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Antibiotics and Arsenicals in Poultry Nutrition

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CONTENTS

SUMMARY

Experimental work conducted by the Texas Agricultural Experiment Station with poultry showed that the addition of antibiotics to the diet of all ages of chickens and turkeys stimulated the growth rate and improved the feed efficiency.

The use of high levels of antibiotics during periods of stress or disease outbreak, at this Station and elsewhere, reduced mortality and morbidity losses. Early mortality in turkey poults was reduced markedly through the use of pre-starter rations containing high levels of antibiotics and other nutrients.

Egg production should increase 3 to 10 percent through the use of antibiotics in the laying ration.

Antibiotics and Arsenicals in Poultry Nutrition

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THE RECENT DISCOVERY of the growth-promoting action of antibiotics in poultry diets opened up a new field of research. Vitamin B_{12} was isolated in 1948 and crude preparations of the vitamin appeared soon for use in feeds. Striking differences which existed between some of these products (fermentation residues) led workers at the Lederle Laboratories to investigate the possibility of residual antibiotic activity. Significant amounts of aureomycin were found in certain of the fermentation products.

Workers in poultry nutrition at the Texas Agricultural Experiment Station were among the first to obtain results indicative of accessory growth promoting effects of fermentation residues (E. L. R. Stokstad, 1953). Investigations had been concerned for some time with the distinctive properties of animal proteins and the APF (animal protein factor) concentrates, which are now known to contain vitamin B_{12}, antibiotics in some cases and other growth factors yet to be identified. Some of the work conducted on the effect of such products and antibiotics in poultry rations are reported in this bulletin.

BROILER STUDIES

The original study of Couch and Reed was reported in *Poultry Science* in 1950, using the diets shown in Table 1. Diet R-1 was deficient in vitamin B_{12}, while diet R-2 contained both fish meal and fish solubles which are good sources of the vitamin. Two APF concentrates were fed in these studies. One was designated as 199-B (Lederle's APF concentrate) and the other as No. 3 (Merck's APF concentrate). The 199-B concentrate contained 3.6 to 4.00 mg. of aureomycin per gm. in addition to vitamin B_{12}, while concentrate No. 3 contained only vitamin B_{12}.

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TABLE 1. COMPOSITION OF DIETS

Ingredients	R-1	R-2
	— Percent —	
Ground yellow corn	30.0	30.0
Ground sorghum grain	28.5	30.0
Soybean oil meal (41%)	35.0	24.5
Sardine meal		6.0
Condensed fish solubles		3.0
Alfalfa leaf meal	3.0	3.0
Steamed bone meal	2.0	2.0
Limestone flour	1.5	1.5
Supplements added, gm. per 100 lb.		
Manganese sulphate	5	5
"D" activated animal sterol	18	18
Y 21 (riboflavin supplement)	30	30

When supplemented with the 199-B concentrate, the basal diet (R-1) produced more rapid growth than the basal control. There also were marked improvements in feed efficiency and mortality. The growth of the birds fed the diet adequate in vitamin B_{12} (R-2), although better than for the birds fed the R-1 diet, was not as good as the birds fed APF 199-B. These data were additional proof that the feeding of aureomycin would stimulate the growth of chicks and improve feed efficiency.

The results obtained with APF concentrate No. 3 also demonstrated the difference between the two supplements, and indicated no antibiotic effect when this supplement was fed (Table 3).

In an effort to determine the mode of action of antibiotics in stimulating the growth of chicks, Elam, Gee and Couch reported in 1951 on the function and metabolic significance of penicillin and bacitracin. The experimental design of this study is shown in Table 4.

Penicillin was injected at levels calculated to be equivalent to the amounts supplied in the feed. Autoclaved penicillin, which failed to show any antibacterial activity against test organisms, also was supplied orally and by injection. The injection of penicillin in a sesame oil suspension to delay diffusion through the body and thus maintain a constant blood level of the antibiotic also was included in the study. Bacitracin was supplied in the feed and through intramuscular injection.

The administration of oral or injected penicillin increased the growth rate of the chicks (Figure 1).

TABLE 2. EFFECT OF DIFFERENT LEVELS OF APF CONCENTRATE 199-B ON THE AVERAGE WEIGHT, FEED EFFICIENCY AND MORTALITY OF NEW HAMPSHIRE CHICKS AT 10 WEEKS OF AGE

Supplementation to diet R-1	Av. weight, gm.	Gm. of feed required per gm. live weight	% mortality
0	689.9	4.3	36.0
0.15% APF 199-B	973.7	3.3	1.5
0.25% APF 199-B	1,065.2	2.9	2.5
0.50% APF 199-B	1,055.8	2.9	2.5
100% APF 199-B	1,137.4	2.9	5.0
Diet R-2[1]	961.6	3.3	2.5

[1]6% fish meal and 3% fish solubles.

