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Effects of Antibiotics Fed to Pigs During the Growing-Fattening Period

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EFFECTS OF ANTIBIOTICS FED TO PIGS DURING THE GROWING-FATTENING PERIOD

by

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This thesis is approved as a creditable independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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INTRODUCTION

Many South Dakota farmers depend upon the pig enterprise for a portion of their yearly income. According to the South Dakota Crop and Livestock Reporting Service, approximately 19 per cent of the cash farm income of South Dakota is obtained from the marketing of hogs.

The successful swine producer's primary objective is to receive the greatest possible financial return for his investment and labor. In order to accomplish this aim, it is often desirable to feed a ration which produces as fast a rate of gain as possible without sacrificing feed efficiency or carcass quality.

The growth response obtained by feeding antibiotics to pigs was first realized in the summer of 1949. Since that time, many experiments have been performed with antibiotic supplementation of various swine rations.

The work reported herein is a portion of a project conducted by the Animal Husbandry Department at South Dakota State College in an effort to determine the value of antibiotic supplementation in pig rations. The objectives of this study were to determine the effects of discontinuing antibiotic supplementation during the growing-fattening period, and the value of combining more than one antibiotic in rations for growing-fattening pigs. Rate of gain, feed efficiency, and carcass quality were used in determining the value of the various treatments.

REVIEW OF LITERATURE

Effects of Antibiotics on Rate of Gain and Feed Efficiency of Growing-Fattening Pigs

The experimental use of antibiotics in swine rations began shortly after Cunha et al. (1949), working with pigs, discovered that the growth response obtained by the feeding of "animal protein factor" (APF) supplement[1] was attributable to some unknown factor in the APF besides vitamin B_{12}. Later, Jukes et al. (1950) observed that pigs on a diet consisting principally of yellow corn and peanut meal grew slowly and showed no growth response to a supplement containing vitamin B_{12}, while a marked increase in growth could be obtained by adding APF supplement to the basal ration. At about this same time, Carpenter (1950) fed the antibiotic aureomycin at a level of 1.25 grams per 100 pounds of feed and obtained the same growth stimulation as an equivalent amount of APF concentrate or a combination of vitamin B_{12} and pure aureomycin. These data were the first in swine nutrition research to suggest that the plus factor in APF concentrate was an antibiotic.

Since the first report that antibiotics fed to swine promote an increase in rate of gain, many experiments have been conducted with various antibiotics. Considering the amount of work done on this subject, the

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[1] Crude preparations from the aureomycin fermentation which supplied not only vitamin B_{12} but also another growth factor.

author finds it impractical in this review of literature to include all the literature pertaining to antibiotic supplementation. As a consequence, only a few of the experiments dealing with rate and efficiency of gain will be discussed along with trials where various antibiotics, singularly and in combination, supplemented different swine rations during various phases of the growing-fattening period.

Although the majority of the experiments have shown favorable effects of antibiotic supplementation; several, Brown (1951), Bridges et al. (1953), Schendel and Johnson (1953), and Wallace et al. (1954), have shown no statistically significant increase in rate of gain with the use of antibiotics in rations fed to growing-fattening pigs.

The addition of antibiotics to an all vegetable diet resulted in marked improvement in the growth rate and feed efficiency of pigs as reported by Miller et al. (1951), Wallace et al. (1951), Barber et al. (1952), Becker et al. (1952), Catron et al. (1952). It may be that workers, who obtained no favorable effects from antibiotics fed to pigs, conducted their experiments in relatively disease-free environments. Antibiotics appear to exert the greatest response when fed to unhealthy pigs. Work with antibiotics fed to unthrifty, runty pigs indicate a significantly faster rate of gain and more thrifty appearance compared to the controls at the end of the experiment (Bowland et al. 1951 and Blight et al. 1952).

A number of experiments have been carried out to determine if different sources of protein and type of rations have any effect on the response to antibiotics. Lepley et al. (1950) fed control pigs a basal

ration consisting of corn and soybean oil meal fortified with B-vitamins, vitamins A and D_2, and minerals. Other lots received the basal ration supplemented with one of the following: dried whole unextracted aureomycin mash, meat and bone scraps, aureomycin mash plus 5 per cent meat and bone scraps, or aureomycin mash plus 2.5 per cent meat and bone scraps. Their results showed that dried whole aureomycin mash increased average daily gains significantly in both dry lot and pasture and also increased rate of gain regardless of the presence or absence of meat and bone scraps in the ration.

Briggs and Beeson (1951) fed 44-pound, healthy weanling pigs on a diet of all plant protein. The ration was composed of yellow corn, soybean oil meal, alfalfa meal, cod liver oil, essential minerals, and three B-vitamins (0.8 milligram of riboflavin, 5 milligrams of niacin, and 4.5 milligrams of calcium pantothenate per pound of ration). An increase of 11 and 13 per cent in rate of gain was obtained and the feed efficiency was improved 14 and 15 per cent, respectively, when 15 milligrams of pure streptomycin or 10 milligrams of pure aureomycin was fed per pound of total ration.

Huang et al. (1953) observed that terramycin stimulated the growth of pigs by more efficient feed utilization. The ration of these pigs was adequate in all known nutritional aspects; yet, terramycin promoted significantly greater growth than did the basal ration.

Antibiotics appear to stimulate the appetites of growing-fattening pigs which generally results in faster and more efficient gains. Catron et al. (1952) reported that antibiotic-fed pigs consumed 28 per cent more

water, 13 per cent more feed, and gained 27.5 per cent faster than non-antibiotic-fed pigs.

Carpenter (1951) using 27-to 33-pound pigs added streptomycin ($CaCl_2$ complex), aureomycin hydrochloride, chloromycetin, terramycin hydrochloride, and penicillin to a basal diet of corn, ground oats, wheat middlings, soybean oil meal, tankage, and alfalfa leaf meal. He reported that all of these antibiotics stimulated growth and increased efficiency of feed utilization. Also in an experiment conducted recently, Fletcher and Barrentine (1954) stated that aureomycin and penicillin appeared to increase feed consumption and efficiency of food utilization, but the increase in rate of gain was not statistically significant. The basal ration consisted of corn, cottonseed meal, alfalfa meal, salt, oyster shell flour, and ferrous sulfate. The levels of aureomycin fed were 6.8 and 13.6 milligrams per pound of ration, while the penicillin was fed at a level of 2 milligrams per pound of ration.

Briggs and Beeson (1952) reported that aureomycin and vitamin B_{12}, fed at a level of 8.5 milligrams and 12.5 micrograms respectively, per pound of total ration, stimulated the growth of pigs which were self-fed a corn, soybean, alfalfa meal ration fortified with cod liver oil, calcium pantothenate, riboflavin, niacin, and essential minerals but exerted only a slight increase in efficiency of gain. They also observed that 15 milligrams of pure streptomycin base per pound of total ration stimulated growth more than the 2.5 milligram level. They concluded that antibiotics exert their more favorable effect at definite optimum levels. A combination of 12.5 micrograms of vitamin B_{12} plus 15 milligrams of streptomycin per pound of ration improved growth rate and feed efficiency more than

when either factor was added singularly. More uniformity was observed in lots of pigs fed antibiotics and/or vitamin B_{12} than in control groups; also they ate more feed than the controls.

Some workers tested the effects of feeding antibiotics during definite periods from weaning to market weight. Terrill et al. (1952) obtained a 27 per cent increase in rate of gain (highly significant) from weaning to 100 pounds by adding 5 milligrams of aureomycin hydrochloride per pound of ration which contained 20 per cent crude protein. The basal dry lot ration of corn and soybean oil meal was fortified with B-vitamins, minerals, and vitamins A and D. Bacitracin, at the level of 5 milligrams per pound of the same ration as above, promoted a 16 per cent increase in rate of gain (significant). Better results were obtained with bacitracin when it was included in rations from weaning to 200 pounds than when it was included in rations of pigs only from 100 to 200 pounds.

