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An experimental investigation of bacitracinpenicillin synergism on the early growth of turkeys

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AN EXPERIMENTAL INVESTIGATION OF BACITRACIN-PENICILLIN SYNERGISM ON THE EARLY GROWTH OF TURKEYS

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CHAPTER I

THE PROBLEM AND DEFINITION OF TERMS

A completely new concept in the field of poultry nutrition has been developed within the span of the past three years. This concept concerns the addition of minimal amounts of certain antibiotics to poultry feeds to improve feed utilization and to produce faster and more economical gains in weight. Supplementing poultry rations with antibiotics--the same "wonder drugs" which have been so effective in controlling some of man's diseases--was discovered as a rather startling outgrowth of vitamin feeding experiments on laboratory animals.

In the recent past, most antibiotic feed supplements have consisted of a single antibiotic, such as penicillin or bacitracin, blended with a suitable inert diluent. The question naturally arose as to whether a combination of two antibiotics would yield superior results over those results obtained by using either antibiotic singly. If superior results were obtained under these conditions, it would be indicative that the two antibiotics were re-enforcing each other. Such a re-enforcing action is termed synergism if the total effect is greater than the sum of the two effects taken independently. The present experimental investigation is concerned with the elucidation of the possible existence

of a bacitracin-penicillin synergism as it affects the growth of turkeys during the first forty-four days of life.

I. THE PROBLEM

Statement of the problem. It was the purpose of this investigation to: (1) compare the weight gains of birds resulting from the use of the antibiotics bacitracin and penicillin as single feed supplements against the weight gains obtained by using mixtures of these antibiotics; (2) compare, under these conditions, the resulting feed efficiency data, that is, the amount of feed required to produce a unit increase in body weight; (3) determine if a relationship existed between the increased growth rate and the corresponding feed efficiency; and (4) determine the degree, if any, to which antibiotic synergism exists under these experimental conditions.

Importance of the study. The production and subsequent sale of antibiotic feed supplements has become a highly competitive business. It has been the practice of most progressive manufacturers of feed supplements to evaluate and compare the antibiotics that show some promise of being useful as the active ingredients for new supplement products. New antibiotics and antibiotic combinations are being studied for this purpose. Research of this type

benefits the "man on the street" by reducing the production costs and by increasing the supply of meat--a food rich in protein--for the betterment of the national diet.

II. DEFINITION OF TERMS

Antibiotics. Drugs, such as penicillin, bacitracin, terramycin, aureomycin, and streptomycin, are known as antibiotics. They are produced by pure culture fermentations of liquid media and are capable of retarding or neutralizing the growth of certain pathogenic organisms.

Antibiotic feed supplements. As used in this paper, the term antibiotic feed supplement denotes an antibiotic mixed with extenders or diluents, to be added to poultry rations. The final mixed ration may not contain less than one nor more than fifty grams of the antibiotic per ton of feed.[1]

Poult growth. The growth of birds used for this investigation was evaluated by only one type of measurement, that is, the increase in weight of the bird, and does not imply any other type of growth measurement, such as feather development, increase in height or other lineal body

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[1] Official Publication of the Association of Feed Control Officials, 1950. College Park, Maryland; 1950.

measures except as they affected increases in weight. The term poult was used here to signify a turkey during the early stages of growth.

Experimental lot. An experimental lot was a separate test group of ten male poults which received water and one of the variously supplemented rations ad libitum throughout the course of the investigation. Each lot was segregated from the other lots on test by physical means.

Feed Efficiency. The terms feed efficiency or feed utilization are used to denote a ratio of the feed, actually eaten by the birds of any one experimental lot, which was required to produce a unit gain in poult weight over the initial weight. This is expressed as grams of feed per gram of gain and is numerically equal to pounds of feed per pound of gain.

Rations. The basal poult ration used in this investigation was a balanced feed containing adequate amounts of nutrients, vitamins, and minerals. The basal ration, as such, contained no added antibiotic feed supplements. This basal ration was fed to the control lot and is referred to as "none" under the supplement headings in the tables. All other experimental rations were supplemented rations and were prepared by mixing antibiotics with the

basal ration. The supplemented rations are referred to by the name of the added antibiotic(s) in the tables.

Sex of birds. Experimental results of poultry growth have indicated that sex was an important factor in determining rate of weight gain. Only male poults, as determined by a competent professional sexor, were used in this investigation. This division of sexes is made on the basis of a primary sex characteristic--vent aspect. If this division is made during the first seventy-two hours after hatching, an accuracy of 95 to 99 per cent will result. The appearance of some secondary sex characteristics during the fourth week of life was not used to determine sex because this latter method is only about 80 per cent accurate.

Synergism. As previously defined, the "co-operative action of discrete agencies such that the total effect is greater than the sum of the two effects taken independently, as in the action of the mixtures of certain drugs."[2]

III. ORGANIZATION OF REMAINING MATERIAL

A review of the literature, pertaining to the uses of antibiotics in poultry feeds and the existence of an

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[2] Webster's Collegiate Dictionary, Fifth Edition, Springfield, Mass. 1942.

antibiotic synergism between penicillin and bacitracin, is presented in Chapter II. A discussion of the basal ration, ration supplements, poults, equipment, and methods employed in this investigation are presented in Chapter III. A summary of the data and the statistical treatment of the results by tests of significance and correlation coefficients are presented in Chapter IV. A summary of the conditions of the experimental investigation and the final conclusions based on the results are reviewed in Chapter V. The basic weight data for each of the twenty experimental lots have been placed in the Appendix.

CHAPTER II

REVIEW OF THE LITERATURE

Much has been published on the use of antibiotics as growth factors in animal rations. A brief summary of certain selected investigations closely related in part to the present problem will be presented. Only two works exist in regard to laboratory studies of bacitracin-penicillin synergism. Neither of the latter is concerned with antibiotics as growth factors, being studies of the curative doses of the drugs against infectious organisms.

I. ANTIBIOTICS AS GROWTH FACTORS

Streptomycin. In a study, in the year 1946, involving the use of sulfasuxidine, streptothricin, and streptomycin, Moore et al[1] noted increased growth as the result of feeding streptomycin to chicks. This appears to be the first report of a growth stimulating action due to feeding an antibiotic.

Aureomycin. The practical application of using antibiotics as dietary growth stimulators was not fully

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[1] P. R. Moore, A. Evenson, T. D. Luckey, E. McCoy, C. A. Elvehjem, and E. B. Hart, "Use of Sulfasuxidine, Streptothricin, and Streptomycin in Nutritional Studies with the Chick," Journal of Biological Chemistry, 165:439, 1946.

appreciated, however, until early in the year 1950, when a paper was presented by Stokstad[2] at a national scientific meeting. The announcement came as a surprise because the meeting abstract made no mention of this seemingly new advance in nutrition.

The formal report published later that year by Stokstad and Jukes[3] concluded that (1) fermentation products of Streptomyces aureofaciens promoted growth of chicks fed rations adequately supplied with Vitamin B_{12}; (2) growth responses in chicks on a corn-soya type ration were produced by crystalline aureomycin hydrochloride; and (3) responses were also obtained with streptomycin, but that antibiotic appeared to be less potent than aureomycin. The possibility that the growth produced by aureomycin was related to its antibiotic activity was raised by these experiments. Numerous experiments by other investigators, such as the one by Whitehall et al,[4] verified the initial work. Streptomycin and aureomycin were also used as

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[2] E. L. R. Stokstad and T. H. Jukes, "Vitamin B_{12} and Some of Its Interrelationships," Abstracts of Papers, 117th Meeting, American Chemical Society, April, 1950, p. 12A.

