

Effects of two feeding periods of tiamulin fed in combination with chlortetracycline for control and treatment of swine respiratory and enteric disease and subsequent growth performance of growing-finishing pigs

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ABSTRACT: The objective of this study was to evaluate the effects of two dietary feeding periods of tiamulin in combination with chlortetracycline for the control and treatment of swine respiratory and enteric disease and subsequent growth performance. The study used 1,151 commercial crossbred barrows and gilts in a randomized complete block design. Pigs were housed in single-sex groups of 25 at a floor space of 0.69 m²/pig. There were two dietary treatments: 1) nonmedicated controls and 2) 39 mg/kg tiamulin + 441 mg/kg chlortetracycline (TIACTC) fed from days 7 to 20 and again days 49 to 62. There were 23 pens per treatment group. Daily observations were made throughout the study, including the number of pigs in each pen coughing, with diarrhea, or showing signs of lameness as well as the number of pigs in each pen requiring individual therapy treatment for each symptom. Pigs were weighed as a group on days 0 (for allocation purposes), 7, 21, 49, 61, 89 (start of marketing), and at time of slaughter. Within pen, animals were selected by visual appraisal and sent for slaughter over 4 wk to a commercial slaughter facility where HCW was collected and used to calculate carcass yield. There was no difference

($P > 0.05$) between treatments for the incidence of morbidity or mortality. Pigs fed TIACTC tended to have less coughing observations ($P = 0.10$) and less diarrhea observations ($P = 0.08$) during the study period, and had less observations of lameness ($P < 0.001$) and required less treatments than nonmedicated controls ($P < 0.001$). For the overall study period, pigs fed TIACTC had greater ($P < 0.05$) total BW gain (43.3 kg greater/pen) and greater ($P < 0.05$) ADG and ADFI than controls. There was no effect ($P > 0.05$) of treatment on G:F. Overall, pigs fed TIACTC weighed 1.3 kg heavier ($P < 0.05$) at the start of marketing and completed the study with an overall BW advantage of 1.6 kg ($P < 0.05$) compared to controls. The difference between treatments for live BW increased with marketing group (1.0 kg in marketing group 1 and 3.3 kg in marketing group 4). Pigs fed TIACTC had greater ($P < 0.05$) HCW (1.0 kg) than controls; however, there was no difference ($P > 0.05$) between treatments for carcass yield. The results of this study suggest that feeding TIACTC was successful at controlling respiratory and enteric disease and, consequently, improved growth performance and carcass weight of grow-finish pigs.

Key words: chlortetracycline, disease, growth, grow-finish, pigs, tiamulin

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INTRODUCTION

It is common for pigs to experience multiple stressors and disease pressures in the growing-finishing phase. Many pork production systems use three-site production, moving pigs from a conventional nursery to finishing facilities. The practice of “double stocking” is also commonly used in the United States, where twice the number of pigs are initially placed into a wean-to-finish facility for the nursery phase and then half of the pigs are moved off-site at a later time. Both of these practices introduce added stress on the animals, as animals are mixed, loaded on a trailer and transported (potentially for large periods of time and distances), placed into new facilities, and again remixed. It has been well documented that stress can increase susceptibility to bacterial and viral infections in multiple species resulting in poorer growth performance (Peterson et al., 1991; Cromwell et al., 2002; Dibner and Richards, 2005). As such, it is common to include feed medications in grow-finish diets as a prevention, control, or treatment of disease (Apley et al., 2012). One combination that may be used is 39 mg/kg (35 g/ton) tiamulin with 441 mg/kg (400 g/ton) chlortetracycline (TIACTC). A synergistic effect has been reported when TIACTC are administered together, enhancing activity of each molecule against important disease causing pathogens in growing-finishing pigs (Burch et al., 1986; Mills et al., 2008; Nitikanchna et al., 2012). As such, this combination has been widely researched previously in grow-finish diets (Hammer et al., 2011; Brumm et al., 2012; Erlandson et al., 2012). However, previous studies have failed to describe both the level of disease pressure as well as the effectiveness of TIACTC on disease. Therefore, the objective of this study was to evaluate the effectiveness of two 14-d feeding periods of TIACTC on the control and treatment of respiratory and enteric disease and the subsequent growth performance and carcass characteristics of grow-finish pigs.

MATERIALS AND METHODS

Experimental procedures in this study were performed in accordance with the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (Federation of Animal Science Societies, 2010). The protocol for this study was reviewed and approved by the Elanco Animal Health Institutional Animal Care and Use Committee. The study was carried out between September 2017 and January 2018.

