FURTHER STUDIES ON THE SUPPLEMENTARY VALUE OF AUREOMYCIN, STREPTOMYCIN, AND VITAMIN B₁₂ IN A PLANT PROTEIN RATION FOR GROWING-FATTENING PIGS¹

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PAST research pertinent to vitamin B₁₂, streptomycin, or aureomycin in pig nutrition has been critically reviewed in a recent paper by Briggs and Beeson (1951). In this same paper, the authors definitely showed that Lederle's B₁₂-aureomycin feeding supplement produced a greater growth response in pigs than Merck's B₁₂ concentrate. Since the two supplements were fed to supply about the same vitamin B₁₂ activity in a practical pig ration, the data strongly suggests the existence of additional growth-stimulating factor or factors, one of which is aureomycin. Evidence was also obtained on the interrelationship of vitamin B₁₂ and pure streptomycin in producing marked stimulation of growth in pigs (1950). Simultaneously, Ferrin and Anderson (1950) reported conflicting results on the combined effects of B₁₂ and streptomycin. In the same experiment, the Minnesota workers observed a synergistic effect of vitamin B₁₂ and aureomycin on growth rate of pigs in a 70-day feeding trial. Oleson et al. (1950) found a definite mutual sparing action of aureomycin and vitamin B₁₂ in a fortified all-plant protein ration for young chicks. This finding was followed by a report of Stokstad and Jukes (1951) in which they observed inconsistent results on the sparing action of aureomycin on the vitamin B₁₂ requirement of chicks. The research workers suggested that the variability in results may be attributed partly to the nature of the intestinal flora encountered.

Stern and McGinnis (1950) have shown that streptomycin, aureomycin, or terramycin stimulated the growth of rats more than vitamin B₁₂ alone when added as supplements to a semi-synthetic ration fed either during the lactation or post-weaning periods. In a brief 28-day pig trial, Carpenter (1950) demonstrated that 12.5 mg. of aureomycin per lb. of total feed gave the same growth stimulation as 12.5 mg. of

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² The authors are grateful to Merck and Co., Rahway, N. J., for supplying the three B-vitamins and streptomycin; to Lederle Laboratories, Pearl River, N. Y., for furnishing the aureomycin; and to Mr. Martin Mohler, Animal Nutrition foreman, for his capable assistance in conducting this trial.
FURTHER STUDIES ON PROTEIN RATIONS

aureomycin plus 10 mcg. of vitamin B\textsubscript{12} in a mixed animal and plant protein ration for unthrifty pigs. At lower feeding levels of aureomycin (5 mg. per lb.), supplementation with vitamin B\textsubscript{12} proved to be beneficial. Catron \textit{et al.} (1950) also presented some data which indicated that a combination of vitamin B\textsubscript{12} and aureomycin, or of vitamin B\textsubscript{12} and streptomycin, improved pig growth more than single additions of the factors to a plant protein ration for pigs challenged with transmissible gastroenteritis. Nesheim and Johnson (1951) increased the growth rate of baby pigs by the addition of 500 mg. of streptomycin per lb. of dry matter to a nutritionally adequate “synthetic” milk diet with added B\textsubscript{12}.

In order to secure more confirmatory or clearer evidence of the interrelationship of vitamin B\textsubscript{12} and pure antibiotics in practical swine rations, a study was set up to measure the effect of adding vitamin B\textsubscript{12} to a fortified corn-soybean-alfalfa meal ration containing either crystalline aureomycin or streptomycin fed to pigs from weaning to market age.

Experimental

\textit{Pigs Used}

Fifty purebred Duroc weanling pigs were equally allotted to five treatments. These pigs were farrowed from sows that had been fed well-balanced dry-lot and pasture rations and managed under sanitary conditions during gestation and lactation. The pigs were not depleted of their vitamin B\textsubscript{12} stores before being started on the test. Approximately equal numbers of barrows and gilts (10–12 weeks old) averaging 44 lb. at the start were used. The pigs were wormed with sodium fluoride before being placed on the experimental rations. The pigs were weighed every 14 days. The experiment which was originally planned to extend from weaning to an average group weight of 200 lb. was terminated at the end of the first 70 days of feeding because of a serious outbreak of bloody dysentery in the basal (control) lot. The other four lots did not become infected with the enteric disease even though they were exposed to the infected group of pigs for the next four weeks.