Burnside et al. (1954) obtained significant increases in rate of gain from pigs fed antibiotics with various protein levels from initial weight to 70 pounds. From 71 to 125 pounds, supplementing 18.2 and 13.7 per cent protein rations with aureomycin significantly increased the rate of gain. With 126- to 213-pound pigs, aureomycin supplementation stimulated rate of gain only in the groups fed 11.5 per cent protein rations.

The effect of adding antibiotics to a small grain ration was reported by Bowland et al. (1951) of the University of Alberta. Their study was to determine the effect of aureomycin in a barley-oats ration with protein supplements of either all vegetable or mixed animal-vegetable protein. APF plus aureomycin caused a marked increase in rate of gain

and feed efficiency when added to either all vegetable or animal-vegetable protein supplements. The effect of APF plus aureomycin was a 24 per cent increase in daily gain and a 9 per cent increase in feed efficiency during the growing period (30 to 125 pounds) compared to a 15 and 5 per cent increase, respectively, during the growing-fattening period (125 to 200 pounds). The average daily feed consumption was also greater in lots receiving APF plus aureomycin. After the pigs were placed on pasture and fed only the basal ration, there was no carry-over effect of the antibiotic insofar as average daily gains were concerned. The APF plus aureomycin lot maintained their lead in weight but failed to gain any faster than the original controls.

In another experiment, Terrill et al. (1951) added 25 milligrams of aureomycin hydrochloride per pound of basal ration containing 20 per cent crude protein. They reported that antibiotic supplementation produced a 28 per cent faster gain from weaning to 75 pounds on dry lot compared to the control group. During this test, it was noted that the pigs which received aureomycin ate more feed, drank more water, and exhibited firmer feces than the pigs in the control lot. In the second experiment with pigs fed from 75 to 225 pounds, the effect on gains by adding 10 or 40 milligrams of streptomycin per pound of ration was observed. Pigs receiving 40 milligrams of streptomycin per pound of ration gained 19 per cent faster than did the basal-fed pigs. The pigs receiving 10 milligrams of streptomycin per pound of ration gained 11 per cent faster than the controls.

There has been limited work with the discontinuance of antibiotic

supplementation after pigs reach a certain weight, even though several workers have observed that the response to antibiotics is greatest in the early part of the growing-fattening period. One experiment was reported by Lehrer et al. (1953) who studied the effect of crystalline aureomycin and crystalline terramycin on suckling, growing, and fattening pigs. They found both antibiotics, when fed from two days or from four weeks of age to 200 pounds, were equally effective in increasing gains 8 to 17 per cent. In this experiment, they stated that antibiotic supplementation for the entire feeding period increased the average daily gains only slightly more than when the antibiotic was fed for only the first eight weeks of the feeding period. These results are in disagreement with those reported by Wallace et al. (1953). These workers stated that on a corn-peanut meal ration gains were not influenced by reducing the level of aureomycin from 20 grams to 10 grams per ton of feed after the pigs reached a weight between 100 and 155 pounds. The animals ate more feed when placed on lower levels of antibiotic. The efficiency of feed utilization was in favor of the groups left on high levels of antibiotic. When aureomycin was discontinued, a significant reduction in rate of gain, lowering of feed consumption, and a declining feed conversion were observed. The effects of withdrawing aureomycin were less pronounced with pigs fed a corn-soybean oil meal ration, but still apparent. These workers stated that if optimum gains are to be obtained, antibiotic supplementation should not be discontinued during the growing-fattening period.

A limited amount of work has been reported on combining two or more antibiotics in pig rations. Bridges et al. (1952) self-fed pigs a 20 per

cent crude protein basal ration consisting of corn and degossypolized cottonseed meal, with and without antibiotics, in dry lot until the pigs reached 100 pounds. The pigs fed penicillin gained 0.26 pound per day faster from weaning to 100 pounds and 0.20 pound faster from 100 pounds to market weight than did the basal-fed pigs, but this increase in gain was not statistically significant. Streptomycin significantly increased the rate of gain over that produced by the basal ration from weaning to 100 pounds. The feed efficiency was increased by feeding penicillin, streptomycin or a combination of the two.

Since antibiotics appear to give the greatest response during the early part of the growing-fattening period, withdrawing them from the ration at certain weights might be economical. The work on this has been rather limited and more should be done before sound recommendations can be made regarding the economy of such practice.

It appears from the limited work reported on combinations of antibiotics that greater response may be obtained by combining certain antibiotics in rations for growing-fattening pigs. More testing needs to be done with several antibiotics and with various rations.

Physiological Influences of Antibiotics

Many experiments have been carried out in an effort to determine the mode of action of antibiotics when they are added to swine rations. A study of the response on water intake produced by feeding antibiotics has been reported by Braude and Johnson (1953). They found that the efficiency of food utilization was significantly higher in animals receiving aureomycin than in control lots. They could not find any increase in

water intake due to the feeding of antibiotics, although a considerably higher (statistically highly significant) urine output was observed. This may indicate a lower metabolic activity of the animal, smaller respiratory losses, and smaller losses through the skin of antibiotic-fed pigs.

Robinson et al. (1953) observed that procaine penicillin made little difference in nitrogen retention and lessened calcium retention along with water intake. They stated that a lower output of heat by the supplemented animals would be consistent with their reduced intake of water.

Workers have conducted research with digestion trials in an attempt to explain the action of antibiotics when fed to swine. Huang et al. (1953) found digestion coefficients of the different nutrients higher in pigs fed terramycin than in the control pigs. The differences between the basal and antibiotic-fed groups were the greatest in digestibility of protein and dry matter. The average pH of the urine and feces of each diet group was the same. The percentage and total excretion of indican were much higher in pigs receiving terramycin than in the controls. All of the internal organs from pigs fed terramycin had a higher specific gravity but were smaller in size than the internal organs of the basal-fed pigs. They found that swine which were fed terramycin had a greater infestation of ascarids than did those pigs which did not receive terramycin. Vitamin A was found to be higher in livers of pigs which received the antibiotic. There was no difference in the iodine number or refractive index of the fat between the two groups.

Brown (1951) found no significant difference in nitrogen balance, metabolizable energy, or apparent digestibility of protein between aureomycin and basal-fed groups. He also reported no effect of aureomycin on rate of passage of substances (Fe_2O_3) through the digestive tract, on the weights of the digestive tract, liver, heart, spleen, kidney, or on size of caecum. But Wahlstrom et al. (1952) conducting experiments with baby pigs, found a threefold increase in caecal size of aureomycin-fed pigs compared to the controls.

Studies have been carried out with various blood constituents in an attempt to discover the physiological influences produced by antibiotics. Squibb et al. (1953) reported no apparent effect of aureomycin on serum proteins, riboflavin, ascorbic acid, carotenoids, vitamin A, tocopherols, red blood cell count, hemoglobin, and hematocrit in the blood of young growing pigs. They reported that the increase in alkaline phosphatase values observed in pigs on a diet of either corn or bananas seemed to be depressed by the addition of aureomycin to the pigs' diet.

Brown et al. (1952) observed that the growth response of aureomycin appeared to be a result of higher daily feed intake. They reported that aureomycin had no effect on such factors as hemoglobin level, efficiency of feed utilization, nitrogen balance, or energy balance. However, Wallace et al. (1954) found that the blood of pigs which received aureomycin was slightly higher in hemoglobin content than that of the non-antibiotic-fed pigs.

A study of hemopoiesis in pigs fed rations of various protein levels was reported by Burnside et al. (1954). They observed the hemoglobin

level to be influenced by aureomycin only in the higher protein rations (21 and 18.2 per cent) until a weight of 125 pounds was reached. From 126 to 213 pounds, aureomycin added to the medium-protein ration (11.5 per cent protein) appeared to increase the rate of hemoglobin synthesis.

