A COMPARISON OF THE PERFORMANCE OF BROILER STRAIN CHICKS FED SINGLE SOURCE AND COMBINATIONS OF ANTIBIOTICS

by

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INTRODUCTION

The use of antibiotics in commercial feeds has developed in the past 10 years for a multitude of purposes. These drugs function as growth and egg production stimulants under certain conditions and in the prevention and treatment of various diseases of livestock and poultry. In all probability the widest present range of their use is in poultry feeds. The amounts of antibiotic added, depending on the purpose for which it is used, may range from as little as two to as high as 200 grams or more per ton of feed. In this presentation the effect of antibiotics on the performance of broiler strain chicks, using a level of 10 grams per ton, will be considered.

Results of antibiotic supplementation of broiler rations the past few years have been very inconsistent. Antibiotics, which in the past have caused increased growth, are now giving only slight responses. New antibiotics are continually entering the picture. Further studies are needed in order to better understand the action of antibiotics.

Two experiments were conducted in order to test the performance of broiler strain chicks fed antibiotics. The following were determined: (1) comparison of single source and combinations of antibiotics, (2) effect of antibiotics on growth of broiler strain chicks, (3) pounds of feed per pound of gain or feed conversion as affected by antibiotics, (4) mortality and abnormalities with the use of antibiotics, and (5) influence of various antibiotics on the hemorrhagic condition.

REVIEW OF LITERATURE

Stokstad and Jukes (1950) were the first to discover that antibiotics would improve growth of broilers. They found fermentation products of Streptomyces aureofaciens promoted growth of depleted chicks on various diets which were adequately supplied with vitamin B_{12}. Using a corn-soybean diet, growth responses were produced also by crystalline aureomycin hydrochloride.

Reed and Couch (1950) carried out feeding tests with groups of 200 to 280 chicks in pens with sand litter and under practical conditions. Results of two APF concentrates showed that one failed to have any growth promoting effect while the other concentrate produced a decided increase in the weight of the chicks. The latter concentrate improved also feed efficiency. It was believed that growth stimulation was due, in part, to the antibiotic found in this concentrate.

The addition of an APF supplement "B" caused a marked increase in the growth rate of chicks fed either all vegetable rations or a ration containing fish meal according to Biely et al. (1951). There was no effect on the growth response of chicks fed APF supplement "A" in similar rations. APF supplement "B" contained the growth stimulating substance aureomycin.

Berg et al. (1950a) found that removing aureomycin from the ration at four and one half weeks resulted in a reduction in the accelerated growth response, adding the aureomycin at four and one half weeks of age caused an immediate acceleration of growth. The results of three experiments by Berg et al. (1950b) indicated that addition of an aureomycin fermentation product to fryer rations promoted significantly increased growth in fryers. Oleson et al. (1950), using dietary supplements of crystalline aureomycin, stimulated the growth of chicks fed a corn-soybean diet supplemented with an excess of vitamin B_{12}. According to Whitehill et al. (1950), aureomycin hydrochloride stimulated the growth of chicks when fed in the diet at levels as low as 25 mg per kilo. Kratzer et al. (1951) fed day-old chicks for the first three days of life droppings from birds fed aureomycin. These chicks produced less growth depression than chicks fed droppings from normal birds.

Elam et al. (1951a, 1951c), observed that feeding penicillin stimulated growth of birds fed an all-vegetable-protein diet. These workers observed no increase in growth when autoclaved penicillin was fed. Heuser and Norris (1952) found penicillin gave the most consistent and slightly better results than other antibiotics used. An analysis of the results revealed that two grams of procaine penicillin produced the greatest gains, according to Runnels et al. (1951). Stern and McGinnis (1953) stated that penicillin produced a significant growth response in every feeding trial.

Dixon and Thayer (1951) administered aureomycin hydrochloride and procaine penicillin G orally and by intramuscular injection to normal chicks and to chicks on which a bilateral cecal ligation had been performed. Functional ceca were not essential for the growth promoting action of the antibiotics. Intramuscular injections of these antibiotics produced a growth response equal to that produced by oral administration. Likewise, Elam et al. (1951b) obtained increased weights in birds fed orally penicillin and aureomycin, but not when the antibiotics were injected. Waibel et al. (1952) found addition of aureomycin or penicillin to a purified ration consistently resulted in substantial increases in growth. Similar results were obtained with various practical rations.

Bacitracin, when administered orally or parenterally, increased the rate of growth of chicks, according to Elam et al. (1951c).

Moore et al. (1946) observed that streptomycin led to increased growth responses in chicks receiving a basal diet supplemented with adequate amounts of folic acid. Streptomycin, although stimulatory, was not as active as other antibiotics, according to Davis and Briggs (1951).

Groschke (1950), Groschke and Evans (1950), and McGinnis et al. (1950) achieved highest gains when vitamin B_{12} was fed in combination with streptomycin or aureomycin. Growth was much superior to that obtained with B_{12} alone.

Terramycin significantly stimulated the growth rate of chicks during two 28-day studies, according to Rosenberg et al. (1952).

Reynolds et al. (1951) found an analysis of the data revealed that two grams of terramycin produced the greatest gain in body weight of chicks grown in batteries. However, there was no statistically significant difference in the growth promoting properties between terramycin and penicillin. Two grams of penicillin appeared also to be the optimum level.

Sherman and Donovan (1958) reported growth increments from oleandomycin ranged from 5-10 percent; whereas, penicillin, in parallel tests, caused responses of only 1-2 percent.