\textit{Basal Ration Fed}

The composition of the all-plant protein basal ration is presented in table 1.
The basal ration was analyzed and found to contain 21.80% crude (total) protein and 14.0 ppm. of manganese. The protein level was reduced according to the needs of the pigs as they matured. A mineral mixture of 40 parts steamed bone meal, 40 parts ground limestone and 20 parts iodized salt was fed free choice. The three crystalline B-vitamins were added to the basal ration in amounts shown in footnote of table 1 which fully meet the vitamin allowances recommended by the National Research Council (1950) for weanling pigs.

**TABLE 1. COMPOSITION OF BASAL RATION**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>% of Ration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground yellow corn</td>
<td>62.60</td>
</tr>
<tr>
<td>Soybean meal, expeller</td>
<td>32.15</td>
</tr>
<tr>
<td>Alfalfa meal</td>
<td>5.00</td>
</tr>
<tr>
<td>Vitamin A and D oil</td>
<td>0.25</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
</tr>
<tr>
<td>Manganese (ppm.)</td>
<td>14.00</td>
</tr>
<tr>
<td>Total protein (per cent)</td>
<td>21.80</td>
</tr>
<tr>
<td>Riboflavin (mg. per lb.)²</td>
<td>1.90</td>
</tr>
<tr>
<td>Niacin (mg. per lb.)²</td>
<td>24.49</td>
</tr>
<tr>
<td>Calcium pantothenate (mg. per lb.)²</td>
<td>9.90</td>
</tr>
</tbody>
</table>

¹ Mineral mixture of ground limestone, steamed bone meal, and iodized salt fed free choice.
² Includes the 0.8 mg. of crystalline riboflavin, 5.0 mg. crystalline niacin, and 4.5 mg. crystalline calcium pantothenate added per lb. of the natural ration plus the estimated amount of each vitamin in the natural ration.

**Treatments**

Various combinations of streptomycin, aureomycin, and B₁₂ were tested in the basal ration. The treatments employed were as follows:

Lot 1. Basal Ration
Lot 2. Basal Ration + 15 mg. streptomycin base per lb.
Lot 3. Basal Ration + 10 mg. aureomycin HCl per lb.
Lot 4. Basal Ration + 15 mg. streptomycin base per lb. + 0.10% Merck's B₁₂ concentrate.
Lot 5. Basal Ration + 10 mg. aureomycin HCl per lb. + 0.10% Merck's B₁₂ concentrate.

Merck's B₁₂ concentrate with a guaranteed potency of 12.5 mg. of vitamin B₁₂ activity per lb. supplied about 12.5 mcg. of B₁₂ per lb. of total ration when fed at the 0.10% level. The levels of antibiotics fed in this experiment were based mostly upon limited research data at the time of the experiment which indicated that the above levels generally produced a qualitative effect.

The vitamin and antibiotic supplements were pre-mixed thoroughly in soybean meal before they were added to the total ration.
Results

The results of adding aureomycin and streptomycin with and without B12 in a plant protein ration for pigs in dry lot are presented in table 2.