Experimental Design and Treatments

The study was carried out for a fixed time of 118 d from 34.0 ± 1.94 kg to 141.7 ± 5.65 kg BW using a randomized complete block design (blocking factors were sex and location within the facility). There were two experimental treatments: 1) nonmedicated controls throughout the study period, and 2) TIACTC fed from days 7 to 20 and again days 49 to 62. There were 23 replicates of each treatment. Pen was the experimental unit.

Animals and Allotment to Study

A total of 1,151 crossbred barrows and gilts that were the progeny of PIC 337 sires \times Camborough dams (PIC USA, Hendersonville, TN) were used in the study. A total of 46 single-sex pens, each initially housing 25 pigs, were used in the experiment.

Allotment to the study was carried out within sex at approximately 63 d of age (6 wk postweaning). Within sex, 2 pens of 25 pigs from the nursery period were mixed together on the pen scale. At random, 25 pigs were removed from the group and BW was recorded. Individual pigs were moved between groups to achieve similar mean pen BW between the two groups. Pens were randomly assigned to experimental treatment and moved into their allocated location within the facility and placed into adjacent pens. Following allotment, pigs were fed a nonmedicated diet for 7 d before the start of experimental diets being fed.

Pretest Management

Before the study, animals were fed and managed according to normal farm protocols and husbandry procedures. Vaccinations, medications, or other interventions were administered according to the production system's standard practices. Pigs received the following vaccinations before the start of the study: *Mycoplasma hyopneumoniae* at approximately 3 d of age, *Lawsonia intracellularis* at approximately 3 d before weaning, *Salmonella choleraesuis* and *Salmonella typhimurium* at approximately 3 d before weaning, *Porcine circovirus* on the day of weaning, and erysipelas at approximately 5 wk after placement into the research facility.

Diagnostic Sampling and Veterinary Feed Directives

In the week before and immediately following allotment, a subset of nontest cohort animals that were previously injured or were ill, were removed

from the population and euthanized. Fresh and fixed tissues were sent for diagnostic sampling to Iowa State University Veterinary Medicine Diagnostic Laboratory (Ames, IA). Diagnostic results showed the presence of *Mycoplasma hyorhinis*, *Actinobacillus suis*, *S. choleraesuis*, haemolytic *Escherichia coli*, and *Streptococcus suis*. Nasal swabs collected at the start of the study also showed the presence of *Pasteurella multocida* and *Bordetella bronchiseptica*. To monitor progress and prevalence of disease pressure, rope samples were collected on days 0, 7, 21, 49, 61, and 89 of study. Over the course of the study, *Mycoplasma hyosynoviae* and *M. hyopneumoniae*, swine influenza, *L. intracellularis*, and *Haemophilus parasuis* were detected in addition to the pathogens listed previously. Pigs remained negative for porcine reproductive and respiratory syndrome throughout the study.

Two separate veterinary feed directives for the treatment of *P. multocida*, *S. choleraesuis*, and *E. coli* were prescribed by the site veterinarian responsible for animal health, one for each treatment feeding period. TIACTC was fed according to the Food and Drug Administration–approved label for both dosage and duration.

Housing and Management

Pigs were housed in a tunnel-ventilated facility that had curtain walls and fully slotted concrete floors. Pen dimensions provided a usable floor space of 17.14 m², which resulted in 0.69 m²/pig. Each pen was equipped with a four-space single-sided dry box feeder mounted on the pen division that provided 122 cm of total linear feeder space (4.88 cm/pig) and two-cup water drinkers. Pen divisions were made of horizontal steel bars, and pigs had nose-to-nose contact with adjacent pens.

Diets and Feeding

A 5-phase dietary program was used during the study—phase 1: fed from days 0 to 20 of study; phase 2: fed from days 21 to 48 of study; phase 3: fed from days 49 to 62 of study; phase 4: fed from days 62 to 89 of study; and phase 5: fed from day 89 to the end of study. Diets were formulated to meet or exceed the nutrient requirements of growing-finishing pigs recommended by [National Research Council \(2012\)](#). Diet formulations and calculated composition of the diets fed during the study are presented in [Table 1](#). Pigs had ad libitum access to feed and water throughout the study period.

Disease Score Measurements

A trained technician who was responsible for pig care checked pigs daily for signs of disease. The technician was not blinded to dietary treatments. Each day, the same technician recorded the number of pigs in each pen showing signs of cough, diarrhea, or lameness (defined as stiff or abnormal gait or extremely unwilling or unable to bear weight on one or more limbs; [Brumm et al., 2012](#)). In addition, the technician recorded the number of animals requiring individual antibiotic therapy for respiratory, diarrhea, or lameness symptoms. Observations were made at approximately the same time each day throughout the study period. Morbidity and mortality were recorded on a pen basis.