Kramke and Fritz (1951), using graded levels of aureomycin, bacitracin, penicillin, and terramycin, found that all gave essentially optimum growth stimulation when used at the rate of 10 grams per ton of feed. At lower levels of intake penicillin proved to be the most effective, giving practically as good results with five grams of antibiotic per ton. The largest percentage increases in rate of growth were obtained when vegetable protein rations were used. Matterson et al. (1952a) obtained good growth responses with aureomycin, bacitracin, penicillin, and terramycin when fed singly. Earlier reports are confirmed by Elam et al. (1953) and Boone and Morgan (1955) in that aureomycin, bacitracin, penicillin, and terramycin stimulate the growth of chicks.

Runnels et al. (1951) found no significant difference between groups receiving antibiotics, but all groups were significantly heavier in average body weight than the control. Growth stimulation was obtained with a number of antibiotics, according to Heuser and Norris (1952). The greatest relative growth stimulation of chicks was found to occur during the first four weeks. The difference in weight disappeared as the chicks grew older. Elam et al. (1952) received increased growth with several antibiotics. Lillie and Bird (1953) found tyrothricin, gramicidin, and neomycin to show evidence of growth stimulating effects, but their effects were less consistent and of lesser magnitude than those produced by the antibiotics being used commercially in feeds. Gard et al. (1958) have reported that antibiotic 13184 improved growth over procaine penicillin. Wiese and Petersen (1959) conducted investigations to compare penicillin G, penicillin V, erythromycin, and spontin as stimulants for chick growth. In four experiments erythromycin supplement consistently resulted in increased chick growth when compared to the basal and other antibiotic supplements.

Matterson et al. (1952a) fed aureomycin, penicillin, terramycin, and bacitracin in all possible combinations of pairs. No combination of antibiotics gave a growth response significantly greater than that obtained by the better of the two antibiotics when fed alone. It was observed by Sanford (1952) that combining two antibiotic-B_{12} feeding supplements resulted in growth superior to combining four. A combination of aureomycin, penicillin, streptomycin, and terramycin was not superior to penicillin alone in stimulating chick growth, according to Johnson (1952).

Matterson et al. (1959) indicated experiments support the theory that antibiotics are losing their response. Using antibiotics procaine penicillin, zinc bacitracin, and aureomycin, they found the percent growth responses over basal in three experiments were considerably less than those obtained in 1951 experiments.

Scott and Glista (1950) found addition of APF or aureomycin hydrochloride to a corn-soya ration did not improve its ability to promote chick growth. Lillie and Bird (1953), in evaluating crystalline antibiotics, found chloromycetin ineffective and tomatidine to exert no growth promoting effect. Fumagillin proved toxic at the levels used. Monson et al. (1959) stated that chicks are no longer responding to low levels of some antibiotics. No antibiotic response was shown with low levels of procaine penicillin, bacitracin, oleandomycin, or atterimin. However, these workers did feel that under practical broiler operations it may still be possible to obtain an antibiotic response in the field because of the increased number of stress factors. Wiese and Petersen (1959) found little response from use of penicillin V or spontin and practically no response from penicillin G.

Davis and Briggs (1951), employing a practical corn-soybean ration supplemented with either aureomycin hydrochloride, procaine penicillin G, bacitracin, or terramycin, obtained increased chick growth in most cases but not in all. Heuser and Norris (1952) indicated variability was apparent for the same antibiotic in different experiments. Burgess et al. (1953), in two experiments, found dietary penicillin to have an inconsistent effect on growth. In the first experiment no growth increase was observed, while in the second experiment birds receiving the antibiotic gained significantly more weight. Waibel et al. (1954) obtained also inconsistent results. During a period from August 1950 to May 1952, the addition of penicillin or aureomycin to adequate diets consistently increased the growth of chicks. From June 1952 to July 1953, these antibiotics no longer increased the growth rate of chicks fed good diets.

Davis and Briggs (1951) reported that feed efficiency showed improvement when the diet was supplemented with an antibiotic. Heuser and Norris (1952) observed considerable variation in feed efficiency. The trend, however, showed that with antibiotic less feed was required to produce a pound of gain.

Procaine penicillin, as compared to other antibiotics, produced the most efficient feed utilization, according to Runnels et al. (1951).

Machlin et al. (1952) and Lindblad et al. (1954) observed improved feed efficiency of chicks fed diets supplemented with aureomycin.

Reynolds et al. (1951) and Rosenberg et al. (1952) found terramycin to increase the efficiency of feed utilization.

Erythromycin improved feed efficiency in three experiments conducted by Gard et al. (1958).

Berg et al. (1950a), working with aureomycin, reported that results indicated the action of the antibiotic was limited to the time the material was being fed, and that it was not stored in the body in such a way that it could be utilized for increased growth.

Groschke (1950) concluded that antibiotics stimulated growth indirectly by changing the intestinal microflora from "undesirable" to "desirable" types and that unknown factors synthesized by the "desirable" types were responsible for the growth effect.

Anonymous workers (1953) suggested that antibiotics improved growth by so altering the intestinal flora that there was an increase in the numbers of bacterial forms which synthesized vitamins required by the host or a decrease in those forms which utilized these vitamins and thus competed with the host.

As a result of decreased numbers of microflora in the small intestine, Sieburth et al. (1954) surmised there was either a greater utilization of the nutrients in the feed by the host animal, or a decreased production of toxic substances by the intestinal microflora, or both.

Waibel et al. (1954) stated their results were in harmony with the concept that antibiotics stimulate growth both by sparing required nutrients and by decreasing low-grade infections.

Evidence produced by Elam et al. (1951c) suggested the antibiotic molecule or a fragment of the molecule might act as a metabolite within the body of the bird.

Two additional theories were suggested for exploration by Eisenstark and Sanford (1953): (1) the antibiotic, in low concentration, may stimulate the growth of certain bacteria and (2) low levels of antibiotics may cause a change in the physiologic activity of some organisms.