Pigs fed the basal plant protein ration with no added B12 or antibiotic supplements (lot 1) made an excellent average daily gain of 1.62 lb. on a total feed requirement of 392 lb. per 100 lb. gain during the 70-day feeding period. The addition of either 15 mg. pure streptomycin per lb. of total basal ration (lot 2) or 10 mg. pure aureomycin per lb. of total ration (lot 3) significantly improved the growth rate (L.s.d., 5%—0.17 lb.) and reduced the feed requirement from 60 to 70 lb. for every 100 lb. pork produced. The difference in performance of pigs in lots 2 and 3 is not significant. The pigs fed 0.10% Merck's B12 concentrate in rations containing 15 mg. streptomycin per lb. (lot 4) or 10 mg. aureomycin per lb. (lot 5) performed significantly better than the basal-fed pigs (lot 1) but only slightly better than pigs receiving only the pure streptomycin or aureomycin supplements. The above results do not concur with previous findings of Briggs and Beeson (1951) which suggested that adequate vitamin B12 is required for marked growth stimulation of pigs with pure streptomycin in an all-

TABLE 2. THE SUPPLEMENTARY VALUE OF STREPTOMYCIN, AUREOMYCIN AND VITAMIN B12 IN AN ALL-PLANT PROTEIN RATION FOR WEANLING PIGS IN DRY LOT--SUMMER, 1950

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Av. Daily Gain</th>
<th>Av. Final Weight (70 days)</th>
<th>Av. Daily Feed</th>
<th>Total Feed per 100 lb. Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot 1: Basal Ration</td>
<td>1.62&lt;sup&gt;1&lt;/sup&gt;</td>
<td>155</td>
<td>6.36</td>
<td>392</td>
</tr>
<tr>
<td>Lot 2: Basal Ration + 15 mg. streptomycin base per lb.</td>
<td>1.80</td>
<td>169</td>
<td>6.01</td>
<td>334</td>
</tr>
<tr>
<td>Lot 3: Basal Ration + 10 mg aureomycin HCl per lb.</td>
<td>1.85</td>
<td>174</td>
<td>5.97</td>
<td>322</td>
</tr>
<tr>
<td>Lot 4: Basal Ration + 15 mg. streptomycin base per lb. + 0.10% Merck's B12 concentrate</td>
<td>1.82</td>
<td>171</td>
<td>6.43</td>
<td>353</td>
</tr>
<tr>
<td>Lot 5: Basal Ration + 10 mg. aureomycin HCl per lb. + 0.10% Merck's B12 concentrate</td>
<td>1.89</td>
<td>176</td>
<td>6.31</td>
<td>333</td>
</tr>
</tbody>
</table>

<sup>1</sup>L.s.d., 5% level is 0.17 lb.; 1% level is 0.23 lb.
<sup>2</sup>Represents the average daily gain of 9 pigs. One pig died suddenly September 15. Death attributed to rat bait poisoning.
plant protein ration. The difference in results of these two experiments may be attributed partly to the half dirt floors of the pens used in the second experiment. These pens were cattle experimental lots which were cleaned thoroughly before the start of the trial. However, the pens contained some left-over manure mixed with the soil. Full concrete floors were used in the first experiment. Perhaps the soil supplied some of the vitamin $B_{12}$, as suggested by Cunha (1949) and Schneider et al. (1950), to fully meet the pig's need, thereby preventing any possible growth response from the added $B_{12}$ concentrate. Another possible explanation is that the older pigs used at the start of the second trial, compared with those of the first trial, permitted greater stores of vitamin $B_{12}$, thus eliminating the need for supplemental vitamin $B_{12}$ in the pig's ration. Almquist and Merritt (1951) have suggested that vitamin $B_{12}$ stores in their turkey poults may have been a complicating factor in testing the true relationship of vitamin $B_{12}$ and aureomycin on growth. Ferrin and Anderson (1951) report conflicting results on combination effects of streptomycin and vitamin $B_{12}$ on pig growth without a suitable explanation. Therefore, it appears to be of paramount importance that $B_{12}$ depleted stock be used in tests to accurately determine the interdependence of vitamin $B_{12}$ and aureomycin or other antibiotics on growth.