Blood glucose levels were studied by Catron et al. (1953b). They found the blood concentration of glucose significantly ($P \leq 0.05$) greater than the controls 20 minutes after administration of glucose if pigs were fed aureomycin. After the pigs were fasted for 30 hours and glucose then placed into their stomachs, there was no difference in blood glucose between aureomycin and basal-fed pigs. This suggests that there is not a prolonged nutritional effect after antibiotics are withdrawn from the ration. They found that combinations of antibiotics resulted in higher (predosage) blood glucose compared with those animals fed aureomycin alone or fed the basal diet. The antibiotics fed in various combinations included aureomycin, penicillin, streptomycin and polymyxin. Sulfathalidine was used in some of the combinations. The possible explanations given for this observation were: (1) changes in the intestinal flora resulting in more glucose being available for absorption, (2) changes in the structure of the absorptive tissues of the gastro-intestinal tract allowing a faster rate of absorption of glucose, or (3) changes in the metabolism of the animal resulting in higher blood glucose levels after oral ingestion of glucose.

Many workers have reported that aureomycin, penicillin, terramycin, and streptomycin exert their growth response by controlling enteric diseases such as bloody dysentery and scours. Bacitracin and chloromycetin do not

seem to produce this effect. (Schneider and Huang, 1950; Carpenter, 1951; Wallace et al., 1951; Briggs and Beeson, 1951, 1952; Burnside et al., 1953.)

An experiment was carried out by Catron et al. (1952) in an attempt to re-evaluate the protein requirements of growing-fattening pigs in concrete dry lot, with and without aureomycin. The pigs were fed a corn and soybean oil meal ration supplemented with minerals and vitamins, including vitamin B_{12}. In the absence of an antibiotic, the 16, 13, and 10 per cent protein level rations supplied the pigs' needs from weaning to 200 pounds, whereas in the presence of antibiotic the 14, 11, and 8 per cent levels of protein produced gains equivalent to the higher levels of protein. These workers stated that aureomycin when added at the rate of 10 milligrams per pound of ration exerted a protein "sparing-like" action. However, Hoefer et al. (1952) reported that terramycin at the level of 5 milligrams per pound of total ration did not seem to affect the requirements of pigs for protein. They stated that a higher level of B-vitamins may be the cause of a lower requirement of protein supplement in pig rations today.

Other reports are in disagreement on the "sparing" action of antibiotics. Powick et al. (1951) showed that aureomycin could cover a nicotinic acid deficiency in pigs for a period of 3 weeks and thereafter become ineffective. Possible explanation was given that aureomycin kills microorganisms in the intestinal tract which then makes the nicotinic acid available to the host. At the end of 3 weeks, only aureomycin resistant strains of bacteria remain in the intestinal tract so that this source

of nicotinic acid would be lost to the host.

Wahlstrom and Johnson (1951) reported that the addition of aureomycin to a group of baby pigs, which possessed a vitamin B_{12} deficiency, gave no beneficial response when given either before or after the deficiency state existed. Wahlstrom's results are in disagreement with those obtained by Catron et al. (1953a). These latter workers stated that aureomycin appears to "spare" both vitamin B_{12} and pantothenic acid although the addition of pantothenic acid or vitamin B_{12} in the presence of aureomycin did not affect the efficiency of feed utilization. Luecke et al. (1953) could find no "sparing" effect on the pantothenic acid requirement of pigs when they fed 5 milligrams of aureomycin per pound of basal ration.

Only preliminary information is available pertaining to the influence of antibiotics on swine carcass composition. Brown (1951) reported that in a paired feeding trial, aureomycin-fed pigs had heavier carcasses and trimmed hams ($P \leq 0.05$) than their paired controls. He also obtained a higher dressing percentage and heavier backfat ($P \leq 0.05$) in favor of the aureomycin-fed pigs.

Perry et al. (1953) found that backfat thickness at the first rib was significantly greater ($P \leq 0.01$), at the same kill weight, on carcasses from swine fed antibiotics than on carcasses from hogs fed the control rations. The weight of bellies was heavier from carcasses of antibiotic-fed hogs than from controls. Carcass analysis was obtained by grinding one-half of the carcass and weighing the bone and hide separately. They found that carcasses of antibiotic-fed hogs contained

significantly more ($P \leq 0.01$) fat and significantly less ($P \leq 0.01$) protein and water than the control animals' carcasses.

Bowland et al. (1951) found a tendency for APF plus aureomycin to increase dressing percentage and lower carcass grades. They reported that the principal effect of aureomycin was a reduction in carcass length and an increase in backfat.

Huang et al. (1953) obtained a higher dressing percentage from terramycin-fed pigs than from those fed the basal ration. Terramycin-fed animals yielded more total lean meat and more fat than the controls. They noted no difference in the thickness of backfat, in body length, or in bone structure between all lots.

Many workers have reported little difference between basal and antibiotic-fed pork carcasses. Wilson et al. (1953) found little difference in dressing percentage or in length of carcass. Terrill et al. (1951) as well as Catron et al. (1952) reported no significant differences in carcass characteristics between antibiotic and non-antibiotic-fed pigs. Viscera from all carcasses appeared normal. More recently, Catron et al. (1953a) obtained no difference between antibiotic and non-antibiotic treatments in respect to depth of body or percentage of lean to fat.

The mode of action of antibiotics when fed in swine rations is still uncertain, and a considerable amount of work will be needed before their action can be fully explained. The effect of antibiotic supplementation on carcass quality is not definitely determined. There is no clear-cut evidence of a fatter-type carcass when antibiotics are fed to growing-fattening pigs. The effect on carcass quality tends to be small and the

techniques now used probably are not sensitive enough to measure the differences, if any, produced by antibiotics.

EXPERIMENTAL PROCEDURE

Discontinuing Antibiotic Supplementation During the Growing-Fattening Period

The experimental animals used in this study were 75 purebred Poland China, Spotted Poland China, Duroc and Hampshire pigs which were farrowed in the spring of 1951. They were allotted into five lots of 15 pigs each on the basis of sex, age, weight; and, as much as possible, the individual's relative weight in its litter. Treatments were then assigned at random to the five lots.

This experiment was conducted at the college swine farm located one-quarter mile north of the college campus. The pigs were housed and fed on concrete in the south feeding barn. Water in self-waterers was available at all times.

Pigs in Lot I were used as the controls. They were self-fed a basal ration consisting of the following ingredients: shelled No. 2 yellow corn; a protein supplement mixture consisting of 42 parts of soybean oil meal, 30 parts of tankage (60 per cent crude protein), and 28 parts of ground suncured alfalfa hay; and a simple mineral mixture consisting of 2 parts ground limestone, 2 parts steamed bonemeal, and 1 part common salt.

Three pounds of alfalfa hay in the protein supplement were replaced

by three pounds of Aurofac[1] in Lots II and III. The pigs in Lot II received the Aurofac throughout the trial; while those in Lot III were fed this supplement to weights of approximately 125 pounds, after which they received the basal ration.

One pound of alfalfa hay in the protein supplement was replaced by one pound of TM-5[2] in Lots IV and V. This rate of substitution supplied nearly the same amount of antibiotic (terramycin) as was used in the rations for Lots II and III (aureomycin). Lot IV received the terramycin throughout the trial; while the antibiotic was discontinued, and the pigs were fed the basal ration in Lot V after reaching approximately 125 pounds.

The average initial weight when the experiment began on June 15, 1951, was approximately 50 pounds. All pigs were individually weighed at this time and every 14 days thereafter until July 27, 1951, at which time they approached 125 pounds. They were then weighed seven days later, and all lots except Lot I averaged over 125 pounds. At this time, Lots III and V were taken off of rations containing an antibiotic and placed on the basal ration. Weighing was continued at approximately 14-day intervals until each lot approached 225 pounds, then the lots were weighed weekly. As each pig reached approximately 225 pounds, it was removed from the

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1/ "Aurofac Vitamin B_{12}" is an antibiotic feed supplement guaranteed to contain 1.8 grams aureomycin and 1.8 milligrams of vitamin B_{12} per pound of supplement. Aurofac for this experiment was supplied by Lederle Laboratories, Pearl River, N. Y.