[3] E. L. R. Stokstad and T. H. Jukes, "Further Observations on the Animal Protein Factor," Proceedings of the Society for Experimental Biology and Medicine, 73:523, 1950.

[4] A. R. Whitehall, J. J. Oleson and B. L. Hutchings, "Stimulatory Effect of Aureomycin on the Growth of Chicks," Proceedings of the Society for Experimental Biology and Medicine, 74:11, 1950.

antibiotic feed supplements in animal rations through the work of Leucke et al,[5] Jukes et al,[6] and Carpenter.[7]

Bacitracin, penicillin, and terramycin. A comprehensive comparison of five antibiotics, each fed singly at a concentration of nine grams per ton of ration to chicks, was reported by Matterson and Singsen.[8] Results at eight weeks of age indicated that: (1) streptomycin was the least effective antibiotic of those tested, in promoting growth responses; (2) penicillin and bacitracin appeared to act differently from the other antibiotics tested, in that these two supplements maintained a greater growth response over a longer period of time; and (3) bacitracin gave the greatest growth response, followed by penicillin, aureomycin,

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[5] R. W. Leucke, W. N. McMillan, and F. Thorpe, Jr., "Effect of Vitamin B_{12}, Animal Protein Factor, and Streptomycin on the Growth of Young Pigs," Archives of Biochemistry, 26:326, 1950.

[6] T. H. Jukes, E. R. L. Stokstad, R. R. Taylor, T. J. Cunha, H. M. Edwards and G. B. Meadows, "Growth-Promoting Effect of Aureomycin on Pigs," Archives of Biochemistry, 26:327, 1950.

[7] L. E. Carpenter, "Effect of Aureomycin on the Growth of Weaned Pigs," Archives of Biochemistry, 27:459, 1950.

[8] L. D. Matterson and E. P. Singsen, "A Comparison of Several Antibiotics as Growth Stimulants in Practical Chick-Starting Rations," Storrs Agricultural Experiment Station Bulletin, University of Connecticut College of Agriculture, Storrs, Conn., 275:18, March, 1951.

terramycin, streptomycin, and the basal ration, in that order.

Bentley[9] reported in late 1951 that bacitracin, procaine penicillin, aureomycin, and terramycin fed at concentrations of twenty grams of antibiotic per ton produced increased growth responses over the basal ration. Therefore, it has been generally established that antibiotics may act as growth factors in chick rations.

II. BACITRACIN-PENICILLIN SYNERGISM

Synergism in laboratory animals. Synergism in drugs represents a phenomenon in which two drugs re-enforce each other's curative action, but true synergism is rare even in medicine. The first instance in which synergism between antibiotics was demonstrated was reported by Eagle and Fleischman.[10] They administered bacitracin, penicillin, and mixtures of the two drugs to rabbits infected with experimentally induced syphilis. Approximately 1/40th of the minimum curative dose of penicillin mixed with

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[9] O. G. Bentley, "Some Factors That Influence the Response to Vitamin B_{12} and Antibiotics," Proceedings, Ohio Animal Nutrition Conference, Columbus, Ohio November, 1951, p. 44.

[10] H. Eagle and R. Fleischman, "Therapeutic Activity of Bacitracin in Rabbit Syphilis, and Its Synergistic Action with Penicillin," Proceedings of the Society for Experimental Biology and Medicine, 68:415, June, 1948.

1/7th of the minimum curative dose of bacitracin produced effective cures of this infection. This in vivo study fulfilled the requirement of the definition of true synergism.

Synergism in laboratory cultures. Bachman[11] studied the in vitro effect of mixtures of bacitracin and penicillin on eighteen strains of streptococci. He concluded that a synergistic effect was exerted on the cultures of the test organisms, although the degree of synergism varied from strain to strain.

The present investigation was a natural extension of these two discoveries: (1) antibiotic growth factors and (2) antibiotic synergism.

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[11] M. C. Bachman, "In Vitro Studies on Possible Synergistic Action Between Penicillin and Bacitracin," Journal of Clinical Investigation, 28:865, September, 1949.

CHAPTER III

RATIONS, METHODS, AND EQUIPMENT

The material presented in this chapter will acquaint the reader with the methods and techniques of conducting this investigation, and the writer has attempted to detail the precise steps and equipment used in the feeding experiment.

I. MIXING THE BASAL RATION

Standard ration ingredients. In any animal feeding experiment, the preparation of the feeds to be evaluated is one of the most important single aspects. The basal ration was well balanced with respect to carbohydrate, protein, fat, fiber, vitamins, and minerals.[1] The basal ration formulated for the experiment is presented in Table I. This corn-soya ration contained sufficient fish meal to provide the Vitamin B_{12} requirement[2] of the poults. Meat and bone scraps, dried buttermilk, and corn distillers solubles were also added. Most of the ingredients in the ration were standard feedstuffs produced by many manu-

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[1] C. H. Hubbell, "1950 Feedstuffs Analysis Table," Feedstuffs, February 25, 1950.

[2] National Research Council, Recommended Nutrient Allowances for Domestic Animals, Number I, Recommended Nutrient Allowances for Poultry, March, 1950, p. 11.

TABLE I

CONTENTS OF THE POULT BASAL RATION BY INGREDIENTS IN POUNDS PER TON AND GRAMS PER TON

Ingredients forming mixed basal ration	Pounds per ton of ration	Grams per ton of ration
Ground yellow corn	631	
Soybean oil meal	500	
Mendaden fish meal	200	
Standard wheat middlings	100	
Ground feed oats	100	
Standard wheat bran	100	
Dehydrated alfalfa meal	100	
Meat and bone scraps	100	
Dried buttermilk	50	
Corn distillers solubles	50	
Steamed bone meal	30	
Pulverized limestone	20	
Iodized salt	10	
Choline Supplement 25	4	
Viadex	4	
B•Y-21	1	
Feed grade manganese sulfate		287
Niacin		22.7
Calcium pantothenate		4.5
Totals	2000	314.2

facturers.

Special-type ingredients. Three special-type ingredients were used in the ration, and each is produced by an individual manufacturer. These ingredients were selected because: (1) they possessed desirable mixing properties and/or (2) they were the most economical source of the desired ingredient.

The dry choline source, Choline Supplement 25,[3] illustrates the first point, in that its use avoided the difficulties involved in mixing a liquid into feed without resorting to special spray mixing equipment.

The riboflavin source, B·Y-21^{R},[4] illustrates the second point because it was an economical form of Vitamin B_2. A further advantage was that the volume of diluent included was a nutritionally effective source of some unidentified growth factors and also made accurate measurement and blending easier.

The Vitamin A and D requirements for the basal

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[3] A dry supplement containing 98,415 milligrams of choline chloride per pound on a hominy feed base, manufactured by the Agricultural Division of Commercial Solvents Corporation, at the Peoria, Illinois plant.