A study of the growth curves of the five lots of pigs in Figure 1 indicates that the antibiotics or antibiotics plus vitamin $B_{12}$ fed under the above experimental conditions exert their most marked effect on pig growth after the first 42 days of the growing-fattening period. The differences between the growth rates of the basal lot (lot 1) and the other four lots are less pronounced during the first 42 days of the growth test period. Another important point is the close similarity of growth trends of the four treated lots from an average weight of 44 lb. to an average weight of 175 to 180 lb.

The pigs fed the antibiotics with and without vitamin $B_{12}$ gained more uniformly than the pigs fed the control ration. The appetites of the pigs were excellent and about the same in all treatments as shown in table 2. There were no evidences of any diarrhea during the 70-day feeding period. This has been observed consistently in all of the trials conducted at the Purdue Station.

The results shown in table 2 do not agree with those reported by Speer et al. (1950). The Iowa investigators failed to increase the daily gain or improve feed efficiency of pigs by the addition of 5 or 10 mg. of aureomycin per lb. to a fortified plant protein ration similar to the one used in the above Purdue trial. They attempted to explain the failure
of the antibiotic (aureomycin) response in their experiments by the "disease level" theory, i.e., healthy, well-managed pigs may respond less to antibiotic feeding than unthrifty, poor-managed pigs. The results obtained at the Purdue Station on three separate experiments testing the supplementary value of the various antibiotics, however, do not
fully support the "disease level" theory. Healthy, thrifty pigs (from gross observations) with an excellent previous nutritional history and management have been used in the present experiment and in two other antibiotic experiments at the Purdue Station, and each time the antibiotics have exerted a significant stimulatory response on the feedlot performance of pigs. In general it appears as if thrifty and unthrifty pigs will respond to oral feeding of most of the antibiotics, and that a correct balance of other known and unknown dietary essentials is probably required for maximum growth expression of the antibiotic.

After 70 days of feeding, the control lot (lot 1) became badly infected with bloody dysentery. This forced us to terminate the trial. The other four lots which were adjacent to the infected lot did not come down with the bloody dysentery during the subsequent four weeks of exposure to the infection. The infected lot responded to treatment within 48 hours after administration of therapeutic doses of 1 gm. of crystalline streptomycin per pig in the feed the first day, and 0.5 gm. the second day. The responses to therapeutic treatments were similar to those reported in a previous paper by Briggs and Beeson (1951). The absence of this particular intestinal infection in the treated lots in the present experiment and in a previous experiment at the Purdue Station strongly suggests that oral feeding of the antibiotics continuously throughout the growing-fattening period of the pig may exert an important protective effect against certain enteric diseases, such as bloody dysentery.

Summary

Healthy, vigorous forty-four-lb. weanling pigs were fed various combinations of aureomycin, streptomycin and vitamin B12 concentrate in an all-plant protein ration composed of yellow corn, soybean meal, alfalfa meal, cod liver oil, essential minerals and the three well-known B-vitamins.

Pigs fed the basal ration gained 1.62 lb. per head daily on a feed requirement of 392 lb. per 100 lb. gain. The addition of 15 mg. of pure streptomycin per lb. of total ration or of 10 mg. of pure aureomycin per lb. significantly increased the average daily gain about 11 to 13% and increased the feed efficiency about 14 to 16%.

The addition of 12.5 mcg. vitamin B12 per lb. of total ration (0.1% Merck's B12 supplement) to the basal ration containing either aureomycin or streptomycin improved the growth significantly above the basal ration but only slightly above the ration containing either antibiotic.
The slight growth stimulatory effect of vitamin B₁₂ in the presence of the antibiotic observed in this trial, compared with that observed in a previous experiment, may be attributed either to the greater reserve storage of vitamin B₁₂ in the heavier pigs used at the start of the test, or to the vitamin B₁₂ in the soil and left-over manure in the half-paved cattle lots, or both.

The supplementation of the practical (basal) ration for pigs with each of the two antibiotics and/or vitamin B₁₂ produced more uniform response, and provided some natural protection against bloody dysentery which infected the basal-fed pigs during the last 4 weeks of the experiment.

**Literature Cited**