2/ "Bi-Con TM-5 Antibiotic Feed Supplement" is a livestock feed supplement guaranteed to contain 5.0 grams of crystalline terramycin hydrochloride per pound of supplement. Bi-Con TM-5 was supplied for this experiment by Chas. Pfizer and Co., Inc., Brooklyn, N. Y.

experiment. The slowest gaining pigs, regardless of their weight, were removed from the experiment when the lot averaged 225 pounds.

Records were kept of all corn, protein supplement, and minerals consumed. The feed in the self-feeders, with the exception of the minerals, was weighed back on the day Lots III and V were changed to the basal ration. This permitted the calculation of feed consumption and efficiency from the beginning of the experiment up to approximately 125 pounds, and from 125 pounds to market weight.

On the 66 day of the trial, August 16, 1951, one of the pigs in Lot IV died of causes not due to the treatment of this experiment. His dead weight was recorded. For the analysis of the data this pig was removed from the experiment on August 3, 1951, the date of his last live weight. An adjustment in feed consumption by this lot was made by subtracting this pig's estimated feed consumption during these 13 days. This was computed from the average feed per pound of gain made by Lot IV up to August 3 multiplied by his daily rate of gain from August 3 to August 16. Fourteen pigs were carried in Lot IV for the remainder of this trial.

Thirty-nine barrows, averaging 209.2 pounds at the time of kill, were slaughtered at the college meats laboratory. Individual weights and measurements were taken. The objective of this work was to determine the effects of aureomycin and terramycin upon the physical characteristics of pork carcasses.

The original plan was to slaughter eight barrows per lot, but failure to reach slaughter weight before the experiment was terminated prevented the use of two barrows from Lot I. Nine barrows were slaughtered from Lot II.

The carcasses were dressed a modified packer style. The total carcass was divided down the midline and the head, ham facings, and leaf fat were loosened but not removed. The dressing percentage was computed on the basis of the entire carcass after a 24-hour chill at a temperature of 32-34 degrees Fahrenheit.

Length of carcass and thickness of backfat were taken after the carcasses were chilled. The measurement for length was taken from the leading edge of the first rib to point of aitch bone. Backfat thickness was measured at the first rib, last rib, and last lumbar vertebrae.

The right side of each carcass was cut into wholesale cuts in a manner similar to the standard procedure as outlined in the report of the proceedings of the Reciprocal Meat Conference (1951). Weights of the four lean cuts (ham, loin, boston butt, and picnic shoulder) were recorded.

Combining Antibiotics in Rations Fed to Growing-Fattening Pigs

A total of 156 pigs were used in three trials conducted on antibiotic combinations at the South Dakota State College swine farm. Four breeds were represented, namely: Poland China, Spotted Poland China, Duroc, and Hampshire.

The pigs were allotted by selective randomization into four lots of 12 pigs each in two dry lot trials, and four lots of 15 pigs each in one trial on pasture. They were stratified according to sex, littermates, weight, and breed. Treatments were then assigned at random to the different lots. All the pigs used in each trial received similar management and feed prior to being placed on the experiment.

All pigs were individually weighed at the start of each experiment and at periodic intervals until they approached the weigh-out weight of 200 pounds. Weights were then taken every seven days until the close of the trial. All weighing in each experiment was done at approximately the same hour of the day in order to avoid any variation resulting from feeding habits. Each lot was removed from the project when the average weight of the lot equaled 200 pounds.

The two experiments in dry lot were conducted in a barn on the college swine farm. This barn contained four 10 X 14-foot pens, each of which opened into a 14 X 20-foot concrete apron to the south. The pigs were allowed access to the outdoor lots at all times. Automatic self-waterers were present in each indoor pen.

The experiment on pasture was conducted in four lots of brome-alfalfa (predominantly brome) pasture. Two 8 X 14-foot portable houses per lot were used for shelter. An 80-gallon steel tank, equipped for automatic watering, was placed in each lot.

The group in the first trial in dry lot and those pigs on pasture were wormed with sodium fluoride before being placed on the experiment. All the experimental animals had been vaccinated for hog cholera and erysipelas prior to the beginning of the experiments.

The pigs in all experiments were fed free-choice from self-feeders. The basal ration for the dry-lot trials consisted of shelled yellow corn and a protein supplement consisting of soybean oil meal, tankage (60 per cent crude protein), and ground alfalfa hay in the respective ratio of 2:2:1. The basal ration for the pasture trial contained shelled yellow

corn and a protein supplement consisting of equal parts of soybean oil meal and tankage. In all trials, a simple mineral mixture of 2 parts steamed bone meal, 2 parts limestone, and 1 part trace-mineralised salt was supplied free-choice. Records were kept of all corn, protein supplement, and mineral consumed.

The antibiotic supplements were originally planned to be fed in the same amount in both the first experiment in dry lot and the experiment on pasture. Due to an error in calculation while mixing, the amount of antibiotics fed was not exactly as planned. In the different experiments the treatments were as follows:

First Dry-Lot Trial:

Lot I - Controls (basal ration)

Lot II - Basal ration plus 27 milligrams of aureomycin[1] per pound of protein supplement.

Lot III - Basal ration plus 13.5 milligrams of aureomycin and 13.5 milligrams of penicillin[2] per pound of protein supplement.

Lot IV - Basal ration plus 13.5 milligrams of aureomycin and 13.5 milligrams of terramycin[3] per pound of protein supplement.

Pasture Trial:

Lot I - Control (basal ration)

1/ Aureomycin fed in the form of Aurofac-2A.

2/ Penicillin fed in the form of Procaine Penicillin (20 per cent).

3/ Terramycin fed in the form of TM-5.

Lot II - Basal ration plus 30 milligrams of aureomycin per pound of protein supplement

Lot III - Basal ration plus 15 milligrams of aureomycin and 10 milligrams of penicillin per pound of protein supplement.

Lot IV - Basal ration plus 15 milligrams of aureomycin and 15 milligrams of terramycin per pound of protein supplement.

Second Dry-Lot Trial:

Lot I - Control (basal ration)

Lot II - Basal ration plus 40 milligrams of aureomycin per pound of protein supplement.

Lot III - Basal ration plus 16 milligrams of penicillin and 20 milligrams of terramycin per pound of protein supplement.

Lot IV - Basal ration plus 16 milligrams of penicillin and 20 milligrams of streptomycin[1] per pound of protein supplement.

The Experiment Station Chemistry Department analyzed representative samples of corn and protein supplement for crude protein content.

The antibiotics were premixed in soybean oil meal and then mixed with the remaining protein supplement in 1000-pound batches.

Two animals died in Lot III of the group on pasture. One died from the effects of over-heating on June 12, 1953, while the other died July 28, 1953. The latter one was found caught under one of the houses used for shelter. Sixty-six feeding days were subtracted from this lot. The product of Lot III's average daily gain during this period multiplied by the calculated feed consumed per pound of gain (3 pounds) was 3.75

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[1] Streptomycin fed in the form of Vet-Strep (streptomycin sulfate).

pounds of feed consumed per day. This value was used to compute the total amount of feed consumed by these two pigs for the 66 days. It was estimated that 80 per cent of the feed consumed was shelled corn and 20 per cent was protein supplement. A total of 198 pounds of corn and 49.5 pounds of protein supplement was subtracted from the total feed consumed by this lot.

In Lot III of the first experiment in dry lot, one pig was not gaining weight. This pig was removed June 10, 1953. It was estimated that this pig's daily feed consumption was one pound of corn and one-third pound of protein supplement. Forty-two pounds of shelled corn and 14 pounds of protein supplement were subtracted from the total feed consumed by this lot.

Carcass measurements were conducted at the John Morrell and Company plant at Sioux Falls, South Dakota. A total of 38 pigs from the first antibiotic-combination trial in dry lot and 42 pigs from the trial on pasture were used for carcass measurements. Individual weights were recorded before slaughter, and dressing percentage were computed from chilled carcass weights.