[4] A source of riboflavin from dried grain and skimmed milk fermentation solubles, and containing 3,630 milligrams of riboflavin per pound (8,000 micrograms per gram), manufactured by the Agricultural Division of Commercial Solvents Corporation, at the Terre Haute, Indiana plant.

ration were met by using Micratized Viadex^{R},[5] a supplement coated with microcrystalline wax. This stable and easily mixed product was available in the correct Vitamin A and D ratio. The foul odors from the fish oil used in its manufacture were effectively masked.

Mixing the basal ration. The manganese sulfate, niacin, and calcium pantothenate were distributed within a small quantity of the choline supplement in a Waring laboratory blender. This first premix was added to the B·Y-21, the Viadex, and the remainder of the choline supplement and mixed in a Patterson-Kelley twin shell laboratory mixer. The second mixture was placed in a McClellan twin cone tumble mixer with all of the minerals and about fifty pounds of the ground corn. Finally, this third and last premix was mixed in a one ton capacity Kelly-Duplex vertical screw mixer with the balance of the ration ingredients. The object of this step-wise mixing process was to insure that a lower mixing ratio was being used which resulted in a more uniform distribution of the

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[5] A dry source of Vitamins A and D_3 containing Vitamin A and D Feeding Oil (a blend of Fish Liver Oil and D-Activated Animal Sterol); Wheat Germ Oil Meal; Soybean Oil Meal; and Microcrystalline Wax. The Vitamin A potency is guaranteed to be not less than 1,814,400 U. S. P. units (544 milligrams) per pound (4,000 units per gram). The guaranteed potency of the Vitamin D is not less than 453,600 A. O. A. C. units per pound (1,000 units per gram). Viadex is manufactured by the Nopco Chemical Company, Harrison, New Jersey.

ingredients within any particular sample of the final basal ration.

II. MIXING THE SUPPLEMENTED RATIONS

According to the information available before starting the experiment, one gram of penicillin was about equal to five grams of bacitracin in producing an antibiotic growth response in poultry. This ratio was accepted for this investigation although the relationship probably varies, to some extent, between experiments conducted under the same conditions.

Bacitracin supplemented rations. Baciferm^{R}-5 Antibiotic Feed Supplement[6] is a dried fermentation product obtained by culturing Bacillus subtillis, Tracy strain, on a media adapted for the microbiological production of bacitracin. The supplement contains the equivalent of five grams of bacitracin (master standard) per pound. The feed for seven lots for the experiment were supplemented with bacitracin by mixing graded amounts of Baciferm-5 with the basal ration. Initially, forty pounds of supplemented ration was prepared for each experimental lot and the concentrations of the Baciferm-5 in these rations were 0.5,

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[6] Manufactured by the Agricultural Division of Commercial Solvents Corporation at the Peoria, Illinois, plant.

0.75, 1.0, 1.25, 1.5, 2.0, and 4.0 pounds per ton of final supplemented ration.

Penicillin supplemented rations. Seven additional forty pound ration mixtures were initially prepared for the experiment by mixing graded amounts of Compenamine^{R},[7] the l-ephenamine salt of penicillin G, with the basal ration. The concentrations of Compenamine in these rations were 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, and 4.0 grams per ton.

Bacitracin-penicillin supplemented rations. Five forty pound ration mixtures were prepared for the experiment by mixing graded amounts of both Baciferm-5 and Compenamine with the basal ration. The concentrations of the Baciferm-5 and Compenamine, respectively, in these ration mixtures were 0.5, 1.5; 0.75, 1.25; 1.0, 1.0; 1.25, 0.75; and 1.5, 0.5 pounds and grams per ton of final supplemented ration. As previously mentioned, one lot of the experiment was fed the basal ration and served as a control lot.

III. BROODING EQUIPMENT

Every attempt was made to equalize the environmental conditions in which the experiment was conducted. The

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[7] Manufactured by the Pharmaceutical Division of Commercial Solvents Corporation at Terre Haute, Indiana.

brooding equipment consisted of twenty electrically heated, thermostatically controlled Oakes 801A Experimental Brooders. Brooder heat was kept at near body temperature for the first fourteen days of the experiment. Each brooder was equipped with two feed troughs, one water trough, a wire screen floor, and a sheet metal dropping pan. As shown in the photograph (Figure I), the brooders were placed one above the other, five per tier, in each brooder rack. The four racks of brooders were housed in an air conditioned brooder room maintained at 75 degrees Fahrenheit.

IV. WEIGHING THE POULTS

Initial weighing and banding. The group of 204 commercially hatched Broad Breasted Bronze male turkeys were received the morning following hatching and sexing. Each poult was given a visual inspection on the scale platform and the four extra poults were culled out at that time. Poults which are very small, very large, weak, sick, crossbilled, or otherwise malformed are not desirable for use in feeding experiments. The remaining 200 poults were individually weighed to a precision of one gram and banded with a numbered metal wing tag. A frequency distribution is presented in Table II based on the record of initial weights and band numbers. Each "x" indicates one poult of a given weight, and a casual examination of the Table

FIGURE 1

EQUIPMENT USED IN THE FEEDING EXPERIMENT

TABLE II

FREQUENCY DISTRIBUTION OF INITIAL MALE POULT WEIGHTS IN GRAMS

Initial weight	Number of birds	Visual representation of the frequency distribution
46	2	x x
47	0	
48	10	x x x x x x x x x x
49	4	x x x x
50	12	x x x x x x x x x x x x
51	12	x x x x x x x x x x x x
52	14	x x x x x x x x x x x x x x
53	16	x x x x x x x x x x x x x x x
54	18	x x x x x x x x x x x x x x x x x x
55	13	x x x x x x x x x x x x x
56	10	x x x x x x x x x x
57	15	x x x x x x x x x x x x x x x
58	13	x x x x x x x x x x x x x
59	12	x x x x x x x x x x x x
60	4	x x x x
61	10	x x x x x x x x x x
62	6	x x x x x x
63	5	x x x x x
64	5	x x x x x
65	5	x x x x x
66	2	x x
67	4	x x x x
68	5	x x x x x
69	0	
70	0	
71	1	x
72	0	
73	1	x
74	0	
75	0	
76	1	x
Total	200	

indicates that the frequency distribution approximated a normal bell-shaped curve.

Distribution into lots. The 200 male poults were distributed into twenty lots of 10 birds each by using this frequency distribution. The 76 gram poult at the bottom of the Table was placed in Lot 1, the 73 gram poult in Lot 2, the 71 gram poult in Lot 3, and one each of the five 68 gram poults in Lots 4 through 8. In this manner one poult was placed in each lot from Lot 1 through Lot 20, then Lot 20 through Lot 1, Lot 1 through Lot 20, until the two 46 gram poults at the top of the Table were finally distributed in Lots 2 and 1. The range of initial weights represented in each lot is not constant because it decreased from Lot 1 to Lot 20, but the average poult weights within the lots are as constant as the distribution will permit.

Periodic weighings. The poults were individually weighed on the fourteenth, twenty-eighth, and the forty-fourth day after the initial weighing. The remaining feed supply including that in the feeders was weighed at those periods and recorded for each lot of poults. The amount of spilled feed along the sides of the dropping pans was estimated and recorded as wasted feed. After the weighing at the twenty-eighth day, an additional fifty pounds of ration was prepared for each lot as previously

described. The basic weight data for the experiment are presented in the tables in the Appendix.