Reyniers et al. (1950) obtained occasional increased growth rate of germ-free chicks over that of control chicks fed the same diet. As a result they thought the net effect of the microorganisms in the gastrointestinal tract of the control birds might be detrimental.

March and Biely (1952) found a marked depression in the number of lactic acid bacteria present in the feces when aureomycin was added to chick diets. These bacteria were suspected of competing with the chick for many of the vitamins. On the other hand, Williams et al. (1951) found no significant change in numbers of lactic acid bacteria when using aureomycin. They did, however, find the anaerobic bacteria reduced 150 to 200 fold. Eisenstark and Sanford (1953) observed no significant change in the intestinal flora of eight-week old chicks fed aureomycin.

Feeding of penicillin caused a significant increase in the total number of intestinal microorganisms, according to Elam et al. (1951a). Anderson et al. (1952b) reported addition of penicillin caused a reduction in numbers of aerobes, anaerobes, coliforms, lactobacilli, and enterococci in the ceca. Romoser et al. (1952, 1953) fed chicks viable cultures of *Aerobacter aerogenes* and *Escherichia coli* in combination with penicillin. They found chick growth improved greatly over penicillin alone.

Sieburth et al. (1954) found all types of microflora studied were consistently decreased in number in the small intestine of chicks fed either penicillin or aureomycin.

No consistent difference was found in species distribution of gut flora between controls and birds fed either penicillin or oleandomycin, according to Sherman and Donovan (1958).

Rosenburg et al. (1952) demonstrated no reduction or elimination of microflora in number, even when 16 times the recommended amount of terramycin was fed.

Rhodes et al. (1954) found antibiotics generally increased the numbers of coliform bacteria in all levels of the intestinal tract and reduced the numbers of lactobacilli. Likewise, Hauser et al. (1954, 1956) found also an increase in intestinal coliforms and a reduction in lactobacilli when using several antibiotics.

Studies were shown by Anderson et al. (1953) that bacterial cultures originally obtained from cecal contents of birds fed antibiotics stimulated growth of poultry.

Eisenstark and Dragsdorf (1953) have reported that antibiotics in low concentration may have a stimulatory effect upon growth of bacteria. These workers found stimulated bacteria to reveal numerous enlarged and filamentous cells under microscopic examinations.

Penicillin caused a significant increase in bone ash of New Hampshire chicks, according to Ross and Yacowitz (1952). This antibiotic appeared to decrease the vitamin D requirement for normal bone calcification.

Biely and March (1951) obtained a lowering of the dietary requirements of nicotinic acid, folic acid, and riboflavin when aureomycin was fed. Waibel et al. (1953) found penicillin, aureomycin, or a mixture of antibiotics increased growth of chicks fed diets containing limiting amounts of thiamine. Monson et al. (1954) reported antibiotics increased folic acid production and growth rate.

On the other hand, Stokstad et al. (1951) observed no large differences in the requirements of certain vitamins when aureomycin was fed. Likewise, Nelson and Scott (1952, 1953) received no improvement in growth or niacin deficiency symptoms when aureomycin or penicillin was added to semi-purified chick diets.

Stokstad and Jukes (1951) observed a sparing effect of aureomycin on the vitamin B_{12} requirement in some experiments, but not in others. An experiment was conducted by McGinnis (1951) in which graded levels of vitamin B_{12} were fed alone and in combination with terramycin. The vitamin B_{12} requirements for maximum growth might have been increased by terramycin supplementation. In contrast, Sunde et al. (1951) noted that chicks fed a corn-soybean oil meal ration supplemented with streptomycin, in the presence of various levels of vitamin B_{12}, resulted in a higher storage of the vitamin in the liver of the chick than that of a similar ration without the antibiotic.

Pepper et al. (1951, 1952, 1953) reported aureomycin enhanced the utilization of manganese for both growth promotion and the prevention of perosis, but did not appear to reduce the dietary requirement for the nutrient. The more inadequate the ration in calcium and phosphorous, the greater was the percentage increase in weight due to aureomycin, according to Lindblad et al. (1954). Ross and Yacowitz (1954), however, found that penicillin did not stimulate growth in chicks fed a vitamin D deficient, low phosphorous diet.

The antibiotics, penicillin and aureomycin, increased the amount of nitrogen absorbed from the intestinal tract of four-week old chicks, according to Thayer and Heller (1955).

Jones and Combs (1951) reared chicks in batteries and fed them practical type rations suboptimal in lysine and tryptophan. Aureomycin supplementation appeared to spare the dietary requirement for tryptophan, but not for lysine. Patrick (1952, 1953) found that antibiotics did not obviate the need for supplementary lysine or methionine.

Machlin et al. (1952) noted a decrease in the protein requirement when aureomycin was added to the diet of young chickens. Using various levels of protein, Weakley et al. (1953) observed increased feed efficiency and a sparing effect on the protein by supplementing a basal ration with penicillin, aureomycin, and bacitracin. In addition, West and Hill (1955) reported a sparing effect upon the protein requirement of the young chicken when crystalline aureomycin, terramycin, and bacitracin were used at the rate of

10 grams per ton of feed.

In contrast, Slinger et al. (1951), Matterson et al. (1952b), Johnson (1952), Scott et al. (1952), and Saxena et al. (1953) found no indication that the presence of antibiotics reduced the protein requirement of young chicks. Anderson et al. (1952a) and Slinger et al. (1952) reported also no sparing effect from use of antibiotics, but they did indicate that antibiotics enhanced protein utilization. White-Stevens and Zeibel (1954) concluded the low level of antibiotic was most effective on the lower protein ration; whereas, the high level was most effective at the higher protein levels. This experiment involved 20,000 commercial broilers in New Jersey and Delaware.

