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Primary Audience: Broiler Producers, Veterinarians, Nutritionists, Researchers

SUMMARY

A study was conducted to examine broiler performance and carcass yield across 5 consecutive commercial broiler flocks after the removal of roxarsone (ROX) and growth-promoting antibiotics (GPA) from the feed. Over a 1-yr period, approximately 552,000 broilers were reared in 4 solid-walled, tunnel-ventilated houses, divided into 2 paired-house facilities, and were assigned 1 of 2 dietary treatments. The treated group received basal diets containing salinomycin, ROX, and GPA, whereas the control group received the same diets without ROX and GPA. Average BW were recorded for 200 sample birds/treatment per flock at 18, 35, and 48 d of age. Average BW, feed conversion, adjusted feed conversion, livability, and condemnation were calculated at the completion of each flock. Coccidiosis lesion scores of 10 birds per treatment were recorded at 14, 21, 28, 35, and 42 d of age. Before birds were transferred to a commercial processing plant, 280 birds/flock were randomly selected, weighed, and tagged for carcass yield analysis. Livability was significantly negatively affected by the removal of ROX and GPA. Coccidiosis lesion scores were not affected by the treatments. Tender yields showed significant improvement, whereas all other cuts were not affected by removal of ROX and GPA.

Key words: growth-promoting antibiotic, broiler, enteric health, yield, performance

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DESCRIPTION OF PROBLEM

Over the past 60 yr, antibiotics and anticoccidial drugs have been used to improve performance in agricultural animal production by reducing the burden of bacteria in the gastrointestinal tract [1–3]. The polyether ionophorous coccidiostats have been used extensively in broiler production for the control of coccidiosis [4]. Monensin and salinomycin (**SAL**) were approved for use in broiler feeds by the FDA in 1971 and 1983, respectively, and have since become the 2 drugs of choice for the prevention of coccidiosis [5]. These drugs achieve control by altering the permeability of protozoan cell membranes for alkaline metal cations, thereby upsetting the osmotic balance [6]. Antibiotics can be used therapeutically to treat poultry diseases but are more commonly used in a prophylactic manner. Since the approval of bacitracin methylene disalicylate (**BMD**) and virginiamycin (**VIR**), they have been included in poultry diets at sub-

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therapeutic levels for increased rate of gain and improved feed efficiency [5]. These antibiotics may also prevent the occurrence of the bacterial infection necrotic enteritis, caused by *Clostridium* spp. [7]. Roxarsone (**ROX**), another feed additive commonly used in broiler diets, is an arsenical drug used for improving BW gain, feed efficiency, and skin pigmentation [5]. Roxarsone is also approved to aid anticoccidials in the control of *Eimeria tenella* oocysts [8]. Further field experience has demonstrated that ROX may be effective at suppressing *Salmonella* and possibly other enteric organisms that can lead to food safety hazards in meat products [9].

Although antibiotics and anticoccidials are effective in their own respect, overall intestinal health shows the greatest improvement when these products are used in combination in broiler diets. The combination of an ionophore, ROX, and an antibiotic in the starter and grower diets and an antibiotic alone in the withdrawal diet has become the industry standard [3]. Although monensin and SAL are approved only for control of coccidiosis, field experience has revealed that these drugs have an effect on controlling gram-positive bacteria; combining them with an antibiotic and ROX takes advantage of the synergism between these drugs [10].

Consumer pressure has forced the poultry industry worldwide to examine pathogen resistance resulting from using feed additives on a continuous basis for prophylactic prevention of disease and improved performance [6, 11]. Concerns have arisen from the antimicrobial resistance to antibiotics used in animal feeds, possibly resulting in microbial resistance in human medicine. This led to the ban of antibiotic growth promoters by the European Union in 2006 and has led to the continuous decrease in use of antibiotics at subtherapeutic levels in the United States [1]. The objective of this study was to evaluate the effects on performance and yield by withdrawing antibiotic growth promoters from diets fed to commercial broilers across 5 consecutive flocks.