CHAPTER IV

STATISTICAL TREATMENT OF RESULTS

Differences in the physical condition of the birds and some environmental conditions, beyond control, caused variation in the data from the ideal. It is not necessary, however, to experiment exhaustively in order to obtain perfect data. The writer's chief interest was to determine the trends and general relationships in regard to poult weights and feed utilization ratios.

I. POULT WEIGHT DATA

Average poult weights. A summary of the average poult weights, from the Basic Data Tables in the Appendix, is presented in Table III. It should be noted that the average weights on the first day were nearly equal. By the fourteenth day the effect of the supplements on the weight of the poults was already apparent. In general, the average weights increased as the concentration of the antibiotic supplement in the ration was increased. The two largest average weights on the fourteenth day were for lots receiving a combination of bacitracin and penicillin. The average weights on the twenty-eighth and forty-fourth day further reflect the direct relationship between poult weight and antibiotic concentration in

TABLE III

AVERAGE POULT WEIGHT DATA, IN GRAMS, FOR THE FIRST, FOURTEENTH, TWENTY-EIGHTH, AND FORTY-FOURTH DAY OF THE FEEDING EXPERIMENT

Lot No.	Ration Supplements/Ton				Average Poult Weights (Grams)			
	Compenamine (penicillin)		Baciferm-5 (bacitracin)		1st Day	14th Day	28th Day	44th Day
1	None				57	247	604	1339
2	0.5	grams			57	285*	678	1475
3	0.75	"			57	286**	735**	1607**
4	1.0	"			56	286**	720*	1574*
5	1.25	"			56	270	641	1459
18	1.5	"			56	272	713*	1638**
19	2.0	"			56	271	705*	1603**
20	4.0	"			56	287**	703**	1691***
6	0.5	"	+	1.5 pounds	56	283*	671	1476
7	0.75	"	+	1.25 "	56	285*	729*	1588*
8	1.0	"	+	1.0 "	56	291*	721*	1616**
9	1.25	"	+	0.75 "	56	294**	729**	1627**
10	1.5	"	+	0.5 "	56	281**	727**	1634**
11				0.5 "	56	261	668	1519*
12				0.75 "	56	267	675	1609**
13				1.0 "	56	263	664	1482
14				1.25 "	56	270	688*	1488
15				1.5 "	56	269	703*	1500
16				2.0 "	56	256	662	1448
17				4.0 "	56	255	684	1559*

* Significantly above Lot 1 (95% confidence level)
** Highly significant (99% confidence level)
*** Very highly significant (99.9% confidence level)

the ration, although discrepancies appeared.

Tests for significance. A statistical analysis of the average poult weights was made by student's "t" tests.[1] The data obtained for a lot fed a supplemented ration were compared to the data obtained for the lot fed the basal ration. Fifty-seven individual comparisons were made between the data of these "treated lots" and the "control lot" over the three weighing periods and the results are indicated by asterisks in Table III.

Briefly, this analysis consisted of the following sequence of operations: (1) determining the total squared deviation of the weight of each poult in a treated lot from the average weight of that lot, plus a similar total squared deviation for the control lot; (2) multiplying this summation by the total number of birds in the two lots compared; (3) dividing the previous result by the number of degrees of freedom (two less than the total number of poults in the two lots); (4) dividing that result by the product of the number of poults in each of the two lots and extracting the square root of the quotient; (5) dividing this root into the difference between the treated average weight and the control average weight to obtain "t"; and (6) entering a special

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[1] G. W. Snedecor, Statistical Methods (fourth edition; Ames, Iowa: Iowa State College Press, 1950), p. 81.

table with "t" and the degrees of freedom to determine the probability that the difference in average weights was a non-chance difference.

Gains due to supplements. Any increase in average poult weights, above that weight indicated for the birds fed the basal ration, is assumed to be a direct effect due to the antibiotic supplements in the rations. The data in Table IV indicate the gains due to the supplements and was computed by finding the difference between the average weights of the treated lots and the control lot.

In order to determine the degree of antibiotic synergism produced, if any, as indicated by these gains, the sum of the observed gains for a Compenamine lot and the corresponding Baciferm-5 lot is compared to the observed gains for the lot fed that particular combination of concentrations. These observed and calculated average poult weight gains are presented in Table V. Synergism was indicated in only two out of fifteen cases and, therefore, was not generally operative in this feeding investigation.

II. FEED EFFICIENCY DATA

Calculation of feed efficiencies. Supplemented rations were mixed for each lot at two different times during the feeding experiment. A record of the amounts of

TABLE IV

AVERAGE POULT WEIGHT GAINS, IN GRAMS, DUE TO THE PENICILLIN, BACITRACIN, AND PENICILLIN-BACITRACIN COMBINATION RATION SUPPLEMENTS

Lot No.	Ration Supplements/Ton				Gains Above Control Lot		
	Compenamine (penicillin)			Baciferm-5 (bacitracin)	14th Day	28th Day	44th Day
1	None				0	0	0
2	0.5	grams			38	74	136
3	0.75	"			39	131	268
4	1.0	"			39	116	235
5	1.25	"			23	37	120
18	1.5	"			25	109	299
19	2.0	"			24	101	264
20	4.0	"			40	99	352
6	0.5	"	+	1.5 pounds	34	67	137
7	0.75	"	+	1.25 "	36	125	249
8	1.0	"	+	1.0 "	44	117	277
9	1.25	"	+	0.75 "	47	125	288
10	1.5	"	+	0.5 "	34	123	295
11				0.5 "	14	64	180
12				0.75 "	20	71	270
13				1.0 "	16	60	143
14				1.25 "	23	84	149
15				1.5 "	22	99	161
16				2.0 "	9	58	109
17				4.0 "	8	80	220

TABLE V

SUMMATION OF THE AVERAGE POULT WEIGHT GAINS, IN GRAMS, DUE TO THE PENICILLIN, BACITRACIN, AND PENICILLIN-BACITRACIN COMBINATION RATION SUPPLEMENTS

Observed and Calculated Average Poult Weight Gains, In Grams, Due to the Supplements Added to the Basal Ration	Ration Supplements/Ton: Compenamine (penicillin) Grams				
	0.5	0.75	1.0	1.25	1.5
			and/or		
	Baciferm-5		(bacitracin)		Pounds
	1.5	1.25	1.0	0.75	0.5
14th Day Data:					
Observed for Compenamine	38	39	39	23	25
Observed for Baciferm-5	22	23	16	20	14
Calculated for Combination	60	62	55	43	39
Observed for Combination	34	36	44	47	34
Synergism Indicated	No	No	No	Yes	No
28th Day Data:					
Observed for Compenamine	74	131	116	37	109
Observed for Baciferm-5	99	84	60	71	64
Calculated for Combination	173	215	176	108	173
Observed for Combination	67	125	117	125	123
Synergism Indicated	No	No	No	Yes	No
44th Day Data:					
Observed for Compenamine	136	268	235	120	299
Observed for Baciferm-5	161	149	143	270	180
Calculated for Combination	297	417	378	390	479
Observed for Combination	137	249	277	288	295
Synergism Indicated	No	No	No	No	No

feed, measured in grams, mixed for each experimental lot and records of the amounts of feed wasted and consumed by the poults are presented in the Basic Data Tables in the Appendix. The feed efficiency for a group of birds is the ratio of feed consumed per gain in body weight. The feed efficiency data are presented in Table VI for each of the experimental lots at the three weighing periods. In general, the feed efficiencies improved (less feed per unit gain) as the concentration of antibiotic supplement in the ration was increased.