A measurement of each carcass length was taken from the leading edge of the first rib to the anterior end of the aitch bone. Backfat thickness of each chilled carcass was taken from the first, seventh, and last rib, and at the last lumbar vertebrae. The left loin was removed from each carcass and divided between the sixth and seventh ribs from the loin end. The loin-lean area was obtained as the product of the length times the width of the longissimus dorsi muscle at this point.

RESULTS AND DISCUSSION

The Effects of Discontinuing Antibiotic Supplementation During the Growing-Fattening Period

A summary of the results of the first 49 days of this experiment is presented in table 1.

A statistical analysis of the data was made by means of the "t" test for unpaired differences (Fisher, 1948). A significantly ($P \leq 0.01$) faster rate of gain was shown by the pigs receiving the antibiotics. Aureomycin and terramycin were equally effective in promoting a rapid rate of gain during this early growing-fattening phase. The pigs receiving the antibiotics consumed 15 per cent more feed per day than the control group, Lot I. This difference was due to a larger daily consumption (20 per cent) of corn. The feeding of antibiotics reduced the feed required for 100 pounds of gain by approximately 8 per cent. This improvement in feed efficiency can be attributed primarily to a lower consumption of protein supplement per 100 pounds of gain by the antibiotic-fed pigs. The control pigs consumed approximately 20 pounds more protein supplement per 100 pounds of gain than the antibiotic-fed pigs.

If one assumes that pigs fed free-choice balance their own rations, the conclusion may be drawn that the antibiotics, aureomycin and terramycin, exert a "sparing" effect on protein requirements of pigs from weaning to 125 pounds. This would be in agreement with the conclusions

TABLE 1

Results of Feeding Antibiotic to Pigs from Weaning to 125 Pounds
June 15 to August 3, 1951

Items Compared	Lot I Basal ration	Lot II Aureo-mycin Vitamin B_{12} to 225 lb.	Lot III Aureo-mycin Vitamin B_{12} to 125 lb.	Lot IV Terramycin to 225 lb.	Lot V Terramycin to 125 lb.
No. of pigs	15	15	15	15	15
Av. no. days on feed	49	49	49	49	49
Av. initial wt., lbs.	49.7	49.5	50.5	50.1	50.5
Av. final wt., lbs.	116.1	136.7	134.5	136.9	132.7
Av. total gain, lbs.	66.4	87.2	84.0	86.8	82.2
Av. daily gain, lbs.	1.36	1.78*	1.71*	1.77*	1.68*
Av. daily feed consumed:					
Shelled yellow corn, lbs.	3.43	4.45	4.44	4.26	4.04
Protein supp., lbs.	0.96	0.92	0.86	0.92	0.84
Total feed, lbs.	4.39	5.37	5.30	5.18	4.88
Feed consumed per cwt. of gain:					
Shelled yellow corn, lbs.	252.9	250.3	258.8	240.5	241.3
Protein supp., lbs.	71.0	51.9	50.4	52.2	50.2
Total feed, lbs.	323.9	302.2	309.2	292.7	291.5
Vitamin B_{12} and antibiotics consumed per lb. of total feed:					
Vitamin B_{12}, mcg.	—	9.25	8.76	—	—
Aureomycin, mg.	—	9.25	8.76	—	—
Terramycin, mg.	—	—	—	8.88	8.61

* $P \leq 0.01$ over the control (Lot I)

drawn by Catron et al. (1952). The protein supplement in the feeders was not weighed back when the pigs reached 125 pounds in the other trials, and their consumption up to this weight could not be determined. Therefore, it cannot be concluded conclusively that the mode of action of antibiotics is a "sparing" of protein from the results of one trial. Further work would seem justifiable to determine what effect antibiotics have on protein requirements of pigs from weaning to 125 pounds.

The results of the feeding trial conducted during the period of August 3 to October 22, 1951, are summarized in table 2. Lot II, receiving aureomycin during the entire feeding period, gained significantly ($P \leq 0.01$) faster than the controls. Lot IV, receiving terramycin throughout the entire feeding period, gained approximately 5 per cent faster than the basal fed pigs, but this increase was not statistically significant.

There was no significant difference in rate of gain by the pigs in Lots III and V, antibiotics discontinued at 125 pounds, and the control lot. During this period, the pigs receiving the basal ration gained approximately 3 per cent faster than did the pigs in Lot V which received terramycin only to 125 pounds. However, the control pigs gained 4 per cent less, during this period, than those pigs which had received aureomycin and vitamin B_{12} only to 125 pounds in weight (Lot III).

Pigs in Lots I, III, and V, all of which were receiving the basal ration during this period, consumed an average of 4.6 per cent less feed per day than those pigs in Lots II and IV which were receiving an antibiotic supplement. This is in agreement with the many reports of increased

TABLE 2

Summary of Results of Discontinuing Antibiotic Supplementation
During the Growing-Fattening Period (125 to 225 pounds)
August 3 to October 22, 1951

Items Compared	Lot I Basal ration	Lot II Aureomycin Vitamin B_{12} to 225 lb.	Lot III Aureomycin Vitamin B_{12} to 125 lb.	Lot IV Terramycin to 225 lb.	Lot V Terramycin to 125 lb.
No. of pigs	15	15	15	14	15
Av. no. days on feed	61.9	45.0	48.1	45.0	53.0
Av. initial wt., lbs.	116.1	136.7	134.5	139.2	132.7
Av. final wt., lbs.	228.3	227.5	225.2	225.2	225.9
Av. total gain, lbs.	112.2	90.8	90.7	86.0	93.2
Av. daily gain, lbs.	1.81	2.02*	1.89	1.91	1.76
Av. daily feed consumed:					
Shelled yellow corn, lbs.	6.35	6.84	6.55	6.55	6.35
Protein supp., lbs.	0.78	0.80	0.80	0.95	0.82
Total feed, lbs.	7.13	7.64	7.35	7.50	7.17
Feed consumed per cwt. of gain:					
Shelled yellow corn, lbs.	350.3	339.1	347.4	342.7	361.0
Protein supp., lbs.	43.0	39.7	42.3	49.8	46.4
Total feed, lbs.	393.3	378.8	389.7	392.5	407.4
Vitamin B_{12} and antibiotics consumed per lb. of total feed:					
Vitamin B_{12}, mcg.	—	5.65	—	—	—
Aureomycin, mg.	—	5.65	—	—	—
Terramycin, mg.	—	—	—	6.33	—

* $P \leq 0.01$ over the control (Lot I)

feed consumption by antibiotic-fed pigs.

Feed efficiency was variable during this period, but in most cases favored Lots II and IV, receiving antibiotics, over Lots I, III, and V, which received the basal ration.

The pigs which had the antibiotics discontinued after they reached 125 pounds made smaller average daily gains from 125 pounds to market weight than did the pigs which continued to receive antibiotics throughout their entire feeding period. However, they had gained sufficiently faster than the control lot during the period up to 125 pounds to reach market weight in a shorter time. These results are similar to those reported by Bowland et al. (1950).

A summary of the results for the entire feeding period from weaning to market weight is presented in table 3.

Those pigs on the basal ration required a longer period of time (14.1 days) to reach market weight than did the pigs fed antibiotics. Statistical analysis of average daily gains during the entire experimental period revealed a highly significant ($P \leq 0.01$) difference due to dietary treatment, Lot I compared to Lots II, III, and IV. Lot V, receiving terramycin only to 125 pounds, gained 6 per cent faster than did the basal fed pigs (Lot I), but this increase in daily gain was not statistically significant.

The pigs receiving antibiotics throughout the entire growing-fattening period (Lots II and IV) consumed 8.6 and 6 per cent more feed daily, respectively, than did the basal-fed pigs. Daily feed consumption was also greater in the lots receiving antibiotics during the entire feeding period than in those lots which had the antibiotics removed after the pigs reached 125 pounds.