Antibiotics did not have a sparing action on the carbohydrate requirements of the chick, according to Biely et al. (1952).

Scott et al. (1951) stated their results supported the belief that response from an antibiotic is dependent, in part, on the makeup of the ration with which it is fed. Corn distiller's solubles, condensed fish solubles, dried whey with fermentation solubles, butyl fermentation solubles (grain base), butyl fermentation solubles (molasses base), all fed at five percent level and grass juice concentrate at two percent gave a definite growth response when added to the basal ration when aureomycin was fed. Dehydrated alfalfa meal, defatted liver meal, dried brewers yeast, and dried cereal grass did not give any improvement when aureomycin was added. Sanford (1952) obtained a greater increase in rate of growth with a vegetable protein as compared with a combination of vegetable and animal sources of protein when antibiotic and vitamin B_{12} supplements were added to chick diets. Lewis and Sanford (1952) noted addition of antibiotics and vitamin B_{12}

feeding supplements promoted superior growth with soybean meal as compared with cottonseed meal. Branion and Hill (1953) and Hill and Kelly (1955) reported increased growth of chicks fed antibiotics when fish meal was included in the diet. The response to aureomycin was found to be greatest with sucrose when Stokstad et al. (1953) experimented with various types of carbohydrates.

Slinger et al. (1954) indicated their results suggested penicillin stimulated chick growth by causing an increase in feed consumption early in the life of the bird.

Coates et al. (1951), Bird et al. (1952), Hill et al. (1953) and Lillie et al. (1953) observed no growth response from the use of antibiotics in a "new" environment, but found chicks increased in rate of growth over controls when antibiotics were fed in an "old" environment. Elam et al. (1954) found the same to be true, but in addition, the clostridia count per gram of feces was decreased in birds maintained in old quarters. In clean quarters penicillin failed to stimulate growth or decrease the clostridia count in birds where the clostridia count was low. On the other hand, Morrison et al. (1954) observed that penicillin produced a significant growth response in both an old and a new environment.

Saxena et al. (1952) and Ackerson et al. (1952) noted more consistent and greater responses from antibiotics when chicks were kept in floor pens as compared to those kept in batteries.

According to Mellen and Waller (1954) and Menge and Connor (1955), aureomycin treatment caused a significant increase in the size of the thyroid gland. Feeding antibiotics resulted in a decrease in the weight of the intestinal tract which was not accounted for by body weight or length of the tract, according to Jukes et al. (1955) and Keeling et al. (1956). The theory was that the wall was thinner when birds were fed antibiotics which resulted in better absorption of nutrients. In addition to a reduction in the weight of the small intestine, Pepper et al. (1953) observed aureomycin brought about a slight increase in cecal weight of birds. Anderson et al. (1952a) reported a marked increase in the size of the ceca when penicillin was fed.

Nordskog and Johnson (1953) fed rations with and without antibiotics (penicillin and aureomycin) to twelve pens of chicks having nine kinds of breeding. A total of 2,454 chicks was involved in the experiment. The differential response of the breed groups, to antibiotics, was statistically highly significant.

Dempsey and Sanford (1960) observed that some antibiotic supplements caused significant increases in the hemorrhagic condition in poultry. Crystalline forms of antibiotics were found to cause significantly less hemorrhages than crude feeding grade antibiotics. Crude feeding grade sources of oxytetracycline and and zinc bacitracin caused an increase in the hemorrhagic condition as compared to procaine penicillin.

MATERIALS AND METHODS

Two separate experiments were conducted at the Kansas State University poultry farm in the poultry nutrition laboratory. A total of 659 birds were used in the two experiments. Experiment I, consisting of 330 birds, was initiated on September 15, 1959, and ran until November 20, 1959. The second experiment lasted from December 18, 1959, to February 12, 1960, and contained 329 birds. Straight run broiler strain chicks of the Peterson

Cornish x Arbor Acres White Rock cross were used in both experiments.

The chicks were randomized into 22 lots of 15 chicks each, wingbanded, and vaccinated by the intranasal method for Newcastle and bronchitis. Electrically heated battery brooders were used to rear the birds to four weeks of age, at which time they were transferred to unheated batteries until the end of the experimental period. Feed and water were provided ad libitum.

Grain was ground and all ingredients were mixed in the feed building located at the university poultry farm. The Kansas State University corn-soybean basal broiler ration was used as the control diet and to which all the various antibiotics were added. The composition of this ration is given in Table 1. A large platform balance was used to weigh all ingredients measured in pounds, whereas, gram levels were weighed on a computagram balance. Two separate premixes were made of the minerals and vitamins. The ingredients were added to approximately 15 pounds of ground yellow corn and mixed for five minutes in a small electrically operated Hobart mixer. This mixture was then blended into approximately 60 pounds of ground yellow corn in a 100 pound horizontal paddle mixer and mixed for another five minutes. Finally all ingredients and premixes were placed into a 1,000 pound horizontal type mixer for the final five minutes of mixing. The completed basal ration was sacked and used for addition of the various antibiotics.

A double pan beam balance was used to weigh the small quantities of the antibiotics. The required amount for 100 pounds was added to approximately 15 pounds of the basal and mixed for five minutes in the Hobart mixer. This premix was then blended into the remaining amount of the 100 pounds and mixed for an additional five minutes in the 100 pound horizontal paddle mixer. The above procedure was repeated for adding an antibiotic or a combination of antibiotics to each 100 pounds of basal. A list of the antibiotics and the levels used are listed in Table 2.

All feed not immediately used was put into paper bags, labeled, and stored on the second floor of the feed building. Feed was added to the diet storage cans as each lot of chickens consumed 25 pounds. These amounts were recorded and at the end of each two week period the feed remaining in the storage cans was weighed back. This amount was then subtracted from the total weighed out to give the pounds consumed per lot. Feed efficiency or pounds of feed required per pound of gain was calculated for each lot of chicks at the end of each eight week experiment. A summary of feed conversion appears in Table 6.