Correlation of data. In order to determine the degree of correlation between the increased growth rate and corresponding improvement in feed efficiency, correlation coefficients were computed by the Spearman Rank-Difference Method.[2] The correlation coefficients were calculated as $\neq 0.626^{**}$[3] at the fourteenth day, $\neq 0.597^{**}$ at the twenty-eighth day, and $\neq 0.615^{**}$ at the forty-fourth day of the feeding experiment. All three correlation coefficients are shown to be highly significant at 19

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[2] H. Arkin, and R. R. Colton, An Outline of Statistical Methods (fourth edition; New York; Barnes and Noble, Inc., 1947) p. 86.

[3] ** Highly significant (99% confidence level)

TABLE VI

FEED EFFICIENCY DATA FOR THE FOURTEENTH, TWENTY-EIGHTH AND FORTY-FOURTH DAY OF THE FEEDING EXPERIMENT

Lot No.	Ration Supplements/Ton			Feed Efficiency Data		
	Compenamine (penicillin)		Baciferm-5 (bacitracin)	14th Day	28th Day	44th Day
1	None			1.75	2.19	2.39
2	0.5	grams		1.53	1.94	2.20
3	0.75	"		1.47	1.90	2.23
4	1.0	"		1.47	1.83	2.14
5	1.25	"		1.46	1.90	2.18
18	1.5	"		1.58	1.87	2.11
19	2.0	"		1.48	1.77	1.97
20	4.0	"		1.51	1.97	2.14
6	0.5	"	+ 1.5 pounds	1.55	1.99	2.20
7	0.75	"	+ 1.25 "	1.51	1.97	2.26
8	1.0	"	+ 1.0 "	1.45	1.96	2.20
9	1.25	"	+ 0.75 "	1.40	1.83	2.14
10	1.5	"	+ 0.5 "	1.50	1.85	2.15
11			0.5 "	1.69	2.33	2.40
12			0.75 "	1.55	1.95	2.10
13			1.0 "	1.61	2.10	2.37
14			1.25 "	1.39	1.92	2.26
15			1.5 "	1.44	1.84	2.21
16			2.0 "	1.66	2.03	2.19
17			4.0 "	1.58	2.10	2.25

degrees of freedom in a table presented by Brownlee.[4]

[4] K. A. Brownlee, Industrial Experimentation (fourth American edition; New York; Chemical Publishing Co., Inc., 1952) p. 187.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary. A feeding experiment was conducted on young turkeys to determine the effects on growth and feed utilization produced by the inclusion of antibiotics in the poultry rations. The two antibiotics used in this investigation were: (1) penicillin, as Compenamine, the l-ephenamine salt of penicillin G; and (2) bacitracin, as Baciferm-5, an antibiotic feed supplement containing five grams of bacitracin per pound of supplement. The Compenamine and Baciferm-5 were each fed singly at concentrations of 0.5, 0.75, 1.0, 1.25, 1.5, 2.0, and 4.0 grams and pounds, respectively, per ton of basal ration. Combinations of Compenamine and Baciferm-5 were also fed at concentrations of 0.5, 1.5; 0.75, 1.25; 1.0, 1.0; 1.25, 0.75; and 1.5, 0.5 grams and pounds per ton respectively, to determine the possible existence of an antibiotic synergism.

The twenty electrically heated brooders with wire screen floors employed in this investigation were housed in an air-conditioned brooder room. The supplemented rations were fed to groups of ten Broad Breasted Bronze male poults between the first and forty-fourth day of life. The two hundred birds were individually weighed at four intervals during the test period and complete records of the poult

weights and feed consumption data were maintained.

The basic data were treated by standard statistical procedures including correlation coefficients and tests for significance of the results.

Conclusions. Under the conditions of this experimental investigation, it was concluded that: (1) the penicillin, bacitracin, and penicillin-bacitracin ration supplements produced an increased growth rate above the unsupplemented control ration; (2) more than half of these increased growth rates were significant, statistically, above the rate of growth of the control group; (3) in general, the average poult weights increased as the concentrations of the antibiotic supplements were increased; (4) the penicillin-bacitracin combinations produced superior gains in poult weight at equivalent total concentrations of antibiotic, but not of such magnitude as to indicate the general existence of an antibiotic synergism; (5) in general, the feed utilization improved as the concentration of the antibiotic supplements were increased; and (6) there was a highly significant positive coefficient of correlation between increased poult growth and improved feed utilization throughout the experiment.

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APPENDIX

TURKEY WEIGHT DATA FOR LOT # 1

SUPPLEMENT: None

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4404	M	51	206	481	1108
2	4432	M	76	278	664	1450
3	4464	M	57	222	583	1315
4	4470	M	57	235	620	1441
5	4482	M	54	254	682	1469
6	4489	M	54	265	581	1214
7	4496	M	61	225	471	1010
8	4499	M	61	298	735	1693
9	4598	M	52	263	695	1520
10	4600	M	46	224	528	1170
Total Weight= $\leq X$			569	2470	6040	13390
Items=N & Average=$\bar{X}$			10 56.9	10 247.0	10 604.0	10 1339.0
Sum of Squared Items=$\leq(X)^2$				617,744	3,723,106	18,333,276

FEED RECORD (Grams)

Feed Added	18144	--	22680
(+) Feed Balance		14628	27953
(-) Feed Remaining	14628	5273	8845
(-) Feed Wasted	198	680	482
(=) Feed Consumed	3318	+ 8675	+ 18626
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	190.1	547.1	1282.1
(=) Feed Eff. (G.Feed/G.Gain)	1.75	2.19	2.39

TURKEY WEIGHT DATA FOR LOT # 2

SUPPLEMENT: 0.5 gram Compenamine/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4433	M	73	325	760	1596
2	4452	M	57	321	722	1500
3	4459	M	51	266	670	1450
4	4474	M	57	294	767	1748
5	4478	M	54	334	763	1610
6	4495	M	61	284	680	1516
7	4504	M	54	235	405	850
8	4518	M	61	311	758	1631
9	4595	M	52	260	666	Died 43
10	4599	M	46	218	585	1370
Total Weight= $\leq X$			566	2848	6776	13271
Items=N & Average=$\bar{X}$			10 | 56.6	10 | 284.8	10 | 677.6	9 | 1474.6
Sum of Squared Items=$\leq(X)^2$				825,140	4,705,012	20,105,137

FEED RECORD (Grams)

	Feed Added	18144	--	22680
(+)	Feed Balance		14401	27698
(-)	Feed Remaining	14401	5018	8165
(-)	Feed Wasted	255	822	454
(=)	Feed Consumed	3488	+ 8561	+ 19079
(÷)	Average Number of Turkeys	10	10	9.98
(÷)	Accumulated Average Gain	228.2	621.0	1418.0
(=)	Feed Eff. (G.Feed/G.Gain)	1.53	1.94	2.20

TURKEY WEIGHT DATA FOR LOT # 3

SUPPLEMENT: 0.75 gram Compenamine/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4444	M	57	285	764	1705
2	4448	M	71	334	773	1550
3	4463	M	54	275	810	1735
4	4476	M	51	283	732	1575
5	4490	M	61	270	697	1527
6	4506	M	57	284	694	1590
7	4524	M	61	322	800	1762
8	4540	M	54	242	665	1500
9	4577	M	48	268	643	1445
10	4585	M	52	298	770	1684
Total Weight= ΣX			566	2861	7348	16073
Items=N & Average=$\bar{X}$			10 56.6	10 286.1	10 734.8	10 1607.3
Sum of Squared Items=$\Sigma(X)^2$				824,927	5,429,168	25,938,729