Growth Study Measurements

All pigs were weighed as a group (i.e., pen) on days 0 (for allocation purposes), 7 (start of first TIACTC feeding period), 21 (end of first TIACTC feeding period), 49 (start of second TIACTC feeding period), 61 (day before the end of second TIACTC feeding period), and 89 (first marketing group selected for slaughter). Animals were weighed on day 61 instead of day 63 due to holiday and staff schedules. In addition, pigs selected for harvest in each marketing group were weighed the day before shipment for slaughter. All feed additions to the feeders were recorded and the amount of feed remaining in the feeders was weighed at the time of pig weighing and used to calculate ADFI and G:F.

Marketing Strategy

Pigs were sent for slaughter according to the following marketing strategy: 1) after 90 d on study, the heaviest 12% of each pen (i.e., 3 pigs) was sent for slaughter (marketing group 1); 2) after 104 d on study, the next heaviest 24% or 28% (i.e., 6 or 7 pigs; similar number between pens within a replicate) was sent for slaughter (marketing group 2); 3) after 110 or 111 d on study, the next heaviest 48% or 52% (i.e., 12 or 13 pigs; depending on number of pigs removed in marketing group 2) was sent for slaughter (marketing group 3); and 4) after 118 d on study, the remaining 12% of each pen (i.e., 3 pigs) was sent for slaughter. Adjustments were made to the number of pigs removed to account for differences in morbidity and mortality. Pigs within each pen were selected for slaughter by visual appraisal of weight

Table 1. Diet formulations, as fed basis

Study day fed	Dietary phase						
	0–20	7–20	21–48	49–62	49–62	63–89	89–end
Ingredient	1	1 + TIACTC	2	3	3 + TIACTC	4	5
Corn	45.7	45.5	60.3	73.9	73.7	75.4	81.6
DDGS	30.0	30.0	20.0	5.00	5.00	5.00	—
Soybean meal	20.0	19.9	15.4	16.5	16.4	15.3	13.8
Choice white grease	1.50	1.50	1.50	1.50	1.50	1.50	2.00
Calcium carbonate	1.33	1.30	1.18	0.98	0.98	0.93	0.88
L-Lysine	0.50	0.50	0.45	0.37	0.37	0.37	0.33
Formaldehyde disinfectant ¹	—	—	—	0.33	0.33	0.33	0.33
Salt	0.48	0.48	0.50	0.50	0.50	0.50	0.50
Monocal	—	—	0.18	0.40	0.40	0.25	0.33
Feed aid	0.18	0.18	0.18	0.18	0.18	0.18	0.00
Methionine hydroxy analogue	0.07	0.07	0.06	0.06	0.05	0.07	0.05
L-Threonine	0.09	0.09	0.11	0.10	0.10	0.10	0.10
L-Tryptophan	0.03	0.03	0.03	0.01	0.01	0.01	0.01
Micro aid ²	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Phytase	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Trace minerals	0.08	0.08	0.08	0.08	0.08	0.05	0.05
Vitamins	0.04	0.04	0.04	0.04	0.04	0.03	0.03
Tiamulin (TIA)	—	0.18	—	—	0.18	—	—
Chlortetracycline (CTC)	—	0.20	—	—	0.20	—	—
Total	100	100	100	100	100	100	100
ME, kcal/kg	3,283	3,283	3,292	3,279	3,279	3,301	3,334
CP, %	21.6	21.6	18.1	14.9	14.9	14.5	12.7
Crude fiber, %	5.50	5.50	5.20	4.50	4.50	4.50	4.80
Ca, %	0.62	0.62	0.58	0.54	0.54	0.50	0.48
P, %	0.49	0.49	0.46	0.43	0.43	0.39	0.38
Available P, %	0.30	0.30	0.29	0.26	0.26	0.24	0.24
Na, %	0.25	0.25	0.25	0.23	0.23	0.22	0.22
SID Lys	1.14	1.14	0.95	0.81	0.81	0.78	0.69
SID Met + Cys:Lys	0.54	0.54	0.54	0.54	0.54	0.55	0.56
SID Thr:Lys	0.60	0.60	0.61	0.62	0.62	0.63	0.64
SID Trp:Lys	0.18	0.18	0.18	0.18	0.18	0.18	0.18
SID Val:Lys	0.69	0.69	0.69	0.68	0.68	0.67	0.67

DDGS = distillers dried grains with solubles; SID = standardized ileal digestible.

¹Trade name = Sal CURB (Kemin Industries, Des Moines, IA).

²Trade name = Micro Aid (DPI Global, Porterville, CA).

by the production site's normal marketing personnel. On the day before shipment for slaughter, the pigs selected for slaughter were removed from the group, weighed, tattooed with a unique pen tattoo, identified, and placed back into their respective test pens. On the day of shipment for slaughter, animals identified for slaughter were removed from the group, loaded on a conventional semitrailer, and transported for approximately 1 h (96.6 km) to a commercial slaughter facility.