Individual body weights were recorded for each two week period. At the end of the experiments weights were adjusted for sex. All female weights were adjusted to male weights by the following procedure: First of all the difference between the average weight of the females and the average weight of the males for each lot was calculated. These differences for all lots were added together and an over-all average was determined. This amount was then added to each female weight for the final adjustment. The average adjusted eight week weights for all lots are listed in Table 3.

At the end of each experiment, the chickens were taken to a commercial processing plant for slaughtering. The birds were scored for the hemorrhagic condition and graded as they came off the eviscerating line. Scoring was done by a university pathologist. Observations for the hemorrhages were made in the muscles of the inner thigh and were scored from 0 to 5 according to intensity. A record of the wing band number, hemorrhagic score, and carcass grade was kept for each bird. The average positive and average total hemorrhagic scores for each lot appear in Table 8.

Analysis of variance was run on eight week weights (adjusted for sex), feed conversion, and transformed hemorrhagic scores for each experiment. A pooled analysis of variance, including both experiments, was obtained also for each of the above criteria.

Multiple range tests were used to locate differences between treatments.

RESULTS

The analysis of variance techniques used are described by Snedecor (1956). The multiple range test is described by Duncan (1955). All Duncan's tests are at the .05 level of significance.

Experiment I

An analysis of variance was run on the adjusted eight week weights. This analysis indicated that diets were not significantly different. However, a partitioning of diets revealed a significant difference at the .05 level between no supplement versus supplement.

Under the conditions of this experiment, any antibiotic supplement significantly increased growth as compared to no supplement. A Duncan's test showed no significant difference among the supplemented groups.

There was no significant difference among treatments in pounds of feed required to produce a pound of gain as indicated by an analysis of variance. A comparison of the feed conversion values, however, indicated that Diet 1 (negative control) required more pounds of feed per pound of gain than those groups supplemented with antibiotics.

Statistical analysis of the data revealed a significant difference between the transformed individual hemorrhagic scores of the birds.[1] Both diets and replications were significant at the .01 level.

Partitioning of diets indicated a significant difference at the .01 level between single source versus combinations of antibiotics. In general, single source antibiotics caused increased hemorrhage; whereas, combinations of antibiotics gave decreased incidence of the hemorrhagic condition. The Duncan's test was used to locate the differences. Diets 3, 10, 4, and 9 were significantly higher than all other diets. Diets 8, 11, and 6 were significantly lower than all other diets, and Diets 6, 7, 1, 2, 5, 3, and 10 were not significantly different.

No explanation can be made for the significant difference between replications. Chicks in lots of replication 1 revealed a lowered incidence than those in replication 2.

Experiment II

An analysis of variance was run on the adjusted eight week weights using the same basis as for Experiment I. This analysis indicated a significant difference among diets at the .01 level. Partitioning of diets revealed a highly significant difference at the .01 level among the zinc bacitracin combinations.

Under the conditions of this experiment, combinations of antibiotics, which included zinc bacitracin, significantly increased growth when compared to other combinations. Location of the differences by a Duncan's test revealed Diet 7 (zinc bacitracin plus erythromycin) was superior in promoting growth to all other zinc bacitracin combinations. When all diets were

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[1] A $\sqrt{y + 1}$ transformation was used in order to adjust the data for statistical treatment.

compared by this method, Diet 7 was significantly different from Diets 2, 11, 1, 5, 3, 8, 6, and 4, but not significantly different from Diets 9 and 10.

Feed efficiency varied between the various antibiotics and in some cases varied between lots receiving the same antibiotic. An analysis of variance, however, showed no significant difference among treatments in pounds of feed required per pound of gain.

An analysis of variance was run on the transformed hemorrhagic scores of birds in Experiment II. This analysis revealed no significant difference between diets or between replications. A partitioning of diets, however, indicated a significant difference among the single source antibiotics at the .05 level.

The Duncan's test was used to locate the differences among the single source antibiotics. Diet 2 (zinc bacitracin) showed a significantly lower incidence of hemorrhage than Diets 3, 4, 5, and 10, but not significantly different than Diet 9. When all diets were compared by this method, Diet 2 was significantly different from Diets 11, 5, and 10. Diets 6, 9, 7, 1, 3, 8, and 4 were not significantly different.

Pooled Analysis

A pooled analysis of variance of Experiments I and II was run on the adjusted eight week weights. This analysis indicated that diets were significantly different at the .01 level. A partitioning of diets revealed a significant difference between no supplement versus supplement at the .05 level. A significant difference was noted also among combinations of antibiotics at the .01 level. The pooled analysis of variance is given in

Table 4.

The ranked diets in Table 5 show that Diet 7 (zinc bacitracin plus erythromycin) significantly increased growth when compared to all other supplements. Since Diet 1 (negative control) gave the least growth response, one may conclude, from the data, that any antibiotic supplement is better than no supplement at all.

Using a pooled analysis of variance, no significant difference was found among diets in pounds of feed required per pound of gain. This result was expected as neither experiment indicated significance when analyzed separately. The pooled analysis of variance is given in Table 7.

A pooled analysis of variance of transformed hemorrhagic scores for all birds in both experiments was run. This analysis indicated that diets were significantly different at the .05 level. Replications were found to be significant at the .01 level. A partitioning of diets showed single source antibiotics versus combinations of antibiotics to be significant at the .01 level. Among single sources was significant at the .05 level. The pooled analysis of variance is given in Table 9.