TABLE 3

Summary of Results of Discontinuing Antibiotic Supplementation
During the Growing-Fattening Period (Weaning to 225 pounds)
June 15 to October 22, 1951

Items Compared	Lot I Basal ration	Lot II Aureomycin Vitamin B_{12} to 225 lb.	Lot III Aureomycin Vitamin B_{12} to 125 lb.	Lot IV Terramycin to 225 lb.	Lot V Terramycin to 125 lb.
No. of pigs	15	15	15	14	15
Av. no. days on feed	110.9	94.0	97.1	94.0	102.0
Av. initial wt., lbs.	49.7	49.5	50.5	51.7	50.5
Av. final wt., lbs.	228.3	227.5	225.2	225.2	225.9
Av. total gain, lbs.	178.6	178.0	174.7	173.5	175.4
Av. daily gain, lbs.	1.61	1.89*	1.80*	1.85*	1.72
Av. daily feed consumed:					
Shelled yellow corn, lbs.	5.06	5.60	5.48	5.37	5.24
Protein supp., lbs.	0.86	0.87	0.83	0.94	0.83
Av. daily mineral mixture, lbs.	0.03	0.04	0.03	0.03	0.03
Total feed, lbs.	5.95	6.51	6.34	6.34	6.10
Feed consumed per cwt. of gain:					
Shelled yellow corn, lbs.	314.2	295.6	304.8	291.2	304.9
Protein supp., lbs.	53.4	45.7	46.2	51.0	48.2
Mineral mixture, lbs.	2.1	1.9	1.9	1.8	1.7
Total feed, lbs.	369.7	343.2	352.9	344.0	354.8
Vitamin B_{12} and antibiotics consumed per lb. of total feed:					
Vitamin B_{12}, mcg.	—	7.22	—	—	—
Aureomycin, mg.	—	7.22	—	—	—
Terramycin, mg.	—	—	—	7.41	—

* $P \leq 0.01$ over the control (Lot I)

The efficiency of feed utilization was greatest in the lots receiving antibiotics throughout the entire growing-fattening period. Lots II and IV, receiving aureomycin and terramycin, respectively, during the entire growing-fattening period, consumed 7 per cent less feed per 100 pounds of gain than did the control group (Lot I); and 3 per cent less feed per 100 pounds of gain than when antibiotics were withdrawn after the pigs reached 125 pounds (Lots III and V).

Compared to the controls (Lot I), 4 per cent less feed was required per 100 pounds of gain during the entire growing-fattening period when pigs were fed aureomycin or terramycin (Lots III and V) from weaning to 125 pounds.

The physical characteristics of the carcasses are presented in table 4. It may be noted from the table that only small differences existed in the means of the dressing percentage and backfat thickness. The pigs fed antibiotics had a slightly greater average depth of backfat and a higher average dressing percentage than the controls. The differences were not statistically significant, but the data would tend to indicate a trend to fatter carcasses when pigs are fed antibiotics. In all lots only slight differences were observed in length of carcasses and percentage of lean cuts.

The data do not reveal any differences between the groups which received antibiotic supplementation during the growing-fattening period to market weight and the groups which received the antibiotic supplementation only until they weighed 125 pounds.

TABLE 4

Summary of Physical Measurements of Swine Carcasses: Discontinuing Antibiotic Supplementation During the Growing-Fattening Period (Weaning to 225 pounds)

Items Compared	Lot I Basal ration	Lot II Aureomycin Vitamin B_{12} to 225 lb.	Lot III Aureomycin Vitamin B_{12} to 125 lb.	Lot IV Terramycin to 225 lb.	Lot V Terramycin to 125 lb.
No. of pigs	6	9	8	8	8
Av. weigh-off, lbs.	223.5	227.9	225.0	226.5	225.1
Av. slaughter wt., lbs.	208.8	211.7	210.2	207.9	207.2
Av. carcass wt., lbs.	155.3	163.0	161.2	158.8	158.7
Av. dressing percentage	74.4	77.0	76.7	76.4	76.6
Av. back fat thickness, inches 1/	1.78	1.94	1.97	1.82	1.87
Av. carcass length, inches 2/	28.9	28.3	28.1	28.8	28.8
Av. carcass percentage of four lean cuts	42.4	41.1	40.9	41.9	42.8

1/ Measurements taken at first and last rib, and last lumbar vertebrae.

2/ Measurement made from leading edge of first rib to point of aitch bone.

The Effects of Combining Antibiotics in Rations Fed to Growing-Fattening Pigs

The results from the first trial of feeding antibiotic combinations in dry lot are summarized in table 5.

No statistically significant differences in daily gains resulted from the feeding of any of the antibiotics in this trial. Lot II, fed aureomycin, gained 6 per cent faster than did the basal-fed pigs, Lot I; and Lot III, which received a combination of aureomycin and penicillin, gained 4 per cent faster than Lot I. However, Lot IV, fed a combination of aureomycin and terramycin, gained 5 per cent slower than the controls.

The faster rate of gain of the pigs in Lots II and III, which received antibiotics, was accompanied by an increased daily feed consumption as in the previous experiment. Lot IV consumed approximately the same amount of feed as Lot I. The relative proportion of concentrate to protein supplement consumed daily was similar between all lots.

Pigs receiving aureomycin in their protein supplement, Lot II, required 3 per cent less feed per 100 pounds of gain than the controls and 5 per cent less than Lots III and IV. The control group made slightly more efficient gains than those fed a combination of antibiotics, Lots III and IV.

The actual amount of antibiotics consumed by the pigs in Lots II, III, and IV was only slightly more than 3 milligrams per pound of feed. This is approximately one-half the amount of antibiotic that was fed to the pigs in the previous experiment. The possibility arises that the level of antibiotics consumed in this trial was below the optimum level that gives the best response. Since the two antibiotics, aureomycin and terramycin,

TABLE 5

Effects of Antibiotic Combinations Fed to Growing-Fattening Pigs in Dry Lot: Trial 1
April 29 to September 30, 1953

Items Compared	Lot I Basal ration	Lot II Basal + 27 mg. Aureomycin/lb. Protein supplement	Lot III Basal + 13.5 mg. Aureomycin and 13.5 mg. Penicillin/lb. Prot. supplement	Lot IV Basal + 13.5 mg. Aureomycin and 13.5 mg. Terramycin/lb. Prot. supplement
No. of pigs	12	12	11	12
Av. no. days on feed	116.2	111.7	114.4	124.2
Av. initial wt., lbs.	39.3	39.2	40.2	39.2
Av. final wt., lbs.	199.5	203.8	205.3	202.2
Av. total gain, lbs.	160.2	164.6	165.1	162.9
Av. daily gain, lbs.	1.38	1.47	1.44	1.31
Av. daily feed consumed:				
Shelled yellow corn, lbs.	4.33	4.50	4.69	4.33
Protein supp., lbs.	0.65	0.71	0.63	0.56
Mineral mixture, lbs.	0.04	0.04	0.05	0.06
Total feed, lbs.	5.02	5.25	5.37	4.95
Feed consumed per cwt. of gain:				
Shelled yellow corn, lbs.	314.6	305.2	325.0	330.4
Protein supp., lbs.	47.5	47.8	43.7	42.9
Mineral mixture, lbs.	3.2	2.5	3.3	4.6
Total feed, lbs.	365.2	355.5	372.0	377.9
Antibiotic levels:				
Antibiotics in feed consumed, mg/lb.	—	3.66	3.17	3.05
Antibiotics consumed daily/pig, mg.	—	19.20	17.01	15.10

in combination were fed at the same total level as aureomycin alone, it appears likely that the levels of the individual antibiotics were too low to produce any favorable effects.

The daily consumption of protein supplement was much less than in the previous experiment. Therefore less antibiotic was consumed daily per pig. The crude protein content of representative samples of the corn and the protein supplement was determined by chemical analysis. It was calculated that the actual amount of corn and protein supplement consumed by these pigs supplied approximately 12.5 per cent crude protein.

The results of antibiotic combinations fed to pigs on pasture are summarized in table 6.