TABLE 3. EFFECTS OF DIFFERENT LEVELS OF APF CONCENTRATE NO. 3 ON THE AVERAGE WEIGHT, FEED EFFICIENCY AND MORTALITY OF NEW HAMPSHIRE CHICKS AT 10 WEEKS OF AGE

Supplementation to diet R-1	Av. weight, gm.	Gm. of Feed required per gm. live weight	% mortality
0	849.83	3.29	7.32
0.018% APF No .3	783.28	3.52	9.64
0.036% APF No. 3	815.95	3.40	9.29
0.054% APF No. 3	819.72	3.34	6.79
0.072% APF No. 3	795.42	3.42	12.14
Diet R-2[1]	963.24	3.47	6.07

[1]6% fish meal and 3% fish solubles.

A somewhat greater growth increase was apparent on the injection of either autoclaved penicillin or the sesame oil suspension. The fact that the feeding of autoclaved penicillin failed to stimulate the growth of the birds, while injection was effective, was highly significant. These data led to the postulation that a fragment of the penicillin molecule might serve as a metabolite in the bird or that the chick was capable of resynthesis of the antibiotic. The results were not altered in the presence of vitamin B_{12} (Figure 1). Bacitracin administered orally or by injection produced an increase in growth over that of the birds fed the basal diet. The birds fed the unsupplemented basal diet weighed 765 gm. at 10 weeks, while the oral and injected bacitracin groups weighed 930 and 900 gm., respectively. In the presence of vitamin B_{12}, these same supplements produced growth increases of 100 and 50 gm., respectively. A study of the effect of the treatments used in this study on the fecal microflora showed that the oral administration of penicillin produced an increase in the number of penicillin-resistant organisms present in the feces as well an an increase in the number of aureomycin-resistant organisms and yeasts (Table 5).

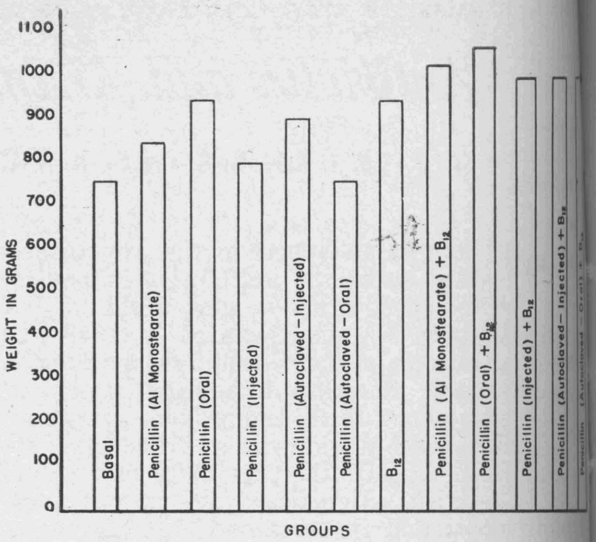

Figure 1. Effect of oral and parenteral administration of penicillin, autoclaved penicillin and injected with vitamin B_{12} on growth of New Hampshire chicks.

There was no significant change in the total number of organisms found, or in the enterococci, lactics or coliforms when penicillin was fed in the diet. The injection of penicillin in water solution failed to produce a significant change in the fecal microflora. The injection of penicillin in sesame oil, containing aluminum monostearate, produced an increase in both penicillin-resistant organisms and yeasts in the feces. These data indicated that the slower assimilation of the sesame oil suspension allowed the maintenance of a higher level of penicillin in the animal over a prolonged period.

The autoclaved penicillin, when injected, did not alter the microfloral counts to an appreciable extent, but did stimulate the growth of the birds. These data led to the postulation of a metabolic function of a portion of the penicillin molecule.

TABLE 4. SUPPLEMENTATION TO BASAL DIET

Group	Penicillin					Bacitracin		
	Oral, mg.	Injected, mg.	Autoclaved injected, mg.	Autoclaved oral, mg.	Injected in sesame oil, units	Oral, mg.	Injected, mg.	Vitamin B_{12}, mcg.
1	0							
2								1[1]
3	33[2]							
4		1.2[3]						
5			1.2[4]					
6				33				
7					15,000[5]			
8	33							1
9		1.2						1
10			1.2					1
11				33				1
12					15,000			1
13						33		
14							1.2	
15						33		1
16							1.2	1

[1] Injected per bird per week.
[2] Per kg. of diet.
[3] Injected per bird per week.
[4] Autoclaved 15 min. at 15 lb.
[5] Injected per bird on alternate days.

TABLE 5. SUMMARY OF STATISTICAL ANALYSIS OF ENUMERATIVE DATA FROM FECAL DROPPINGS OF CHICKENS 2 TO 10 WEEKS OF AGE

Ingredients	Basal	Oral	Injected	Autoclaved Injected	Autoclaved Oral	Aluminum Monostearate	F Value[1]	LSD[2]
		Penicillin						
Penicillin[3]	4.91[4]	6.66	5.75	6.09	6.26	6.67	3.88[5]	1.22
Aureomycin[6]	2.33	4.06	2.62	3.21	2.72	3.03	3.65[5]	.85
Potato-dextrose (yeast)	2.08	3.24	2.24	2.31	2.04	2.36	5.57[5]	.59
		Penicillin + B_{12}						
Penicillin[3]	6.03	7.60	5.64	6.18	5.75	7.61	3.88[5]	1.22
Aureomycin[6]	2.43	3.84	3.31	3.21	3.03	3.25	3.65[5]	.85
Potato-dextrose (yeast)	2.27	3.42	2.32	2.32	2.44	2.98	5.57[5]	.59

[1] F value calculated for all 12 groups.
[2] Least significant difference—calculated for all 12 groups.
[3] Penicillin resistant.
[4] Average number of microorganisms in logarithms.
[5] Significant at the 1% level.
[6] Aureomycin resistant.