Results presented in Table 10 indicate that Diet 2 (zinc bacitracin) caused significantly less hemorrhage than other single source antibiotics. In general, zinc bacitracin or a combination of zinc bacitracin and other antibiotics caused less hemorrhage. The single source antibiotics, except for zinc bacitracin, caused an increase in the hemorrhagic condition as compared to the nonsupplemented basal controls.

The percent incidence of the hemorrhagic condition was used as another measure of hemorrhage. A summary of the percent incidence for all lots in both experiments is given in Table 11.

DISCUSSION

Results of two experiments, using antibiotics at levels of 10 grams per ton, indicated a beneficial effect on growth of broiler strain chicks. The use of single source or combinations of antibiotics resulted in increased growth when compared with the nonsupplemented basal control diet. These results are in agreement with the work of Stokstad and Jukes (1950), Berg and co-workers (1950a, b), Oleson and co-workers (1950), Whitehill and co-workers (1950), Kratzer and co-workers (1951), who found that aureomycin improved growth of chicks; Elam and co-workers (1951a, c), Heuser and Norris (1952), Runnels and co-workers (1951), Stern and McGinnis (1953), who noted improved growth from use of penicillin; and Dixon and Thayer (1951), Elam and co-workers (1951b), Waibel and co-workers (1952), who found increased growth when aureomycin or penicillin was used.

The results are also in agreement with the work of Elam and co-workers (1951c), who observed increased growth in chicks fed bacitracin; Moore and co-workers (1946), Davis and Briggs (1951), who found streptomycin led to increased growth responses; Lillie and Bird (1953), who noted neomycin showed evidence of growth stimulating effects; and Wiese and Petersen (1959), who found that erythromycin consistently resulted in increased chick growth when compared to the basal.

The results obtained are in contrast to the work reported by Scott and Glista (1950), who found that aureomycin did not improve the ability of a corn-soya ration to promote growth of chicks, and Lillie and Bird (1953), Monson and co-workers (1959), Wiese and Petersen (1959), who observed no beneficial effects on growth of chicks when various antibiotics were used.

It was found that only a combination of zinc bacitracin and erythromycin significantly increased growth over the nonsupplemented controls. Growth from additions of single source antibiotics and other combinations was not significantly greater than the controls; nevertheless, antibiotics did cause an improvement in growth. A combination of zinc bacitracin and erythromycin was significantly better than either of these antibiotics fed singly. This observation is not in agreement with the work of Matterson et al. (1952a), who found that combinations of antibiotics did not give growth responses significantly greater than those obtained by the same antibiotics when fed alone.

In some cases, variability in growth response was apparent for the same antibiotic when compared between the two experiments. This is in general agreement with the work of Davis and Briggs (1951), Heuser and Norris (1952), Burgess and co-workers (1953), and Waibel and co-workers (1954), who found antibiotics to have an inconsistent effect on growth of chicks.

There was no significant difference in feed efficiency when experiments were pooled. Results of Experiment I, however, indicated that birds fed antibiotics required fewer pounds of feed per pound of gain than birds fed no antibiotics. This agrees favorably with the work of Davis and Briggs (1951), Runnels and co-workers (1951), Machlin and co-workers (1952), Lindblad and co-workers (1954), Gard and co-workers (1958), who reported improved feed efficiency when diets were supplemented with an antibiotic. Heuser and Norris (1952) observed considerable variation in feed efficiency. The trend, however, showed that with antibiotics less feed was required to produce a pound of gain.

Results indicated crystalline zinc bacitracin caused significantly less hemorrhage than other single source antibiotics, and less hemorrhage than the nonsupplemented basal control. These results are not in agreement with the work of Dempsey and Sanford (1960), in which they found zinc bacitracin, as the crude feeding grade source, caused an increase in the hemorrhagic condition. These workers found, however, that crystalline forms of antibiotics caused significantly less hemorrhages than crude feeding grade antibiotics.

SUMMARY AND CONCLUSIONS

Two experiments were conducted in order to test the performance of broiler strain chicks fed low levels of single source and combinations of antibiotics. A total of 659 crossbred birds of the Peterson Cornish x Arbor Acres White Rock strain were used in the two experiments. The chicks were kept in electrically heated battery brooders with raised floors to four weeks of age. At four weeks they were transferred to unheated batteries. Body weights and feed consumption data were taken at two week intervals during the eight week period of the experiments.

The Kansas State University corn-soybean basal broiler ration was used as the control diet. Ten grams of single sources and combinations of antibiotics per ton of feed were added to the basal ration to provide 20 supplemented diets. The following antibiotics were used: crystalline zinc bacitracin, erythromycin, neomycin, streptomycin and crude penicillin and aureomycin.

There was a significant increase in growth of birds fed low levels of a combination of two antibiotics as compared to the control or any other antibiotic supplement.

Supplementing the basal ration with antibiotics resulted in no significant difference in pounds of feed required per pound of gain.

Feeding chicks zinc bacitracin, as a single source of antibiotic supplement, resulted in significantly less hemorrhage than other antibiotics fed singly. This antibiotic caused also less hemorrhage than the nonsupplemented basal control.

The following conclusions were drawn from the results of these experiments:

1. A combination of zinc bacitracin and erythromycin significantly increased growth.

2. Any single source or combinations of antibiotics increased growth as compared with the control.

3. There was no significant difference in feed efficiency by feeding 10 grams per ton of feed of a single source or combinations of antibiotics.

4. Mortality and abnormalities were found to be at a minimum.

5. Zinc bacitracin caused significantly less hemorrhage than other single source antibiotics.

6. Zinc bacitracin in combination with neomycin, streptomycin, or erythromycin and a combination of aureomycin and penicillin caused less hemorrhage than the control.

7. Feeding rations supplemented with penicillin, erythromycin, streptomycin, neomycin, and aureomycin, as single sources, resulted in an increase in the hemorrhagic condition as compared to the control.