FEED RECORD (Grams)

	Feed Added	18144	-- 22680
(+)	Feed Balance		14515 27046
(-)	Feed Remaining	14515	4366 4763
(-)	Feed Wasted	255	652 539
(=)	Feed Consumed	3374	+ 9479 + 21744
(÷)	Average Number of Turkeys	10	10 10
(÷)	Accumulated Average Gain	229.5	678.2 1550.7
(=)	Feed Eff. (G.Feed/G.Gain)	1.47	1.90 2.23

TURKEY WEIGHT DATA FOR LOT # 4

SUPPLEMENT: 1.0 gram Compenamine/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4407	M	68	337	840	1810
2	4430	M	57	279	760	1582
3	4436	M	54	235	626	1385
4	4465	M	61	293	696	1545
5	4493	M	51	295	696	1488
6	4510	M	57	264	550	1089
7	4541	M	54	249	623	1380
8	4545	M	61	307	805	1859
9	4575	M	48	293	748	1660
10	4582	M	52	310	852	1940
Total Weight= $\leq X$			563	2862	7196	15738
Items=N & Average=$\bar{X}$			10 | 56.3	10 | 286.2	10 | 719.6	10 | 1573.8
Sum of Squared Items=$\leq(X)^2$				827,404	5,267,970	25,363,620

FEED RECORD (Grams)

	Feed Added	18144	-- 22680
(+)	Feed Balance		14515 27726
(-)	Feed Remaining	14515	5046 6804
(-)	Feed Wasted	255	709 567
(=)	Feed Consumed	3374	+ 8760 + 20355
(÷)	Average Number of Turkeys	10	10 10
(÷)	Accumulated Average Gain	229.9	663.3 1517.5
(=)	Feed Eff. (G.Feed/G.Gain)	1.47	1.83 2.14

TURKEY WEIGHT DATA FOR LOT # 5

SUPPLEMENT: 1.25 grams Compenamine/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4419	M	68	316	796	1710
2	4420	M	54	290	712	1700
3	4428	M	57	273	625	1508
4	4461	M	61	244	510	1113
5	4505	M	51	246	635	1527
6	4513	M	57	256	648	1542
7	4557	M	54	291	715	1714
8	4568	M	52	213	514	1142
9	4576	M	61	268	501	951
10	4573	M	48	306	755	1683
Total Weight= $\leq X$			563	2703	6411	14590
Items=N & Average=$\bar{X}$			10 | 56.3	10 | 270.3	10 | 641.1	10 | 1459.0
Sum of Squared Items=$\leq(X)^2$				739,583	4,210,861	22,015,276

FEED RECORD (Grams)

Feed Added	18144	--	22680
(+) Feed Balance	XXXXX	14742	28605
(-) Feed Remaining	14742	5925	8533
(-) Feed Wasted	284	822	539
(=) Feed Consumed	3118	+ 7995	+ 19533
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	214.0	584.8	1402.7
(=) Feed Eff. (G.Feed/G.Gain)	1.46	1.90	2.18

TURKEY WEIGHT DATA FOR LOT # 6

SUPPLEMENT: 0.5 gram Compenamine + 1.5 pounds Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4412	M	54	273	635	1446
2	4425	M	57	258	538	1158
3	4438	M	60	326	803	1780
4	4454	M	68	344	830	1870
5	4515	M	51	263	665	1500
6	4559	M	54	276	680	1428
7	4567	M	52	267	583	1240
8	4572	M	48	236	530	1170
9	4521	M	57	299	737	1580
10	4594	M	62	290	710	1583
Total Weight= $\leq X$			563	2832	6711	14755
Items=N & Average=$\bar{X}$			10 56.3	10 283.2	10 671.1	10 1475.5
Sum of Squared Items=$\leq(X)^2$				811,536	4,599,061	22,295,153

FEED RECORD (Grams)

	Feed Added	18144	--	22680
(+)	Feed Balance		14373	27584
(-)	Feed Remaining	14373	4904	8051
(-)	Feed Wasted	255	765	567
(=)	Feed Consumed	3516	+ 8704	+ 18966
(÷)	Average Number of Turkeys	10	10	10
(÷)	Accumulated Average Gain	226.9	614.8	1419.2
(=)	Feed Eff. (G.Feed/G.Gain)	1.55	1.99	2.20

TURKEY WEIGHT DATA FOR LOT # 7

SUPPLEMENT: 0.75 gram Compenamine + 1.25 pounds Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4410	M	54	295	816	1508
2	4460	M	68	358	885	1850
3	4466	M	60	258	645	1486
4	4469	M	62	322	853	1898
5	4525	M	51	254	543	1270
6	4529	M	57	285	700	1427
7	4543	M	52	287	793	1748
8	4560	M	48	237	632	1451
9	4563	M	54	267	721	1737
10	4597	M	58	288	697	1500
Total Weight= $\leq X$			564	2851	7285	15875
Items=N & Average=$\bar{X}$			10 | 56.4	10 | 285.1	10 | 728.5	10 | 1587.5
Sum of Squared Items=$\leq(X)^2$				823,949	5,411,487	25,584,467

FEED RECORD (Grams)

Feed Added	18144	---	22680
(+) Feed Balance		14458	26677
(-) Feed Remaining	14458	3997	4876
(-) Feed Wasted	227	680	425
(=) Feed Consumed	3459	+ 9781	+ 21376
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	228.7	672.1	1531.1
(=) Feed Eff. (G.Feed/G.Gain)	1.51	1.97	2.26

TURKEY WEIGHT DATA FOR LOT # 8

SUPPLEMENT: 1.0 gram Compenamine + 1.0 pound Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4405	M	54	286	740	1674
2	4458	M	62	357	771	1652
3	4484	M	60	334	842	1773
4	4492	M	68	317	756	1658
5	4519	M	52	277	680	1451
6	4527	M	51	245	672	1639
7	4550	M	57	285	748	1669
8	4555	M	48	285	783	1721
9	4564	M	54	227	407	Died 35
10	4569	M	58	296	807	1307
Total Weight= ΣX			564	2909	7206	14544
Items=N & Average=$\bar{X}$			10 | 56.4	10 | 290.9	10 | 720.6	9 | 1616.0
Sum of Squared Items=$\Sigma(X)^2$				859,639	5,326,016	23,671,246

FEED RECORD (Grams)

	Feed Added	18144	--	22680
(+)	Feed Balance		14515	26847
(-)	Feed Remaining	14515	4167	5840
(-)	Feed Wasted	227	709	482
(=)	Feed Consumed	3402	+ 9639	+ 20525
(÷)	Average Number of Turkeys	10	10	9.80
(÷)	Accumulated Average Gain	234.5	664.2	1559.6
(=)	Feed Eff. (G.Feed/G.Gain)	1.45	1.96	2.20