Bacitracin administration did not affect the enterococci, lactics, yeasts, coliforms, penicillin-resistant or bacitracin-resistant organisms; however, the growth rate of the birds was increased. This provided further evidence that the antibiotics tested might serve as metabolites in the bird, and thus exert a beneficial growth effect in this manner. Later studies will show that although there is no significant alteration in the aerobic organisms, the anaerobic (*Clostridia*) count is altered in antibiotic feeding and may be another explanation of the growth responses obtained.

Later work of Elam *et al.* (1953) further demonstrated the growth effects of oral and injected penicillin as well as the effect of the inactivated antibiotic (Table 6).

The oral or injected penicillin, injected inactivated penicillin or combinations of penicillin and aureomycin or bacitracin produced highly significant decreases in the fecal *Clostridia* counts. The oral feeding of inactivated penicillin failed to stimulate the growth of the birds, although it did produce a slight decrease in the *Clostridia* count per gm. of feces.

In vitro studies with *Clostridia* isolates showed that 1 mcg. of either penicillin, aureomycin or bacitracin would inhibit growth completely, while 1,000 mcg. of the inactivated penicillin did not inhibit the growth of such isolates. The data obtained with the *Clostridia* counts were in agreement with the work of Sieburth *et al.* (1951), where the inhibition of *Clostridium perfringens* was given as an explanation for the growth-promoting effects of penicillin and terramycin. Kiser *et al.* (1952) also reported that a number of *Clostridia* were destroyed by the addition of aureomycin, penicillin or terramycin to the medium.

In a second experiment in the same report, Elam *et al.* (1953), showed that, although the growth rate of the birds was retarded by the onset of summer, the feeding of penicillin, aureomycin, bacitracin, terramycin, arsanilic acid or sodium arsanilate produced an increase in growth rate. Inactivated penicillin, when injected, produced a growth response. The injection of penicillin decomposition products failed to exert a stimulating effect on growth (Table 7).

As in the previous study, the feeding of antibiotics again produced a significant reduction

TABLE 6. EFFECT OF FEEDING ANTIBIOTICS WITH AND WITHOUT 3% DRIED WHEY (50% LACTOSE) ON THE WEIGHTS AND THE ANAEROBIC MICROFLORA (CLOSTRIDIUM) OF NEW HAMPSHIRE CHICKS[1]

Group	With whey: Average weight, gm.	With whey: Total number of Clostridium isolates per gm. of feces	Without whey: Average weight, gm.	Without whey: Total number of Clostridium isolates per gm. of feces
Control	1252	12,450	1153	45,580
Penicillin (Oral)	1392	138	1295	275
Penicillin (Injected)	1338	850	1242	300
Inactivated penicillin (oral)	1256	1,250	1179	1,100
Inactivated penicillin (injected)	1242	563	1257	100
Aureomycin	1270	100	1278	125
Bacitracin	1284	2,812	1286	100
Penicillin + aureomycin	1371	100	1335	100
Bacitracin + penicillin	1391	100	1263	150

[1] Amount of antibiotic administered: penicillin, 2 mg. per lb.; aureomycin, 5 mg. per lb.; bacitracin, 5 mg. per lb.; inactivated penicillin, 2 mg. per lb. The injected antibiotics were administered at a level of 1.2 mg. per bird per week.

TABLE 7. EFFECT OF ANTIBIOTICS, COMBINATIONS OF ANTIBIOTICS, DERIVATIVES OF PENICILLIN, ARSENICALS AND COMBINATIONS OF ARSENICALS AND PENICILLIN ON THE WEIGHTS AND ANAEROBIC MICROFLORA (CLOSTRIDIUM) OF NEW HAMPSHIRE CHICKS AT 10 WEEKS OF AGE

