			Average weaning wt/pig (kg)[b]			Average no. of pigs weaned/litter		
	Treatment		Treatment			Treatment			Treatment			Treatment			Treatment		
	0 added biotin	.55 ppm added biotin	0 added biotin	.55 ppm added biotin	SD[d]	0 added biotin	.55 ppm added biotin	SD	0 added biotin	.55 ppm added biotin	SD	0 added biotin	.55 ppm added biotin	SD	0 added biotin	.55 ppm added biotin	SD
1	75	87	8.7	8.6	2.9	1.3	1.3	1.8	1.33	1.37	.29	7.51	7.59	1.4	7.47[e]	7.85[e]	1.9
2	47	61	9.0	8.8	2.7	1.4	.7	1.9	1.51	1.50	.26	8.41	8.40	1.3	7.68	8.11	1.5
3	28	43	9.9	9.9	2.3	1.2	1.1	1.5	1.54[e]	1.40[e]	.25	8.36	8.04	1.4	8.12	8.24	1.5
4	15	22	10.5	10.3	1.6	1.1	1.2	1.4	1.40	1.48	.20	8.10	8.33	1.2	8.36	7.90	1.6
5[f]	16	21	10.2	8.8	2.5	1.7	1.7	1.9	1.39	1.45	.29	8.36	7.95	1.2	7.13	7.31	1.5
Overall mean	181	234	9.2	9.1	2.7	1.3	1.1	1.7	1.42	1.42	.27	7.99	7.99	1.4	7.66[g]	7.95[g]	1.6

[a]Mummified fetuses and stillborn pigs.
[b]Adjusted to 28-d basis.
[c]Period = the number of consecutive gestation-lactation cycles that sows were maintained on their respective experimental diets.
[d]Standard deviation.
[e]Treatment differences (P<.05) within period.
[f]Pooled data for periods 5, 6 and 7.
[g]Treatment differences (P<.05) for data pooled across all periods.

about 100% available to animals (Frigg, 1976; Anderson et al., 1978). Even though the biotin levels in wheat, barley, oats and milo were two to four times greater than in corn, the biotin availability, as determined with chicks, was low and ranged from 0 to 30% for these grains (Frigg, 1976; Anderson et al., 1978). Thus, the available biotin in these grains appears to be less than that in corn. The reason for the poor availability of biotin in these grains is not fully understood. Naturally occurring biotin derivatives may differ in their biological activity when determined microbiologically (Frigg, 1976). The biotin analogues present in corn may have biotin-like activitiy for chicks and not for microorganisms (Whitehead et al., 1982), allowing for the high bioavailability of biotin present in corn. Variation in the biotin availability in grains and oilseeds (Whitehead et al., 1982) may account for the inconsistency of reported response to added dietary biotin found in the literature. Biotin supplementation of wheat-based sow diets (Brooks et al., 1977; Bryant et al., 1981a,b) has produced a positive response, which is not surprising because available biotin levels in wheat are low and of questionable importance (Frigg, 1976). Our data and that of Easter et al. (1979) suggest that the addition of biotin to corn-based sow diets is unnecessary provided the naturally occurring biotin in the corn is about 100% available and not destroyed by overdrying, poor storage conditions or molds.

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