TURKEY WEIGHT DATA FOR LOT # 9

SUPPLEMENT: 1.25 grams Compenamine + 0.75 pound Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4422	M	67	325	786	1693
2	4434	M	62	298	712	1624
3	4500	M	60	273	712	1665
4	4501	M	52	286	715	1589
5	4542	M	48	233	515	1058
6	4556	M	58	313	785	1770
7	4561	M	51	310	791	1758
8	4571	M	54	310	749	1651
9	4581	M	57	295	787	1845
10	4593	M	55	297	733	1615
Total Weight= ΣX			564	2940	7285	16268
Items=N & Average=$\bar{X}$			10 | 56.4	10 | 294.0	10 | 728.5	10 | 1626.8
Sum of Squared Items=$\Sigma(X)^2$				870,446	5,367,699	26,881,650

FEED RECORD (Grams)

Feed Added	18144	--	22680
(+) Feed Balance		14515	27443
(-) Feed Remaining	14515	4763	5670
(-) Feed Wasted	312	737	539
(=) Feed Consumed	3317	+ 9015	+ 21234
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	237.6	672.1	1570.4
(=) Feed Eff. (G.Feed/G.Gain)	1.40	1.83	2.14

TURKEY WEIGHT DATA FOR LOT # 10

SUPPLEMENT: 1.5 grams Compenamine + 0.5 pound Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4411	M	59	265	726	1700
2	4421	M	62	292	752	1627
3	4435	M	56	297	737	1662
4	4441	M	67	300	772	1755
5	4498	M	52	278	715	1544
6	4528	M	58	286	750	1815
7	4536	M	48	243	692	1508
8	4565	M	51	298	761	1719
9	4587	M	54	244	575	1291
10	4589	M	55	310	790	1719
Total Weight= ΣX			562	2813	7270	16340
Items=N & Average=$\bar{X}$			10 | 56.2	10 | 281.3	10 | 727.0	10 | 1634.0
Sum of Squared Items=$\Sigma(X)^2$				796,267	5,318,168	26,908,226

FEED RECORD (Grams)

Feed Added	18144	--	22680
(+) Feed Balance		14515	27443
(-) Feed Remaining	14515	4763	5557
(-) Feed Wasted	255	709	454
(=) Feed Consumed	3374 +	9043 +	21432
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	225.1	670.8	1577.8
(=) Feed Eff. (G.Feed/G.Gain)	1.50	1.85	2.15

TURKEY WEIGHT DATA FOR LOT # 11

SUPPLEMENT: 0.5 pound Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4401	M	53	238	600	1279
2	4416	M	59	288	704	1583
3	4417	M	62	285	706	1635
4	4446	M	56	281	755	1651
5	4479	M	52	251	671	1500
6	4502	M	67	236	546	1355
7	4523	M	58	268	680	1582
8	4530	M	48	240	645	1457
9	4566	M	51	280	710	1604
10	4580	M	55	242	662	1542
Total Weight= $\leq X$			561	2609	6679	15188
Items=N & Average=$\bar{X}$			10 56.1	10 260.9	10 667.9	10 1518.8
Sum of Squared Items=$\leq(X)^2$				684,859	4,493,203	23,202,934

FEED RECORD (Grams)

Feed Added	18144	--	22680
(+) Feed Balance	XXXXX	14487	25770
(-) Feed Remaining	14487	3090	4309
(-) Feed Wasted	199	624	539
(=) Feed Consumed	3458	+ 10773	+ 20922
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	204.8	611.8	1462.7
(=) Feed Eff. (G.Feed/G.Gain)	1.69	2.33	2.40

TURKEY WEIGHT DATA FOR LOT # 12

SUPPLEMENT: 0.75 pound Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4415	M	53	244	586	1411
2	4451	M	59	230	630	1417
3	4456	M	52	258	701	1588
4	4488	M	56	313	825	1941
5	4512	M	58	278	694	1590
6	4516	M	48	216	442	Died 44
7	4520	M	63	280	719	1666
8	4544	M	67	300	778	1749
9	4570	M	55	255	635	1397
10	4590	M	51	293	742	1721
Total Weight= ΣX			562	2667	6752	14480
Items=N & Average=$\bar{X}$			10 56.2	10 266.7	10 675.2	9 1608.9
Sum of Squared Items=$\Sigma(X)^2$				720,183	4,665,356	23,564,142

FEED RECORD (Grams)

	Feed Added	18144	-- 22680
(+)	Feed Balance		14685 27896
(-)	Feed Remaining	14685	5216 6889
(-)	Feed Wasted	198	680 482
(=)	Feed Consumed	3261	+ 8789 + 20525
(÷)	Average Number of Turkeys	10	10 10
(÷)	Accumulated Average Gain	210.5	619.0 1552.7
(=)	Feed Eff. (G.Feed/G.Gain)	1.55	1.95 2.10

TURKEY WEIGHT DATA FOR LOT # 13

SUPPLEMENT: 1.0 pound Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	3068	M	59	236	570	1259
2	4409	M	66	285	692	1535
3	4418	M	50	237	593	1320
4	4429	M	53	223	541	1210
5	4449	M	52	270	713	1577
6	4503	M	56	258	648	1393
7	4507	M	63	293	770	1794
8	4508	M	58	307	748	1556
9	4533	M	55	235	590	1357
10	4583	M	49	281	773	1819
Total Weight= $\leq X$			561	2625	6638	14820
Items=N & Average=$\bar{X}$			10 56.1	10 262.5	10 663.8	10 1482.0
Sum of Squared Items=$\leq(X)^2$				696,567	4,474,400	22,364,966

FEED RECORD (Grams)

	Feed Added	18144	22680
(+)	Feed Balance		14600 27216
(-)	Feed Remaining	14600	4536 5670
(-)	Feed Wasted	227	624 482
(=)	Feed Consumed	3317	+ 9440 + 21064
(÷)	Average Number of Turkeys	10	10 10
(÷)	Accumulated Average Gain	206.4	607.7 1425.9
(=)	Feed Eff. (G.Feed/G.Gain)	1.61	2.10 2.37

TURKEY WEIGHT DATA FOR LOT # 14

SUPPLEMENT: 1.25 pounds Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4408	M	52	275	730	1560
2	4414	M	66	284	728	1600
3	4427	M	50	265	658	1390
4	4455	M	63	266	662	1340
5	4457	M	58	288	752	1691
6	4462	M	59	Died 14		
7	4497	M	53	261	650	1405
8	4509	M	56	303	741	1547
9	4522	M	55	236	605	1369
10	4553	M	49	254	665	1490
Total Weight= $\leq X$			561	2432	6191	13392
Items=N & Average=$\bar{X}$			10 56.1	9 270.2	9 687.9	9 1488.0
Sum of Squared Items=$\leq(X)^2$				660,348	4,279,427	20,042,276

FEED RECORD (Grams)

	Feed Added	18144	-- 22680
(+)	Feed Balance		14883 28267
(-)	Feed Remaining	14883	5587 9216
(-)	Feed Wasted	284	737 482
(=)	Feed Consumed	2977	+ 8559 + 18569
(÷)	Average Number of Turkeys	10	9.50 9.32
(÷)	Accumulated Average Gain	214.1	631.8 1431.9
(=)	Feed Eff. (G.Feed/G.Gain)	1.39	1.92 2.26