Group	Average weight, gm.	Total number of Clostridium isolates per gm. of feces
Control	907	11,930
Penicillin (2 mg. per lb.)	1056	233
Aureomycin (5 mg. per lb.)	1064	392
Bacitracin (5 mg. per lb.)	1011	423
Terramycin (5 mg. per lb.)	1143	83
Arsanilic acid (45 mg. per lb.)	1097	72
Sodium arsanilate (45 mg. per lb.)	1029	1,402
Arsanilic acid (22.5 mg. per lb.) + penicillin (1 mg. per lb.)	1064	146
Sodium arsanilate (22.5 mg. per lb.) + penicillin (1 mg. per lb.)	1044	366
Inactivated penicillin (1.2 mg.)[1]	1007	164
Sodium potassium benzylpenilloate (1.5 mg.)[1]	902	5,750
Sodium benzylpenicilloate (1.2 mg.)[1]	(88% mortality)	7,004
Beta-diethylaminoethanol (0.4 mg.)[1]	(100% mortality)	
Penicillin (1 mg. per lb.) + aureomycin (2.5 mg. per lb.)	1032	360
Penicillin (1 mg. per lb.) + bacitracin (2.5 mg. per lb.)	1026	102
Penicillin (1 mg. per lb.) + terramycin (2.5 mg. per lb.)	1081	153
Aureomycin (2.5 mg. per lb.) + bacitracin (2.5 mg. per lb.)	1051	277
Aureomycin (2.5 mg. per lb.) + terramycin (2.5 mg. per lb.)	1054	95
Bacitracin (2.5 mg. per lb.) + terramycin (2.5 mg. per lb.)	1066	288
Penicillin (0.67 mg. per lb.) + aureomycin (1.67 mg. per lb.) + bacitracin (1.67 mg. per lb.)	1077	391
Penicillin (0.67 mg. per lb.) + aureomycin (1.67 mg. per lb.) + terramycin (1.67 mg. per lb.)	1071	21
Penicillin (0.67 mg. per lb.) + bacitracin (1.67 mg. per lb.) + terramycin (1.67 mg. per lb.)	1114	138
Aureomycin (1.67 mg. per lb.) + bacitracin (1.67 mg. per lb.) + terramycin (1.67 mg. per lb.)	1109	84
Penicillin (0.5 mg. per lb.) + bacitracin (1.25 mg. per lb.) + aureomycin (1.25 mg. per lb.) and terramycin (1.25 mg. per lb.)	1084	55

[1] Injected intramuscularly into each bird weekly.

in the number of *Clostridia* in the feces. The number of *Clostridia* per gm. of feces was decreased in all instances in which antibiotics were fed singly or in combination (Table 7). The feeding of the arsenicals (arsanilic acid and sodium arsanilate) likewise produced a significant decrease in the total number of fecal *Clostridia*. The injection of inactivated pencillin also produced a significant reduction in *Clostridia*, which seems to indicate that there was an excretion of active penicillin into the gut in this group.

Another facet of antibiotic feeding is the old versus clean environment studies which have been conducted. These studies may explain the variable results which have been reported with antibiotic feeding.

Coates *et al.* (1951, 1952), working in England, reported that chicks reared from 1 day to 3 weeks of age in quarters not previously used for poultry failed to show a growth response to antibiotic feeding, whereas such response occurred in old quarters. The chicks fed no antibiotics in the new quarters grew more rapidly than those fed the antibiotic diet in the old environment. These authors concluded that the reason for the antibiotic response in the old quarters was the presence of an 'infection" that made the birds sensitive to the antibiotic. Lillie *et al.* (1953) reported that the weight of chicks fed no antibiotic in new quarters was greater than that of chicks given 10 mg. aureomycin per kg. of diet in old quarters. Hill *et al.* (1953) reported that growth responses to penicillin were greater in old quarters than in new ones. These

TABLE 8. EFFECT OF FEEDING PENICILLIN AND FECAL CLOSTRIDIA ON WEIGHTS AND NUMBER OF CLOSTRIDIA IN OLD AND CLEAN QUARTERS

Supplements to basal diet	Average weight at 10 weeks, gm.	Total number of Clostridium isolates per gm. of feces
FIRST EXPERIMENT		
Old Quarters		
None	969	15,570
Penicillin	1085[1]	265[1]
Clean Quarters		
None	1167	1,215
Penicillin	1210	615
Fecal Clostridia	1042[1]	10,260[1]
Fecal Clostridia + penicillin	1180	450
Heat inactivated fecal Clostridia	1150	1,110
SECOND EXPERIMENT		
Old Quarters		
None	1134	12,450
Penicillin	1262[1]	640[1]
Fecal Clostridia	1170	16,710
Fecal Clostridia + penicillin	1310[1]	740[1]
Clean Quarters		
None	1324	940
Penicillin	1343	650
Fecal Clostridia	1210[1]	9,440[1]
Fecal Clostridia + penicillin	1339	625

[1] Significant at the 1% level.

workers reported further that bacteriological examination of cecal microflora of representative birds revealed striking differences between the two animal houses.

Similar studies by Elam *et al.* (1954) at the Texas Agricultural Experiment Station demonstrated that the feeding of penicillin to birds in clean quarters failed to produce a significant decrease in fecal *Clostridia* or an increase in growth, while the same diets fed to birds in old quarters resulted in a significant decrease in *Clostridia* and a significant improvement in the growth of the birds (Table 8).

There also was a significant difference between the two control groups. The birds reared in the clean environment weighed more at the end of the 10-week experimental period than those fed the basal diet in the old quarters.

The addition of fecal *Clostridia* isolated from the birds fed the basal diet in the old quarters to birds in the clean environment resulted in a significant decrease in the growth of these birds. The combined feeding of the *Clostridia* with penicillin returned the growth to that of the control group (Table 8). Heat inactivated *Clostridia* were without effect on the growth of the birds or on the microflora counts.