MATERIALS AND METHODS

Birds and Housing

This study was conducted in 4 solid-walled, tunnel-ventilated commercial broiler houses, with dimensions of 43 ft wide and 500 ft long, located at the Stephen F. Austin State University Broiler Research Center. Each house was identical in feeding, water, and ventilation equipment. The 4 houses were divided into 2 paired-house facilities, with each paired-house facility receiving 1 of 2 treatments (treated or control group) consistently throughout the 5 consecutive flocks. For each flock, 27,600 straight-run broiler chicks were placed in each house at a stocking density of 0.78 ft^2/bird. Multiple breeds of birds were placed throughout the trial, with the majority being Ross 708. At the hatchery, an equal number of chicks from the respective breeder flocks were randomly divided before placement in the paired-house facilities. Birds were reared to an average of 49 d under standard commercial industry practices. The same environmental and lighting regimens were used consistently from flock to flock. Birds received light for 23 h at an intensity of 3.0 footcandles for 7 d. From d 8 to 21, the photoperiod was reduced to 12 h/d and the intensity was lowered to 0.10 footcandles. The photoperiod was increased 2 h each week for the remainder of the flock while the light intensity remained the same. Birds were placed on built-up litter from 5 previous flocks, and no clean pine shavings were added between flocks.

Feeding and Dietary Treatments

Birds were fed standard commercial corn- and soy-based diets formulated to meet the requirements of broilers chickens. Feeding phases consisted of a starter diet, grower diet, withdrawal diet I, and withdrawal diet II, with feed changes occurring at approximately 18, 35, and 42 d, respectively. Feed and water were provided ad libitum via an automated feeding system and nipple drinkers. The treated group was fed a basal diet that included SAL (60.0 g/ton of starter and grower diets), ROX (45.4 g/ton of starter diet and 34.0 g/ton of grower diet), BMD (50.0 g/ton of starter diet and 25.0 g/ton of grower diet), VIR (10.0 g/ton of withdrawal diet I), and no SAL, BMD, ROX, or VIR (withdrawal diet II). The control group was fed the same diets containing SAL (60.0 g/ton of starter and grower diets), with ROX, BMD, and VIR removed from all diets, respectively. Each flock received the same treatment over the course of

the study. Samples were taken from each batch of feed and analyzed to ensure that diets contained the proper levels of coccidiostat, ROX, and antibiotics or the absence of ROX and antibiotics.

Yield Study and Data

A yield study was conducted at the completion of each flock using a total of 280 birds from the 4 houses. At 48 d of age, 70 birds per house (35 males and 35 females) were randomly selected from each house. Males were differentiated from females by their visually larger body size and larger combs. Each house was divided into five 100-ft sections, and 14 birds (7 males and 7 females) were selected to ensure a uniform representation of the house. A numbered wing-tag was placed in the wing of each bird and the birds were individually weighed and data recorded. The birds were then removed from the house and placed in an isolation pen, where feed was removed for 12 h before processing. Water was not removed from the birds until immediately before processing. Each yield study was conducted at approximately 49 d of age. At the Stephen F. Austin State University Pilot Processing Facility, the birds were stunned and then bled by using a sharp knife to sever at least 1 carotid artery and jugular vein. The birds were then scalded, defeathered, and manually eviscerated, with the head, neck, and feet being removed and discarded. Carcasses were then cut into front and hind halves and were weighed along with the abdominal fat. The front halves were skinned, wings were removed, and breast fillet and tenders (pectoralis major and pectoralis minor muscles) were deboned, leaving the frame (spine and rib cage). The hind halves were dissected to remove the drums and thighs, leaving the back. All parts were weighed individually and yields were calculated relative to final BW. Total white meat (breast fillet + tenders) and percentage of total white meat [(total white meat/BW) × 100] were later calculated.

The remaining broilers in the houses were taken to a processing plant and slaughtered in a commercial setting. Each paired-house treatment group was removed, processed, and tracked through the plant separately.

Data Collected

For each flock of the trial, 200 randomly selected birds (100 males and 100 females) were individually weighed for each treatment group on d 18, 35, and 48. Birds were selected equally (10 males and 10 females) from five 100-ft sections within each house to ensure uniform distribution. From the commercial processing data of the remaining chickens, average BW, feed conversion, adjusted feed conversion, livability, and condemnation were calculated for each paired-house treatment group. Coccidiosis lesion scores [12] of the duodenum, ileum, and ceca were recorded from 5 randomly selected birds per house at 14, 21, 28, 35, and 42 d of age. Performance and yield data were analyzed by using the GLM procedure of SAS software [13]. When significance between the treatments was observed ($P < 0.05$), means were separated by using the least squares means test with the PDIFF option of this procedure.