TURKEY WEIGHT DATA FOR LOT # 15

SUPPLEMENT: 1.5 pounds Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4406	M	65	295	789	1715
2	4447	M	63	303	800	1729
3	4450	M	58	280	751	1543
4	4467	M	50	252	635	1395
5	4473	M	59	278	672	1241
6	4511	M	56	293	747	1510
7	4517	M	55	227	566	1235
8	4526	M	53	276	729	1624
9	4552	M	49	235	672	1510
10	4596	M	53	248	670	1495
Total Weight= $\leq X$			561	2687	7031	14997
Items=N & Average=$\bar{X}$			10 | 56.1	10 | 268.7	10 | 703.1	10 | 1499.7
Sum of Squared Items=$\leq(X)^2$				728,305	4,991,621	22,755,447

FEED RECORD (Grams)

	Feed Added	18144	--- 22680
(+)	Feed Balance		14770 27868
(-)	Feed Remaining	14770	5188 7484
(-)	Feed Wasted	312	737 454
(=)	Feed Consumed	3062	+ 8845 + 19930
(÷)	Average Number of Turkeys	10	10 10
(÷)	Accumulated Average Gain	212.6	647.0 1443.6
(=)	Feed Eff. (G.Feed/G.Gain)	1.44	1.84 2.21

TURKEY WEIGHT DATA FOR LOT # 16

SUPPLEMENT: 2.0 pounds Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4423	M	63	239	609	1315
2	4439	M	58	277	565	Died37
3	4440	M	65	293	753	1577
4	4468	M	50	176	541	1233
5	4485	M	59	269	709	1474
6	4531	M	56	274	718	1563
7	4532	M	49	284	738	1610
8	4534	M	53	269	726	1609
9	4591	M	53	233	650	1400
10	4494	M	55	241	608	1247
Total Weight= ΣX			561	2555	6617	13028
Items=N & Average=$\bar{X}$			10 56.1	10 255.5	10 661.7	9 1447.6
Sum of Squared Items=$\Sigma(X)^2$				663,499	4,431,885	19,064,168

FEED RECORD (Grams)

	Feed Added	18144	— 22680
(+)	Feed Balance		14543 27471
(-)	Feed Remaining	14543	4791 9299
(-)	Feed Wasted	284	794 482
(=)	Feed Consumed	3317	+ 8958 + 17690
(÷)	Average Number of Turkeys	10	10 9.84
(÷)	Accumulated Average Gain	199.4	605.6 1391.5
(=)	Feed Eff. (G.Feed/G.Gain)	1.66	2.03 2.19

TURKEY WEIGHT DATA FOR LOT # 17

SUPPLEMENT: 4.0 pounds Baciferm-5/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4431	M	58	275	712	1575
2	4443	M	65	273	710	1583
3	4475	M	50	228	723	1656
4	4486	M	55	270	753	1727
5	4491	M	59	287	809	1787
6	4535	M	53	257	691	1542
7	4546	M	64	224	508	Died 44
8	4554	M	56	244	670	1437
9	4584	M	53	274	734	1592
10	4586	M	50	218	526	1129
Total Weight= $\leq X$			563	2550	6836	14028
Items=N & Average=$\bar{X}$			10 56.3	10 255.0	10 683.6	9 1558.7
Sum of Squared Items=$\leq(X)^2$				655,768	4,755,140	22,156,586

FEED RECORD (Grams)

	Feed Added	18144	--- 22680
(+)	Feed Balance		14685 26706
(-)	Feed Remaining	14685	4026 5500
(-)	Feed Wasted	312	652 567
(=)	Feed Consumed	3147	+ 10007 + 20639
(÷)	Average Number of Turkeys	10	10 10
(÷)	Accumulated Average Gain	198.7	627.3 1502.4
(=)	Feed Eff. (G.Feed/G.Gain)	1.58	2.10 2.25

TURKEY WEIGHT DATA FOR LOT # 18

SUPPLEMENT: 1.5 grams Compenamine/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4403	M	58	263	668	1515
2	4471	M	55	323	845	1916
3	4472	M	64	275	752	1713
4	4477	M	65	286	755	1747
5	4480	M	50	281	765	1763
6	4514	M	59	333	836	1831
7	4538	M	53	137	388	1048
8	4558	M	56	293	750	1730
9	4562	M	50	253	656	1519
10	4578	M	53	271	711	1594
Total Weight= $\leq X$			563	2715	7126	16376
Items=N & Average=$\bar{X}$			10 56.3	10 271.5	10 712.6	10 1637.6
Sum of Squared Items=$\leq(X)^2$				762,837	5,228,800	27,352,790

FEED RECORD (Grams)

Feed Added	18144	--	22680
(+) Feed Balance		14487	27528
(-) Feed Remaining	14487	4848	6041
(-) Feed Wasted	255	737	454
(=) Feed Consumed	3402	+ 8902	+ 21033
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	215.2	656.3	1581.3
(=) Feed Eff. (G.Feed/G.Gain)	1.58	1.87	2.11

TURKEY WEIGHT DATA FOR LOT # 19

SUPPLEMENT: 2.0 grams Compenamine/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4402	M	58	218	560	Died 31
2	4437	M	55	273	686	1481
3	4445	M	64	256	650	1519
4	4481	M	50	263	699	1596
5	4537	M	50	233	618	1431
6	4539	M	53	287	765	1675
7	4548	M	59	322	839	1855
8	4574	M	53	272	689	1475
9	4588	M	65	302	773	1673
10	4592	M	56	282	772	1723
Total Weight= $\leq X$			563	2708	7051	14428
Items=N & Average=$\bar{X}$			10 | 56.3	10 | 270.8	10 | 705.1	9 | 1603.1
Sum of Squared Items=$\leq(X)^2$				741,812	5,034,601	23,285,632

FEED RECORD (Grams)

	Feed Added	18144	--	22680
(+)	Feed Balance		14713	28267
(-)	Feed Remaining	14713	5587	9582
(-)	Feed Wasted	255	794	567
(=)	Feed Consumed	3176	+ 8332	+ 18118
(÷)	Average Number of Turkeys	10	10	9.70
(÷)	Accumulated Average Gain	214.5	648.8	1546.8
(=)	Feed Eff. (G.Feed/G.Gain)	1.48	1.77	1.97

TURKEY WEIGHT DATA FOR LOT # 20

SUPPLEMENT: 4.0 grams Compenamine/ton

	Wing Band	Sex F M	Individual Turkey Weights in Grams Initial	14 days	28 days	44 days
1	4413	M	64	287	662	1557
2	4424	M	55	310	791	1936
3	4426	M	55	294	771	1866
4	4442	M	64	303	749	1814
5	4483	M	50	264	656	1574
6	4487	M	50	267	656	1525
7	4547	M	53	268	657	1660
8	4549	M	59	285	631	1416
9	4551	M	53	293	732	1736
10	4579	M	59	297	729	1827
Total Weight= ΣX			562	2868	7034	16911
Items=N & Average=$\bar{X}$			10 | 56.2	10 | 286.8	10 | 703.4	10 | 1691.1
Sum of Squared Items=$\Sigma(X)^2$				824,806	4,977,114	28,860,279

FEED RECORD (Grams)

Feed Added	18144	--	22680
(+) Feed Balance		14373	26989.
(-) Feed Remaining	14373	4309	4196
(-) Feed Wasted	284	794	567
(=) Feed Consumed	3487	+ 9270	+ 22226
(÷) Average Number of Turkeys	10	10	10
(÷) Accumulated Average Gain	230.6	647.2	1634.9
(=) Feed Eff. (G.Feed/G.Gain)	1.51	1.97	2.14