In a second experiment of this report, the addition of penicillin increased growth and decreased the total *Clostridia* count in the old quarters, but failed to affect the growth rate in the clean environment. The total *Clostridia* count was low in both studies conducted with birds reared under the clean conditions. Fecal *Clostridia,* when fed under the "old" conditions, did not affect the growth rate of the birds; but, in the clean environment it produced significant reductions in the growth rate with a concurrent increase in fecal *Clostridia.* Penicillin, when fed with the *Clostridia* culture in the clean environment, reversed the detrimental effects of the *Clostridia* (Table 8).

Further evidence of the effect of antibiotics in old and clean environments was obtained with the opening of the new poultry facilities at the Texas A. and M. College in 1951. Results of the first experiment conducted at the new quarters are shown in Table 9. At the end of 9 weeks, the birds in this study weighed around 2.75 pounds, regardless of the supplement fed. There were no marked differences in feed efficiency which could be attributed to the supplements tested and no difference in mortality. The weights of all birds were good at that time.

The next study conducted in the same house showed different results (Table 10). The basal group weighed only 966 gm. at 10 weeks, while the previous basal group weighed 1,238 gm. at 9 weeks. Antibiotic supplementation produced growth responses of 10 and 18 percent, respectively, for bacitracin and penicillin fed singly. Combinations of bacitracin and penicillin produced 24 to 26 percent more growth to 10 weeks of age. The weights of the birds, however, failed to approach that obtained under the "low-disease level conditions" observed in the previous study (Table 9). If higher levels of the antibiotics had been used, growth comparable with that of the previous study may have been obtained.

TABLE 9. EFFECT OF SUPPLEMENTING AN ALL-VEGETABLE PROTEIN RATION WITH DRIED WHEY, FISH MEAL AND ANTIBIOTICS ON THE GROWTH, FEED EFFICIENCY AND MORTALITY OF NEW HAMPSHIRE CHICKS AT 9 WEEKS OF AGE KEPT UNDER A "LOW-DISEASE LEVEL"

Supplement to basal diet	Average weight, 9 weeks, (males & females), gm.	Increase due to supplement, %	Feed efficiency, gm. of feed per gm. gain	% mortality
None	1238	—	2.81	3.4
3% dried whey product	1267	2.34	2.84	3.4
3% fish meal	1246	0.65	2.87	0.0
Aureomycin (5 mg. per lb.)	1263	2.01	2.95	6.7
Bacitracin (5 mg. per lb.)	1257	1.53	2.63	3.4
Penicillin (2 mg. per lb.)	1284	3.72	2.70	0.0

TURKEY STUDIES

Concurrent investigations with turkeys also were made to determine the effect of antibiotics on the growth and feed efficiency of the turkey poult. Atkinson and Couch reported in 1951 that the feeding of either aureomycin or streptomycin would stimulate the growth of turkey poults (Tables 11, 12, 13).

The results of the first experiment (Table 11) indicated that the feeding of streptomycin

TABLE 10. EFFECT OF SUPPLEMENTING AN ALL VEGETABLE PROTEIN RATION WITH ANTIBIOTICS AND FISH SOLUBLES ON THE GROWTH, FEED EFFICIENCY AND MORTALITY OF NEW HAMPSHIRE CHICKS AT 10 WEEKS OF AGE UNDER A "HIGH-DISEASE LEVEL"

Supplement to basal diet	Average weight at 10 weeks, males & females, gm.	Increase due to supplement, %	Feed efficiency, gm. of feed per gm. gain	% mortality
None	966	—	3.35	24.1
Bacitracin (5 mg. per lb.)	1064	10.14	3.30	10.2
Penicillin (2 mg. per lb.)	1142	18.22	2.90	3.5
Fish solubles (3%)	1048	8.49	3.50	27.6
Bactracin (5 mg. per lb.) + penicillin (1 mg. per lb.)	1202	24.43	3.02	6.9
Bacitracin (5 mg. per lb.) + penicillin (2 mg. per lb.)	1220	26.29	2.80	0.0

TABLE 11. EFFECT OF FEEDING STREPTOMYCIN, APF 4, FISH MEAL AND FISH SOLUBLES, AND LIVER "L" AND INJECTING VITAMIN B_{12} ON THE WEIGHTS OF BROAD BREASTED BRONZE POULTS AT 8 WEEKS OF AGE WHEN KEPT ON LITTER

Group	Supplement to basal ration	Average weight, gm.	Feed efficiency, gm. of feed per gm gain	% mortality
1	None	1139	2.6	2
2	Vitamin B_{12} injected (2 mcg. per bird per week)	1177	2.5	2
3	MK-23 (66 mg. streptomycin + 13 mcg. vitamin B_{12} per kg.)	1547	2.2	10
4	2% APF 4 (12 mcg. B_{12} per kg.)	1534	2.3	5
5	Fish meal (6%) + fish solubles (3%)[1]	1255	2.7	16
6	Liver "L" (4%) (49.4 mcg. B_{12} per kg.)	1392	2.3	2

[1] Supplied 25.8 mcg. B_{12} per kg. of diet.

produced a marked improvement in growth and feed efficiency. The APF 4 used in this study also supplied significant quantities of aureomycin and produced improvements in both feed efficiency and growth over the group receiving the vitamin B_{12} supplementation or the group fed the fish meal and fish solubles diet.