RESULTS AND DISCUSSION

Growth Performance

Table 1 shows the means of the treated and control groups for the 200 chickens that were weighed per treatment group at d 18, 35, and 48. At 18 d of age, the control group had an equal or higher average BW for each of the 5 flocks, with the difference for flock 2 being significant. The overall 5-flock cumulative average between the treatments was 0.02 kg, with no significant difference. On d 35, the control group had a higher average BW for each flock and a cumulative average differential of 0.02 kg, but the difference was not significant. The 5-flock cumulative average BW between the treatments at 48 d of age was equal; therefore, significance was not detected.

Table 2 shows the impact of removing ROX and GPA from the diet of broilers processed in a commercial processing plant. The data reflect an average of 54,000 broilers/treatment taken to market at approximately 49 d of age. The cumulative average BW for the 5 flocks showed that the control group had an overall 0.01-kg higher average than the treated group, which was not significantly different. Engster et al. [14] demonstrated that average BW was not adversely

Table 1. Effect of removing growth-promoting antibiotics (GPA) and roxarsone (ROX) on the average BW of broilers at 18, 35, and 48 d of age[1]

	Average BW,[3] kg					
	18 d		35 d		48 d	
Flock[2]	Treated	Control	Treated	Control	Treated	Control
1 (06/08/06 to 07/27/06)	0.60[a]	0.62[a]	1.75[a]	1.78[a]	2.65[a]	2.67[a]
2 (08/10/06 to 09/28/06)	0.48[b]	0.50[a]	1.74[a]	1.76[a]	2.74[a]	2.74[a]
3 (10/12/06 to 11/30/06)	0.48[a]	0.49[a]	1.84[a]	1.85[a]	2.73[a]	2.76[a]
4 (12/22/06 to 02/08/07)	0.53[a]	0.56[a]	1.80[a]	1.83[a]	2.78[a]	2.76[a]
5 (03/06/07 to 04/24/07)	0.48[a]	0.48[a]	1.80[a]	1.82[a]	2.81[a]	2.80[a]
Cumulative average (flocks 1 to 5)	0.51[a]	0.53[a]	1.79[a]	1.81[a]	2.74[a]	2.74[a]

[a,b]Means between treatment groups without a common superscript are significantly different ($P < 0.05$).
[1]Diets: treated = basal diets with coccidiostat, ROX, and GPA; control = basal diets with coccidiostat.
[2]Placement date of flock to ending date of flock.
[3]Average BW of 200 randomly selected individual bird BW per treatment group.

affected by removal of GPA for approximately 1 yr. This study suggests similar results because average BW was not adversely affected over the 1-yr study period.

Actual feed conversion followed a trend similar to average BW throughout the study. Cumulative feed conversion across the 5 flocks of the treated group was 0.01 lower than for the control group, which was not statistically significant. Feed conversion was adjusted for a 5-lb bird and a 1,500-kcal (ME) diet with 7 weight/point of feed conversion. When adjusted feed conversion was averaged across the 5 flocks, both groups were equal and were not significantly different. Research has shown that broiler performance may not be negatively affected until after the first year without prophylactic drug use [14] and that the environmental conditions can have a large role in the success or failure of an enteric health medication program [15].

Table 3 shows the differences between the treatment groups for livability (%) and condemnation (%) of the paired-house groups at 49 d of age. Across the 5-flock study, livability was shown to be negatively affected by the omission of GPA and ROX from the diets. The treated group had a higher livability percentage for every flock, and the cumulative average of 0.37% was statistically different when compared with the control group. Condemnation at the process-

Table 2. Effect of removing growth-promoting antibiotics (GPA) and roxarsone (ROX) on average BW, feed conversion, and adjusted feed conversion of broilers at 49 d of age[1]

	Average BW[3] (kg)		FCR[4] (g/g)		Adjusted FCR[5] (g/g)	
Flock[2]	Treated	Control	Treated	Control	Treated	Control
1 (06/08/06 to 07/27/06)	2.62	2.67	1.83	1.80	1.62	1.59
2 (08/10/06 to 09/28/06)	2.60	2.65	1.81	1.82	1.61	1.61
3 (10/12/06 to 11/30/06)	2.62	2.59	1.90	1.94	1.69	1.74
4 (12/22/06 to 02/08/07)	2.60	2.60	1.92	1.92	1.71	1.72
5 (03/06/07 to 04/24/07)	2.62	2.63	1.96	1.96	1.75	1.74
Cumulative average (flocks 1 to 5)	2.61[a]	2.62[a]	1.88[a]	1.89[a]	1.68[a]	1.68[a]

[a]Means between treatment groups with a common superscript are not significantly different ($P < 0.05$).
[1]Diets: treated = basal diet with coccidiostat, ROX, and GPA; control = basal diet with coccidiostat.
[2]Placement date of flock to ending date of flock.
[3]Average BW of remaining broilers processed in a commercial setting.
[4]FCR = (lb of feed/lb of total BW).
[5]Adjusted to a 5-lb bird and 1,500 kcal with 7 weight/point of feed conversion.