Lot II, receiving aureomycin, made 6 per cent faster daily gains than the group fed the basal ration, Lot I. This increase in rate of gain was statistically significant ($P \leq 0.05$). Lot III, receiving a combination of aureomycin and penicillin, gained 7 per cent faster than the control pigs. This increase in rate of gain was statistically significant ($P \leq 0.01$). The differences in rate of gain exhibited by pigs fed these antibiotic combinations compared to the controls are similar to those in the previous dry-lot trial; but due to more uniform performance in this trial, the differences were statistically significant.

As in the dry-lot trial, the pigs receiving a combination of aureomycin and terramycin, Lot IV, did not exhibit any growth response over the control group. In fact, they again gained slower than the controls.

The faster rate of gain exhibited by the pigs in Lots II and III was accompanied by an increase in daily feed consumption. This is in agree-

TABLE 6

Effects of Antibiotic Combinations Fed to Growing-Fattening Pigs on Pasture
June 2 to October 7, 1953

Items Compared	Lot I Basal ration	Lot II Basal + 30 mg. Aureomycin/lb. Protein supplement	Lot III Basal + 15 mg. Aureomycin and 10 mg. Penicillin/lb. Prot. supplement	Lot IV Basal + 15 mg. Aureomycin and 15 mg. Terramycin/lb. Prot. supplement
No. of pigs	15	15	13	15
Av. no. days on feed	108.5	101.8	101.1	109.7
Av. initial wt., lbs.	43.6	43.4	43.9	43.4
Av. final wt., lbs.	203.1	201.7	204.8	201.6
Av. total gain, lbs.	159.5	158.3	160.8	158.2
Av. daily gain, lbs.	1.47	1.56*	1.59**	1.44
Av. daily feed consumed:				
Shelled yellow corn, lbs.	4.32	4.56	4.66	3.81
Protein supp., lbs.	0.79	0.95	0.91	0.86
Mineral mixture, lbs.	0.02	0.02	0.03	0.02
Total feed, lbs.	5.13	5.53	5.60	4.69
Feed consumed per cwt. of gain:				
Shelled yellow corn, lbs.	293.8	293.1	293.0	264.2
Protein supp., lbs.	53.5	61.1	57.4	59.4
Mineral mixture, lbs.	1.5	1.5	1.7	1.5
Total feed, lbs.	348.8	355.7	352.1	325.1
Antibiotic levels:				
Antibiotics in feed consumed, mg/lb.	—	5.15	4.10	5.5
Antibiotics consumed daily/pig, mg.	—	28.5	22.8	25.8

* $P \leq 0.05$ over the control (Lot I)
** $P \leq 0.01$ over the control (Lot I)

ment with the results of the previous trial.

Pigs in Lots II and III required slightly more feed per 100 pounds of gain than the controls; and approximately 8 per cent more than Lot IV, which received a combination of aureomycin and terramycin. Lot IV made 7 per cent more efficient gains than Lot I.

The consumption of corn was comparable between Lots I, II, and III, but Lot IV consumed less corn per 100 pounds of gain than the other lots. The control group, Lot I, consumed 12 per cent less protein supplement per 100 pounds of gain than did the pigs in Lot II, 7 per cent less than those in Lot III, and 10 per cent less than the pigs in Lot IV. The consumption of mineral was similar in all lots.

The concentration of antibiotics consumed in this trial was approximately 5 milligrams per pound of feed consumed. Pigs receiving antibiotics in this trial consumed approximately 33 per cent more antibiotics daily per pig than those pigs receiving antibiotics in the previous dry-lot trial. It was calculated that the actual amount of corn and protein supplement consumed by these pigs supplied approximately 15.3 per cent crude protein.

This increase in consumption of antibiotics and protein may account for the fact that the pigs fed in this trial showed less variability within lots than the pigs fed in the previous trial in dry lot. This uniformity is realized when the differences in rate of gain between Lots I and II are compared in both trials. The difference in rate of gain is the same in both trials (0.09 pound). This difference was statistically significant ($P \leq 0.05$) in the pasture trial but not in the one in dry lot.

The results of combining antibiotics in rations fed to growing-fattening pigs in the second trial in dry lot are summarized in table 7.

No statistically significant differences in daily gains resulted from the feeding of any antibiotics in this second trial of pigs fed in dry lot. However, all lots receiving antibiotics gained slightly faster than did the controls. Lot II, receiving aureomycin, gained 6 per cent faster than the controls (Lot I). Lot III, receiving a combination of penicillin and terramycin, gained only slightly faster; while Lot IV, receiving a combination of penicillin and streptomycin in their protein supplement, gained 7 per cent faster than did the basal-fed pigs.

The difference in feed consumption between lots was not as great in this trial as in the other experiments. Lot II consumed 6 per cent more feed daily (9 per cent more corn) than the controls; but Lots I, III, and IV consumed approximately the same amount of feed per day. However, Lot IV consumed 14 per cent less protein supplement daily than did the basal-fed pigs.

The pigs fed combinations of antibiotics made the most efficient utilization of their feed. The lots receiving antibiotic combinations consumed less corn per 100 pounds of gain than did the controls. All lots receiving antibiotics consumed less protein supplement per 100 pounds of gain than did the pigs fed the basal ration. Lot II, receiving aureomycin, consumed 17 per cent less protein supplement per 100 pounds of gain than the controls. Lot III consumed only slightly less while Lot IV consumed 20 per cent less protein supplement per 100 pounds of gain than did the basal-fed pigs, Lot I. Mineral consumption was comparable between all

TABLE 7

Effects of Antibiotic Combinations Fed to Growing-Fattening Pigs in Dry Lot: Trial 2
September 21 to January 4, 1954

Items Compared	Lot I Basal ration	Lot II Basal + 40 mg. Aureomycin/lb. Protein supplement	Lot III Basal + 16 mg. Penicillin and 20 mg. Terramycin/lb. Prot. supplement	Lot IV Basal + 16 mg. Penicillin and 20 mg. Streptomycin/lb. Prot. supplement
No. of pigs	12	12	12	12
Av. no. days on feed	93.9	86.9	88.7	87.5
Av. initial wt., lbs.	49.5	49.8	49.8	49.7
Av. final wt., lbs.	204.9	202.0	199.3	204.3
Av. total gain, lbs.	155.4	152.2	149.5	154.6
Av. daily gain, lbs.	1.65	1.75	1.69	1.77
Av. daily feed consumed:				
Shelled yellow corn, lbs.	4.71	5.18	4.72	4.81
Protein supp., lbs.	0.90	0.80	0.89	0.77
Mineral mixture, lbs.	0.04	0.05	0.05	0.05
Total feed, lbs.	5.64	6.03	5.66	5.63
Feed consumed per cwt. of gain:				
Shelled yellow corn, lbs.	284.8	295.8	279.9	272.0
Protein supp., lbs.	54.4	45.4	53.0	43.6
Mineral mixture, lbs.	2.7	2.6	2.9	3.0
Total feed, lbs.	341.9	343.8	335.8	318.8
Antibiotic levels:				
Antibiotics in feed consumed, mg/lb.	---	5.3	5.7	4.9
Antibiotics consumed daily/pig, mg.	---	32.0	32.3	27.6

lots. It was calculated that the actual amount of corn and protein supplement consumed by these pigs supplied approximately 13.9 per cent crude protein.

Approximately 5 milligrams of antibiotic supplemented each pound of feed consumed. This concentration is comparable to that supplied in the trial on pasture, but the amount consumed daily per pig was slightly higher in this trial.

The initial weight of the pigs in this trial was approximately 10 pounds greater than the weight of the pigs in the first dry-lot trial. This is probably one of the reasons for the faster rate of gain produced by all lots in this trial.

The results obtained from these trials do not indicate that a combination of antibiotics are any better than one alone when the total amount of antibiotics fed is the same.

The physical characteristics of the carcasses are presented in tables 8 and 9. Table 8 is the summary of carcass measurements of pigs in the first dry lot trial, while table 9 is the summary of those from the pasture trial.