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Generous quantities of the following materials were supplied: Aurofac 1.8-1.8 (aureomycin) by American Cyanamid Company, New York, New York; Pro Pen-50 (penicillin), Merck 58A (B-complex vitamin mix), and DL-methionine by Merck and Co., Inc., Rahway, New Jersey; zinc bacitracin, neomycin, erythromycin, streptomycin, vitamin B_{12}, and choline chloride by Commercial Solvents Corp., Terre Haute, Indiana; CCC-244 (trace mineral mix) by Calcium Carbonate Company, Quincy, Illinois; vitamins A and D_3 by NOPCO Chemical Company, Harrison, New Jersey. This research project was financed, in part, by a grant-in-aid from Commercial Solvents Corporation, Terre Haute, Indiana.

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APPENDIX

Table 1. Composition of the KSU soybean oil meal basal diet used in both experiments.

Ingredients	Quantity used per 100 pounds
Corn (yellow ground)	61.5 pounds
Alfalfa meal (dehydrated, 17% protein)	1.0
Wheat middlings	4.0
Soybean oil meal (solvent extract, 44% protein)	30.0
Calcium carbonate	1.0
Steamed bone meal	2.0
Sodium chloride (salt)	0.5
Total	100.0 pounds
Added per 100 pounds of ration	
CCC 244$^{(R)}$ (trace mineral mix)	23 grams
Vitamin A (10,000 U.S.P. per gm.)	20
Vitamin D_3 (3,000 I.C.U. per gm.)	10
Merck 58A$^{(R)}$ (B-complex vitamin mix)	46
D-L methionine (crystalline)	23
Proferm 12$^{(R)}$ (12 mg. vitamin B_{12} per lb.)	19
Choline Chloride (25%)	20

Table 2. The levels and kinds of antibiotics used in both experiments.

Diet	Lots	Antibiotics	Levels
1	1 & 7 KSU Basal	+ None	None
2.	2 & 8 KSU Basal	+ Cryst. zinc bacitracin	10 gms/ton
3	3 & 9 KSU Basal	+ Cryst. erythromycin	10
4	4 & 10 KSU Basal	+ Cryst. neomycin	10
5	5 & 11 KSU Basal	+ Cryst. streptomycin	10
6	6 & 12 KSU Basal	+ Cryst. zinc bacitracin + Cryst. streptomycin	5 5
7	13 & 18 KSU Basal	+ Cryst. zinc bacitracin + Cryst. erythromycin	5 5
8	14 & 19 KSU Basal	+ Cryst. zinc bacitracin + Cryst. neomycin	5 5
9	15 & 20 KSU Basal	+ Crude penicillin	10
10	16 & 21 KSU Basal	+ Crude aureomycin	10
11	17 & 22 KSU Basal	+ Crude penicillin + Crude aureomycin	5 5

Table 3. Average eight week weights for all lots in both experiments (adjusted for sex).

Diet	Lot No.	Experiment I weight in gms.	Experiment II weight in gms.
1	1	1362	1418
	7	1392	1332
2	2	1426	1374
	8	1373	1371
3	3	1451	1374
	9	1438	1387
4	4	1459	1427
	10	1449	1367
5	5	1372	1404
	11	1469	1355
6	6	1430	1412
	12	1393	1412
7	13	1428	1473
	18	1510	1514
8	14	1510	1393
	19	1431	1371
9	15	1398	1434
	20	1422	1430
10	16	1435	1431
	21	1361	1431
11	17	1448	1384
	22	1394	1365

Table 4. Pooled analysis of variance of eight week weight in grams (adjusted for sex).

Source of variation	Degrees of freedom	Mean square	F-ratio
Replications (within experiments)	2	23,296	1.56^{ns}
Diets	10	46,487	3.11**
No supplement vs. supplement	1	91,319	6.10*
Single vs. combination	1	40,401	2.70^{ns}
Among other comparisons	8	41,644	2.78**
Among singles	5	12,960	.87^{ns}
Among combinations	3	89,450	5.98**
Bacitracin combinations vs. aureomycin + penicillin	1	68,367	4.57**
Among bacitracin combinationss	2	99,992	6.68**
Diets x Experiments	10	23,972	1.60^{ns}
Reps x Diets (within experiments)	20	18,648	1.25^{ns}
Within	615	14,962	

^{ns}Nonsignificant
**Significant P<.01
*Significant P<.05

Table 5. Ranked diets based on Duncan's (1955) method.[1] Diets ranked from low to high for pooled eight week weight in grams (adjusted for sex).

Diets										
1	2	11	5	6	3	10	9	4	8	7
1376.0	1386.0	1397.8	1399.5	1400.0	1412.8	1414.5	1421.0	1425.5	1426.3	1481.3

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[1] Any two diets not underscored by the same line are significantly different, and any two diets underscored by the same line are not significantly different.

Table 6. Summary of feed conversion for all lots in both experiments.

Diet	Lot No.	Experiment I Lbs. feed per lb. gain	Experiment II Lbs. feed per lb. gain
1	1	2.39	2.45
	7	2.56	2.58
2	2	2.35	2.35
	8	2.44	2.39
3	3	2.20	2.42
	9	2.53	2.36
4	4	2.43	2.36
	10	2.37	2.38
5	5	2.47	2.45
	11	2.36	2.58
6	6	2.35	2.41
	12	2.34	2.39
7	13	2.35	2.26
	18	2.41	2.43
8	14	2.22	2.47
	19	2.40	2.66
9	15	2.29	2.37
	20	2.46	2.24
10	16	2.45	2.47
	21	2.43	2.67
11	17	2.34	2.42
	22	2.31	2.33

Table 7. Pooled analysis of variance of feed conversion.