TABLE 12. EFFECT OF FEEDING STREPTOMYCIN, AUREOMYCIN, APF 4, LIVER "L," FISH MEAL AND FISH SOLUBLES, AND INJECTING VITAMIN B_{12} ON THE WEIGHTS OF BROAD BREASTED BRONZE TURKEY POULTS AT 8 WEEKS OF AGE

Group	Supplement to basal ration	Average weight, gm.	Feed efficiency, gm. of feed per gm. gain	% mortality
1	None	1391	2.6	8
2	MK-23 (66 mg. streptomycin + 13 mcg. B_{12} per kg. of diet)	1498	2.6	7
3	Vitamin B_{12} injected (2 mcg. per bird per week)	1313	2.4	5
4	Aureomycin (100 mg. per kg.)	1585	2.2	2
5	Aureomycin (44 mg. per lb.) + vitamin B_{12} injected (2 mcg. per bird per week)	1740	2.0	6
6	Fish meal (6%) + fish solubles (3%)[1]	1652	2.3	3
7	2% APF 4 (12 mcg. B_{12} per kg.)	1644	2.0	9
8	Liver "L" (4%) (49.6 mcg. B_{12} per kg.)	1539	2.3	5

[1] Supplied 25.8 mcg. B_{12} per kg. of diet.

TABLE 13. EFFECT OF FEEDING AUREOMYCIN AND LIVER "L" AND INJECTING VITAMIN B_{12} ON THE WEIGHTS OF BROAD BREASTED BRONZE TURKEY POULTS AT 14 WEEKS OF AGE MAINTAINED ON LITTER

Group	Supplement to basal ration	Average weight, lb.	Feed efficiency, lbs. of feed per lb. of gain	% mortality
3	None	7.0	3.3	8
5	Aureomycin (44 mg. per lb.)	8.8	2.8	6
8	Liver "L" (4%) (49.6 mcg. B_{12} per kg.)	8.1	3.0	5

The use of crystalline aureomycin in the next study made it possible to evaluate more clearly the benefits of feeding the antibiotic (Table 12). The addition of aureomycin to the diet resulted in an increase in growth of approximately 400 gm. over the group fed vitamin B_{12}.

In a third experiment (Table 13), aureomycin produced an increase in weight of 1.8 pounds over the control group at 14 weeks of age. Feed efficiency likewise was improved (Table 13).

LAYING HEN STUDIES

Nutrition studies with mature hens also were conducted during this period. The studies had determined that vitamin B_{12} was an essential nutrient for both egg production and hatchability. However, after 9 to 11 weeks, the effect of vitamin B_{12} was no longer apparent and presumably the birds were being depleted of a second hatchability factor which could be supplied by liver or fish solubles.

A continuation of these studies involved the determination of the effects of antibiotics in the diet of mature hens. Halick and Couch reported in 1951 the results of studies using a purified diet composed of 63 percent sucrose, 5 percent dried whey, 22 percent soybean protein, 3 percent soybean oil, 2 percent fortified fish oil (3,000 A-400 D) and 5 percent Salts IV. The diet was supplemented adequately with vitamins and with methionine and glycine.

The data of this study pointed out that the injection of vitamin B_{12} increased hatchability slightly, but there existed another factor required for hatchability, which could be supplied by liver fraction "L." The feeding of crystalline aureomycin and penicillin apparently assisted in the depletion of the birds of both vitamin B_{12} and the second factor required for hatchability (Table 14). Antibiotics produced no apparent increase in hatchability. The study was of too short duration to allow a significant evaluation of the effect of antibiotics on egg production.

Concurrently with the previous study, the effect of penicillin on the growth and fecal microflora of the chick also was investigated. Elam, Gee and Couch (1951) obtained an increase in the growth of chicks by feeding vitamin B_{12} and penicillin either alone or in combination in an all-vegetable protein diet (Table 15).

The pullet chicks were reared to maturity on the same diets and the effect of penicillin on egg production and hatchability was determined (Table 15). An improvement in egg production was obtained by the injection of crystalline vitamin B_{12}. Penicillin alone failed to affect the rate of egg production. However, the combination of both vitamin B_{12} and penicillin stimulated egg production 12 percent over the group injected with vitamin B_{12}. Thus, an antibiotic, penicillin, was found to exert an effect on egg production as well as on the growth in the chicken. A slight stimulation in hatchability also was observed, but it was not considered significant.

Bacteriological examinations of the fecal droppings showed that the feeding of penicillin caused an alteration in the intestinal microflora. The feeding of penicillin increased the total number of organisms present, increased the enterococci and also increased the number of penicillin-resistant organisms present. It was concluded that the beneficial effect of penicillin was due to a change in the microflora of the intestinal tract. The basal group in this study had received penicillin intravenously after the fourteenth week of the test. There was a stimulation in growth of the birds injected with penicillin and a shift in the microflora of the gastrointestinal tract. These data on the "shift" in microfloral population in the bird are in agreement with the work of Kratzer *et al.* (1951) and Williams *et al.* (1951).