Table 3. Effect of removing growth-promoting antibiotics (GPA) and roxarsone (ROX) on broiler livability (%) and condemnation (%) at 49 d of age[1]

	Livability[3] (%)		Condemnation[4] (%)	
Flock[2]	Treated	Control	Treated	Control
1 (06/08/06 to 07/27/06)	98.29	97.73	0.45	0.86
2 (08/10/06 to 09/28/06)	98.05	97.76	0.41	0.51
3 (10/12/06 to 11/30/06)	98.28	97.82	0.54	0.45
4 (12/22/06 to 02/08/07)	97.70	97.16	0.34	0.44
5 (03/06/07 to 04/24/07)	97.98	97.95	0.41	0.33
Cumulative average (flocks 1 to 5)	98.05[a]	97.68[b]	0.43[a]	0.52[a]

[a,b]Means between treatment groups without a common superscript are significantly different ($P < 0.05$).
[1]Diets: treated = basal diets with coccidiostat, ROX, and GPA; control = basal diets with coccidiostat.
[2]Placement date of flock to ending date of flock.
[3]Livability (%) of remaining broilers processed in a commercial setting.
[4]Condemnation (%) of remaining broilers processed in a commercial setting.

ing plant varied from flock to flock between the treatments throughout the study. The treated group had a lower cumulative condemnation percentage at 49 d of age, but was not significantly different from the control group.

Coccidiosis Lesion Scores

Coccidiosis lesion scores were examined throughout the study to evaluate the effects of withdrawing ROX and GPA from the diets. Coccidial lesions were similar between the treatments from week to week, with the amount and severity of lesions increasing gradually across the 5 flocks for both treatments. Lesion scores between the 2 treatment groups were not affected by treatment (data not shown).

Yield Performance

Average BW of the birds selected and tagged for the yield study were not significantly different for any of the flocks or when accumulated for the entire study. The control group had a 1,952-g average carcass weight, compared with a 1,933-g average carcass weight for the treated group over the course of the study; this difference was not significant. After the carcasses were divided into front and hind halves and the abdominal fat pad was removed, there was no difference between the treatments for each carcass half.

Table 4 shows the yield of the breast fillet, tenders, and wings after the front half was dissected into each of the respective parts. Breast yield was not significantly affected by the removal of ROX and GPA throughout the course of the study. At the completion of the study for flock 2, the control group had an average tender yield of 108.86 g and was significantly different from the 98.43-g average yield for the treated group. The control treatment had a 2.27-g greater cumulative average for tenders at the comple-

Table 4. Effect of removing growth-promoting antibiotics (GPA) and roxarsone (ROX) on breast fillet, tender, and wing yield of broilers at 49 d of age[1]

	Breast fillet (g)		Tenders (g)		Wings (g)	
Flock[2]	Treated	Control	Treated	Control	Treated	Control
1 (06/08/06 to 07/27/06)	391.45[a]	404.60[a]	94.80[a]	96.62[a]	205.48[a]	206.38[a]
2 (08/10/06 to 09/28/06)	413.68[a]	439.53[a]	98.43[b]	108.86[a]	212.28[b]	221.81[a]
3 (10/12/06 to 11/30/06)	410.50[a]	412.32[a]	99.34[a]	102.51[a]	211.83[a]	211.83[a]
4 (12/22/06 to 02/08/07)	437.26[a]	420.03[a]	107.96[a]	102.97[a]	220.45[a]	214.10[a]
5 (03/06/07 to 04/24/07)	435.45[a]	435.00[a]	106.14[a]	106.14[a]	215.46[a]	210.47[a]
Cumulative average (flocks 1 to 5)	417.67[a]	422.29[a]	101.15[b]	103.42[a]	213.00[a]	213.00[a]

[a,b]Means between treatment groups without a common superscript are significantly different ($P < 0.05$).
[1]Diets: treated = basal diets with coccidiostat, ROX and GPA; control = basal diets with coccidiostat.
[2]Placement date of flock to ending date of flock.