Source of variation	Degrees of freedom	Mean square	F-ratio
Among Diets	10	.01380	1.53^{ns}
No supplement vs. supplement	1	.03440	3.81^{ns}
Single vs. combination	1	.00780	$.86^{ns}$
Among other comparisons	8	.01198	1.33^{ns}
Among singles	5	.01550	1.71^{ns}
Among combinations	3	.00610	$.67^{ns}$
Bacitracin combinations vs. aureomycin + penicillin	1	.00500	$.55^{ns}$
Among bacitracin combinations	2	.00665	$.74^{ns}$
Diets x Experiments	10	.00851	$.94^{ns}$
Within	22	.00904	

^{ns}Nonsignificant

Table 8. Average positive and average total hemorrhagic scores for each lot in both experiments.

Diet	Lot No.	Experiment I		Experiment II	
		Av. Positive	Av. Total	Av. Positive	Av. Total
1	1	.3	1.0	1.1	1.9
	7	1.6	2.2	1.5	2.8
2	2	.7	1.4	.8	1.7
	8	1.2	1.8	.5	1.3
3	3	.5	1.8	1.3	1.7
	9	2.1	2.1	1.3	2.1
4	4	1.2	2.0	1.3	2.0
	10	1.5	2.1	1.4	1.9
5	5	.7	1.8	2.0	2.0
	11	1.3	2.2	1.3	2.5
6	6	.5	2.0	.7	1.4
	12	1.0	1.9	1.5	2.6
7	13	.7	2.8	1.3	1.7
	18	1.1	2.1	1.1	1.8
8	14	.1	1.0	1.6	2.2
	19	.9	1.8	1.4	1.7
9	15	.9	1.8	.9	1.3
	20	1.8	2.7	1.5	2.2
10	16	1.1	2.0	2.0	2.7
	21	1.5	1.7	1.5	2.0
11	17	.3	1.7	1.5	2.3
	22	1.1	2.0	1.5	1.8

Table 9. Pooled analysis of variance of transformed hemorrhagic scores.

Source of variation	Degrees of freedom	Mean square	F-ratio
Replications (within experiments)	2	2.48	17.71**
Diets	10	.31	2.21*
No supplement vs. supplement	1	.03	$.21^{ns}$
Single vs. combination	1	1.19	8.50**
Among other comparisons	8	.23	1.64^{ns}
Among singles	5	.34	2.43*
Among combinations	3	.04	$.29^{ns}$
Bacitracin combinations vs. aureomycin + penicillin	1	.07	$.50^{ns}$
Among bacitracin combinations	2	.03	$.21^{ns}$
Diets x Experiments	10	.25	1.79^{ns}
Reps x Diets (within experiments)	20	.15	1.07^{ns}
Within	615	.14	

**Significant $P < .01$
*Significant $P < .05$
^{ns}Nonsignificant

Table 10. Ranked diets based on Duncan's op. cit. method. Diets ranked from low to high for pooled average transformed hemorrhagic scores.

Among singles					
2	9	3	5	4	10
1.305	1.458	1.460	1.475	1.485	1.528

Table 11. Percent incidence of hemorrhagic condition for each lot in both experiments.

Diet	Lot No.	Experiment I	Experiment II
1	1	30.8	60.0
	7	73.3	53.3
2	2	53.3	46.7
	8	66.6	40.0
3	3	26.7	80.0
	9	100.0	60.0
4	4	60.0	66.6
	10	73.3	73.3
5	5	40.0	100.0
	11	60.0	53.3
6	6	26.7	50.0
	12	53.3	60.0
7	13	26.7	80.0
	18	53.3	60.0
8	14	13.3	73.3
	19	53.3	78.6
9	15	53.3	66.6
	20	66.6	66.6
10	16	53.3	73.3
	21	86.7	73.3
11	17	20.0	66.6
	22	53.3	80.0

A COMPARISON OF THE PERFORMANCE OF BROILER STRAIN CHICKS FED SINGLE SOURCE AND COMBINATIONS OF ANTIBIOTICS

by

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B.S., Kansas State University, 1959

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Two replicate experiments were conducted to study the effect of feeding various low levels of single antibiotics or combinations of antibiotics on the performance of broiler strain chicks.

A total of 659 crossbred chicks of the Peterson Cornish x Arbor Acres White Rock strain were used in the two experiments. They were reared in batteries under normal poultry husbandry practices. The Kansas State University corn-soybean basal broiler ration was used as the control diet. All feed was mixed at the university poultry farm, at intervals of approximately two weeks to ensure freshness. The single source or combination of antibiotics were supplemented at a level of 10 grams per ton of feed in the following manner: crystalline zinc bacitracin, erythromycin, neomycin, and streptomycin as single sources; equal parts by weight of zinc bacitracin combined with erythromycin, zinc bacitracin combined with neomycin, and zinc bacitracin in combination with streptomycin; crude feeding grades of penicillin and aureomycin as single sources; and equal amounts of penicillin and aureomycin fed in combination.

Body weights and feed consumption data were taken at two week intervals. The experiments were conducted for a period of eight weeks each. At the end of each experiment the birds were taken to a commercial processing plant for slaughtering. They were scored for hemorrhagic intensity in the muscles of the inner thigh. These scores were then transformed and used in a statistical analysis.

Conclusions based on pooled data indicate growth was significantly increased by a combination of zinc bacitracin and erythromycin. Any single source or combinations of antibiotics increased growth as compared with the control.

Feeding 10 grams per ton of feed of a single source or combinations of antibiotics had no significant effect on feed efficiency.

Mortality and abnormalities were found to be at a minimum whether antibiotics were used or not.

Zinc bacitracin was found to cause significantly less hemorrhage than other single source antibiotics.