Results of several studies with laying hens in cages and on the floor have shown an increase in egg production from the use of aureomycin, penicillin, bacitracin, terramycin, streptomycin, 3-nitro-4-hydroxphenylarsonic acid and arsanilic

TABLE 14. EFFECT OF VITAMIN B_{12}, LIVER EXTRACT, ANTIBIOTICS, LEDERLE APF AND LIVER "L" ON HATCHABILITY AND VITAMIN B_{12} CONTENT OF EGG YOLKS

Group	Supplement to basal diet	Average percent hatchability		Average vitamin B_{12} content of egg yolks, mcg. per gm.	
		2-4 wk.	5-8 wk.	2-4 wk.	5-8 wk.
1	None	25	0	1.4	0.9
2	2 mcg. B_{12} injected[1]	38.4	14.2	7.5	5.2
3	0.5 ml. liver extract injected[1]	50	33.3	7.2	4.1
4	Aureomycin HCl (66 mg. per kg. of diet)	0	0	2.6	1.1
5	Aureomycin HCl (66 mg. per kg. of diet) + 2 mcg. B_{12}[1]	26.6	10	5.8	5.7
6	Streptomycin dihydrochloride (66 mg. per kg. of diet)	52.9	4.3	3.0	1.4
7	Streptomycin dihydrochloride (66 mg. per kg. of diet + 2 mcg. vitamin B_{12}	50	6.6	7.8	4.0
8	Procaine penicillin (G) (33 mg. per kg. of diet)	5	0	2.3	1.3
9	Procaine penicillin (G) (33 mg. per kg. of diet) + 2 mcg. B_{12}[1]	62.9	10	3.6	4.5
10	2% APF 4 (24 mcg. B_{12})	71.4	26.6	7.1	6.1
11	4% liver "L" (49.6 mcg. B_{12})	95.4	78.3	7.8	6.8
12	Practical	96.2	90.4	2.7	1.2

[1]Per hen per week.

TABLE 15. EFFECT OF PARENTERAL ADMINISTRATION OF VITAMIN B_{12} AND PENICILLIN ON THE GROWTH OF CHICKS TO 10 WEEKS OF AGE AND SUBSEQUENT EGG PRODUCTION AND HATCHABILITY

Supplement to basal diet	Average weight of males and females at 10 wks., gm.	Egg production, %	Hatchability, %
None	565	29	0
1 mcg. B_{12} injected per bird per week	800	38	72
Penicillin (33 mg. per kg. of diet)	725	22	39
Penicillin (33 mg. per kg. of diet) + 1 mcg. B_{12} per bird per week	1030	50	80

TABLE 16. EFFECT OF AUREOMYCIN ON EGG PRODUCTION AND FEED EFFICIENCY

Supplement	Pre-experimental		% egg production			Average for period
	0-4 wk.	5-8 wk.	0-4 wk.	4-8 wk.	8-12 wk.	
None	65.2	40.4	22.93	24.09	14.28	17.23
Aureomycin (5 mg. per lb.)	71.8	43.9	28.37	22.69	16.37	22.64
Aureomycin (25 mg. per lb.	63.0	45.1	38.47	26.65	24.49	30.12
Aureomycin (50 mg. per lb.)	70.8	50.6	40.53	44.86	45.86	43.48
	Feed efficiency, lb. of feed per dozen eggs					
None	3.93	5.47	9.66	12.66	15.25	11.65
Aureomycin (5 mg per lb.)	3.56	4.91	6.80	8.79	12.06	8.68
Aureomycin (25 mg. per lb.)	3.86	5.38	5.17	8.05	8.57	6.90
Aureomycin (50 mg. per lb.)	3.66	5.07	5.78	5.76	5.99	5.83

TABLE 17A. EFFECT OF PENICILLIN AND STREPTOMYCIN ON EGG PRODUCTION, CAGE STUDY

Group	Dietary treatment	% egg production by period						Average
		1	2	3	4	5	6	
P-1	Basal	74.56	70.18	58.11	50.07	45.68	41.12	56.78
P-2	1.25 mg. penicillin + 3.75 mg streptomycin per lb.	73.22	70.01	61.83	55.87	51.73	44.64	59.73
P-3	6.25 mg. penicillin + 18.75 mg. streptomycin per lb.	69.11	65.92	62.79	59.59	50.78	42.06	58.50
P-4	12.5 mg. penicillin + 37.5 mg. streptomycin per lb.	77.28	69.27	58.99	54.66	53.80	40.18	59.58