It may be noted from the above tables that there was little difference in dressing percentage or carcass length between all lots. The pigs fed aureomycin or antibiotic combinations in dry lot (table 8) had greater thickness of backfat, but this difference was not statistically significant. There was little difference in backfat thickness between any of the lots fed antibiotics on pasture (table 9).

The surface area of the loin eye muscle was nearly the same in all

TABLE 8

Summary of Physical Measurements of Swine Carcasses: Effects of Antibiotic Combinations Fed to Growing-Fattening Pigs in Dry Lot: Trial 1

Items Compared	Lot I Basal ration	Lot II Basal + 27 mg. Aureomycin/lb. Protein supplement	Lot III Basal + 13.5 mg. Aureomycin and 13.5 mg. Penicillin/lb. Prot. supplement	Lot IV Basal + 13.5 mg. Aureomycin and 13.5 mg. Terramycin/lb. Prot. supplement
No. of pigs	9	10	11	8
Av. weigh-off, lbs.	203.0	204.0	205.4	203.2
Av. slaughter wt., lbs.	197.0	196.1	199.4	197.4
Av. carcass wt., lbs.	140.4	140.0	141.5	141.7
Av. dressing percentage	71.3	71.4	70.9	71.8
Av. back fat thickness, inches[1/]	1.64	1.71	1.75	1.73
Av. carcass length, inches[2/]	28.4	28.4	28.2	28.4
Av. area of loin eye, sq. in.	3.60	3.42	3.62	3.42
Av. choice grade	1.00	1.30	1.45	1.25

1/ Measurements taken at first, seventh, and last rib, and last lumbar vertebrae.

2/ Measurement made from leading edge of first rib to point of aitch bone.

TABLE 9

Summary of Physical Measurements of Swine Carcasses: Effects of Antibiotic Combinations Fed to Growing-Fattening Pigs on Pasture

Items Compared	Lot I Basal ration	Lot II Basal + 30 mg. Aureomycin/lb. Protein supplement	Lot III Basal + 15 mg. Aureomycin and 10 mg. Penicillin/lb. Prot. supplement	Lot IV Basal + 15 mg. Aureomycin and 15 mg. Terramycin/lb. Prot. supplement
No. of pigs	10	11	10	11
Av. weigh-off, lbs.	204.7	202.7	203.5	203.9
Av. slaughter wt., lbs.	198.7	197.4	197.0	197.7
Av. carcass wt., lbs.	140.7	141.5	139.4	140.0
Av. dressing percentage	70.8	71.7	70.8	70.8
Av. back fat thickness, inches[1]	1.56	1.53	1.66	1.57
Av. carcass length, inches[2]	28.9	29.0	28.8	28.7
Av. area of loin eye, sq. in.	4.06	4.49	3.51	4.10
Av. choice grade	1.10	1.10	1.20	1.00

1/ Measurements taken at first, seventh, and last rib, and last lumbar vertebrae.

2/ Measurement made from leading edge of first rib to point of aitch bone.

lots. There was a tendency for the choice grade to be lowered when the pigs were fed antibiotic or antibiotic combinations in dry lot. This was due to more pigs grading Choice No. 2.

From the data in tables 8 and 9, it appears that antibiotics fed alone or in combination in dry lot or on pasture have small, if any, effect on physical characteristics of pork carcasses.

SUMMARY

Four feeding trials were conducted with antibiotics added to the protein supplement fed to growing-fattening pigs. One experiment was conducted to compare the effects produced by discontinuing antibiotics at 125 pounds, and the merits of feeding antibiotics to market weight. Three other trials were conducted with antibiotic combinations. Two of the combination trials were conducted in dry lot and one on pasture.

In the experiment with antibiotics fed for different lengths of time, 75 pigs, averaging 49 pounds, were used as experimental animals. They were self-fed shelled No. 2 yellow corn; a protein supplement consisting of soybean oil meal, tankage (60 per cent crude protein), and ground, suncured alfalfa hay in the respective ratio of 42:30:28; and a mineral supplement composed of ground limestone, steamed bonemeal, and common salt.

Aureomycin and terramycin, when added to the protein supplement of growing-fattening pigs, produced significantly ($P \leq 0.01$) faster daily gains than the basal ration. When the antibiotics were removed at 125 pounds, the pigs made gains comparable to the control group. There appeared to be no carry-over effect after antibiotics were removed from the ration.

Pigs fed antibiotics for the entire feeding period made faster and more efficient gains than controls or those which received antibiotics up to 125 pounds. Controls up to 125 pounds in weight consumed 19.8 pounds

more protein supplement per 100 pounds gain than those pigs fed aureomycin or terramycin.

In the trials with antibiotic combinations, a total of 156 pigs were used. The two trials in dry lot each contained four lots of 12 pigs each. The average weight of the pigs in these two trials was 44 pounds. The trial on pasture contained four groups of 15 pigs each. These pigs averaged approximately 44 pounds in weight.

All the pigs were fed free-choice. The pigs in dry lot received a basal ration of shelled yellow corn, a protein supplement of soybean oil meal, tankage (60 per cent crude protein), and ground alfalfa hay in the respective ratio of 2:2:1. The pigs on pasture received shelled yellow corn and a protein supplement consisting of equal parts of soybean oil meal and tankage. All rations contained a simple mineral mixture of ground limestone, steamed bonemeal, and trace mineral salt in the respective ratio of 2:2:1 fed free-choice.

The various antibiotics used in the first dry-lot trial and the pasture trial were: aureomycin, aureomycin and penicillin, and aureomycin and terramycin. The combinations used in the second trial in dry lot were: aureomycin, penicillin and terramycin, and penicillin and streptomycin.

No statistically significant difference in daily gains resulted from the feeding of antibiotics in either of the two trials in dry lot. However on the pasture trial, a statistically significant ($P \leq 0.05$) increase in rate of gain was found in Lot II, receiving aureomycin, compared to the controls and a statistically significant ($P \leq 0.01$) increase in rate of gain was shown in Lot III, receiving a combination of aureomycin and penicillin, compared to the basal-fed lot.

In all trials, pigs fed a single antibiotic, aureomycin, consumed more feed and produced a faster rate of gain than did the pigs fed the basal ration.

The combining of two antibiotics in the protein supplement, at the levels stated in these trials, produced no clear-cut supplementary effect. In some lots the combining of antibiotics resulted in more efficient utilization of feed compared to controls while in other lots the reverse was found. Further work would seem justifiable to determine what effects would be produced by adding greater amounts of each antibiotic in combination.

Carcass analysis on a total of 119 animals indicate no significant physical differences produced by the feeding of antibiotics alone or in combination when compared with the controls.

CONCLUSIONS

The following conclusions are drawn from the results obtained in these feeding trials:

1. Pigs fed aureomycin or terramycin until they reach 125 pounds gained significantly faster than the control group.
2. Pigs receiving aureomycin or terramycin up to 125 pounds made more efficient utilization of their feed than did the pigs receiving only a basal ration.
3. Pigs fed aureomycin or terramycin until they reached 125 pounds required less protein supplement than pigs fed a basal ration.
4. Pigs which had the antibiotics discontinued from 125 pounds to market weight maintained their lead in weight, but their rate of gain during this feeding period was similar to the original controls.
5. The most efficient feed utilization and most rapid rate of gain was obtained when pigs were fed antibiotics throughout the growing-fattening period.
6. The feeding of antibiotics alone or in combination produced little if any change in physical characteristics of hog carcasses.
7. Pigs fed a combination of aureomycin and terramycin, in dry lot or on pasture, gained slower than did the pigs fed a basal ration. These antibiotics appeared not to supplement one another at the level fed in these trials.
8. Combinations of penicillin plus streptomycin, and penicillin plus terra-

mycin produced slightly faster rates of gain than did the basal ration.

9. A combination of aureomycin and penicillin fed to growing-fattening pigs on pasture produced a 7 per cent faster (highly significant) rate of gain than did the basal ration. However, this combination increased the rate of gain by only 4 per cent when the pigs were in dry lot.

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