Table 5. Effect of removing growth-promoting antibiotics (GPA) and roxarsone (ROX) on total white meat and percentage of total white meat yield of broilers at 49 d of age[1]

	Total white meat[3] (g)		Total white meat[4] (%)	
Flock[2]	Treated	Control	Treated	Control
1 (06/08/06 to 07/27/06)	485.80[a]	501.67[a]	18.59[a]	19.23[a]
2 (08/10/06 to 09/28/06)	511.65[a]	549.30[a]	19.17[b]	19.85[a]
3 (10/12/06 to 11/30/06)	509.84[a]	515.28[a]	18.85[a]	18.88[a]
4 (12/22/06 to 02/08/07)	545.22[a]	523.45[a]	19.62[a]	19.02[a]
5 (03/06/07 to 04/24/07)	541.14[a]	540.68[a]	19.35[a]	19.56[a]
Cumulative average (flocks 1 to 5)	518.73[a]	526.08[a]	19.12[a]	19.31[a]

[a,b]Means between treatment groups without a common superscript are significantly different ($P < 0.05$).
[1]Diets: treated = basal diets with coccidiostat, ROX, and GPA; control = basal diets with coccidiostat.
[2]Placement date of flock to ending date of flock.
[3]Total white meat (g) = (breast fillet + tenders).
[4]Total white meat (%) = (total white meat/BW) × 100.

tion of the study, which was significant. Average wing yield was significantly higher for the control group for flock 2, with an average of 221.81 g, as compared with the treated group, with an average of 212.28 g. However, the cumulative average for the study was not statistically different between the 2 groups, with an average of 213 g.

Table 5 shows the sum of breast fillet and tender yields as total white meat production for each group. By the end of the study, the removal of ROX and GPA had no effect on the yield of total white meat produced. The control group had a significantly higher percentage of total white meat related to BW for flock 2 (19.85%), as compared with the treated group (19.17%). The cumulative average across all flocks showed that the removal of ROX and GPA from the diet had no adverse effect on the percentage of total white meat produced.

The hind half was dissected to evaluate the drums, thighs, and back yield of the carcass. Drum yield was significantly higher for the control group for the first flock of the study, with a difference of 6.85 g over the treated group (Table 6). Both treatments had an equal cumulative average yield for drums of 270.34 g and were therefore not significant. Thigh and back yields were not affected by removing ROX and GPA from flock to flock, or at the completion of the study.

CONCLUSIONS AND APPLICATIONS

1. Removal of ROX and GPA from the diets of commercial broilers across 5 consecutive flocks showed no negative effects on broiler performance.
2. Feed conversion was not affected by the removal of ROX and GPA from the di-

Table 6. Effect of removing growth-promoting antibiotics (GPA) and roxarsone (ROX) on drum, thigh, and back yield of broilers at 49 d of age[1]

	Drum (g)		Thigh (g)		Back (g)	
Flock[2]	Treated	Control	Treated	Control	Treated	Control
1 (06/08/06 to 07/27/06)	261.72[b]	268.07[a]	307.08[a]	308.90[a]	199.58[a]	202.30[a]
2 (08/10/06 to 09/28/06)	267.62[a]	275.78[a]	304.81[a]	317.97[a]	212.73[a]	233.15[a]
3 (10/12/06 to 11/30/06)	265.81[a]	266.71[a]	316.61[a]	308.90[a]	208.20[a]	213.19[a]
4 (12/22/06 to 02/08/07)	286.22[a]	271.70[a]	320.24[a]	308.90[a]	207.29[a]	206.84[a]
5 (03/06/07 to 04/24/07)	268.53[a]	268.53[a]	323.41[a]	318.88[a]	214.10[a]	212.74[a]
Cumulative average (flocks 1 to 5)	270.34[a]	270.34[a]	314.34[a]	312.98[a]	208.65[a]	213.64[a]

[a,b]Means between treatment groups without a common superscript are significantly different ($P < 0.05$).
[1]Diets: treated = basal diets with coccidiostat, ROX, and GPA; control = basal diets with coccidiostat.
[2]Placement date of flock to ending date of flock.

ets throughout the study. The cumulative average feed conversion and adjusted feed conversion were not significantly different at 49 d of age.

3. Removal of ROX and GPA had no impact on coccidiosis lesion scores throughout the study.
4. Livability percentage was negatively affected by the removal of ROX and GPA across the 5 flocks.
5. Overall meat yield performance was not affected by the removal of these drugs from the diets.
6. Although the data from this study demonstrated that broilers reared without ROX and GPA in a commercial setting can perform as well as birds receiving prophylactic antimicrobial drugs; these results must be interpreted in context.

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