TABLE 17B. EFFECT OF PENICILLIN AND STREPTOMYCIN ON FEED EFFICIENCY, CAGE STUDY

Group	Dietary treatment	Feed efficiency by period, lb. of feed per dozen eggs						Average
		1	2	3	4	5	6	
P-1	Basal	4.88	5.10	5.94	6.41	6.68	6.32	5.75
P-2	1.25 mg. penicillin + 3.75 mg. streptomycin per lb.	5.02	5.15	5.38	5.73	6.02	6.01	5.48
P-3	6.25 mg. penicillin + 18.75 mg. streptomycin per lb.	5.38	5.59	5.54	5.46	6.23	6.29	5.69
P-4	12.5 mg. penicillin + 37.5 mg. streptomycin per lb.	4.70	5.10	5.56	5.55	5.54	5.83	5.29

acid. Egg production may be increased 3 to 10 percent through the use of antibiotics in laying rations. The use of high levels of antibiotics (100 to 400 gm. per ton) during periods of stress, such as a respiratory disease outbreak, also helped maintain the level of egg production. A study conducted in 1955 illustrates the beneficial effect of antibiotics at higher levels (Table 16). A group of New Hampshire hens housed on litter had egg production rates as shown in the experimental columns of Table 16. After the initial high production, there was a rapid drop for the next month of the pre-experimental period; at this time the birds were fed levels of 0, 5, 25 and 50 mg. of aureomycin HCl per pound of diet. Production in the unsupplemented group continued to drop until after 12 weeks on the study it was only 14.3 percent, with an average for the 3-month experimental period of 17.23 percent. The 5 mg. per pound level of aureomycin produced a slight stimulation in egg production, while the two higher levels used (25 and 50 mg. per pound) allowed the hens to maintain egg production rates of 30.12 and 43.48 percent, respectively for the 3-month period. Feed efficiency also was improved highly under these conditions with the antibiotic feeding (Table 16).

TABLE 18. EFFECT OF ANTIBIOTICS ON EGG PRODUCTION AND FEED EFFICIENCY TO 5 MONTHS, FLOOR STUDY

Supplement to basal diet	Average egg production	% average feed efficiency, lb. of feed per doz. eggs
None	45.7	5.39
25 mg. penicillin per lb.	53.2	4.63
50 mg. streptomycin per lb.	54.7	4.82
12.5 mg. penicillin + 25 mg. streptomycin per lb.	57.7	4.67

The use of a combination of penicillin and streptomycin in cage-housed birds also was beneficial (Table 17A), especially during the latter portion of the experimental period, which in this study corresponded to the onset of hot weather. The overall differences in egg production for the 6-months study were not too wide, but there were improvements in feed required to produce a dozen eggs (Table 17B). When these antibiotics were fed at higher levels to birds housed on litter, average egg production was increased with the addition of either penicillin or streptomycin or a combination of these two antibiotics. Improvements in feed utilization amounting to almost 1 pound per dozen eggs also were found (Table 18).

Two arsenicals, 3-nitro-4-hydroxyphenylarsonic acid and arsanilic acid, had a beneficial effect when supplemented to the rations of laying hens. Studies using these compounds have been carried out on different strains of New Hampshire pullets maintained on litter. The effect of 3-nitro-4-hydroxyphenylarsonic acid supplementation is shown in Table 19. Increased

TABLE 19. EFFECT OF AN ARSONIC ACID ON EGG PRODUCTION, FLOOR STUDY

Strain	Basal	+ 22.5 mg. 3-Nitro-4-hydroxyphenylarsonic acid, per lb. of feed
	Percent production	
1	29.9	35.5
2	29.5	33.4
3	35.7	42.2
	Feed efficiency, lb. of feed per dozen eggs	
1	8.44	7.78
2	9.57	8.04
3	7.55	6.30

TABLE 20. EFFECT OF ARSANILIC ACID ON EGG PRODUCTION AND FEED EFFICIENCY TO 5 MONTHS, FLOOR STUDY

Strain	Basal diet	45 mg. arsanilic acid per lb.
	Average production, %	
1	37.2	44.5
2	35.7	44.3
	Feed efficiency	
1	6.75	5.83
2	7.58	7.66

egg production and marked improvements in feed utilization were noted when this arsenical was added to the control ration, regardless of the strain of birds used. Similar results were obtained with arsanilic acid in the same type of study (Table 20). An overall increase in egg production in both strains was noted. Feed efficiency was improved greatly in one strain but not in the other.

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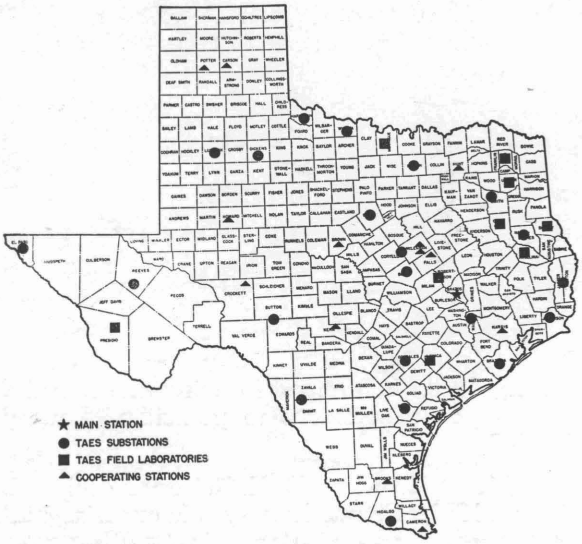

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

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★

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- Ornamental plants
- Brush and weeds
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