Slaughter and Carcass Measurements

Pigs were unloaded and held for at least 2 h in lairage with access to water but not feed. Pigs

were slaughtered using standard commercial procedures. Immediately after carcass dressing, HCW was recorded and used to calculate carcass yield. Research staff were present at the hot carcass scale and sequenced individual carcasses as they crossed the scale.

Statistical Analysis

All growth performance and carcass variables were analyzed using PROC MIXED of SAS (SAS Inst. Inc., Cary, NC). The pen of pigs was the experimental unit for growth performance measurements (BW, BW gain, ADG, ADFI, and G:F) and carcass characteristics (HCW and carcass yield). The model included the

fixed effect of dietary treatment and random effects of block and replicate nested within block. Sex was not included in the model but was accounted for as single-sex replicates were used in the study. Least-squares means were separated using the PDIF option of SAS with means being considered different at a $P \leq 0.05$.

All disease parameters were analyzed using PROC GLIMMIX of SAS (SAS Inst. Inc., Cary, NC) and assumed a Poisson distribution. The pen of pigs was the experimental unit for all measurements. The model included the fixed effect of dietary treatment and random effects of block and replicate nested within block. Sex was not included in the model but was accounted for as single-sex replicates were used in the study. Least-squares means were separated using the logit option of SAS with means being considered different at a $P \leq 0.05$.

Morbidity and mortality data did not meet normality assumptions. As such, the PROC GLIMMIX procedure of SAS was used to analyze the incidence levels of morbidity and mortality. The model included the fixed effect of treatment and the random effect of block. Least-squares means were separated using the PDIF option of SAS with means being considered different at a $P \leq 0.05$.

RESULTS AND DISCUSSION

Disease Incidence

Disease incidence during the study was relatively low (Table 2). Overall incidence of coughing tended ($P = 0.10$) to be lower in TIACTC-fed pigs than nonmedicated controls, although interim analyses showed no difference ($P > 0.05$) between treatments. Pigs fed TIACTC had lower ($P < 0.05$) diarrhea incidence during the second feeding period of TIACTC and tended ($P = 0.08$) to have lower diarrhea incidence than nonmedicated controls for the overall study period (Table 2). In addition, TIACTC-fed pigs exhibited ($P < 0.05$) less lameness than nonmedicated controls from days 7 to 62 of study, whereas lameness observations tended ($P = 0.07$) to be higher in TIACTC-fed pigs from day 63 to the end of study. Overall, however, TIACTC-fed pigs exhibited less ($P < 0.05$) lameness during the study period than controls (Table 2).

There was no difference ($P > 0.05$) between TIACTC-fed pigs and nonmedicated controls for incidence of respiratory treatments (Table 3). Pigs

Table 2. Effects of TIACTC¹ on the incidence of disease in growing-finishing pigs

Item	Treatment		SEM	P value
	Control	TIACTC ¹		
No. of pens	23	23	—	—
Coughing, total no. of observations/pen				
Days 0–6	0.57	0.22	0.127	0.08
Days 7–20 (first feeding period)	0.57	0.43	0.147	0.54
Days 21–48	1.35	1.48	0.248	0.71
Days 49–62 (second feeding period)	0.83	0.78	0.203	0.87
Days 63–89	10.65	9.74	1.164	0.34
Day 90 to end	18.13	16.61	1.059	0.23
Overall (start to end)	32.09	29.26	1.753	0.10
Diarrhea, total no. of observations/pen				
Days 0–6	0.26	0.09	0.084	0.19
Days 7–20 (first feeding period)	0.17	0.04	0.061	0.23
Days 21–48	0.13	0.22	0.091	0.49
Days 49–62 (second feeding period)	0.09	0.00	0.029	<0.001
Days 63–89	0.13	0.00	0.038	0.94
Day 90 to end	0.04	0.04	0.031	1.00
Overall (start to end)	0.83	0.39	0.172	0.08
Lameness, total no. of observations/pen				
Days 0–6	1.91	1.61	0.332	0.45
Days 7–20 (first feeding period)	11.87	5.39	1.000	<0.001
Days 21–48	19.22	12.35	1.682	<0.001
Days 49–62 (second period)	7.91	5.52	0.771	0.01
Days 63–89	15.87	18.17	1.748	0.07
Day 90 to end	17.65	20.00	2.119	0.08
Overall (start to end)	74.43	63.04	5.378	<0.001

¹TIACTC = 39 mg/kg (35 g/ton) tiamulin + 441 mg/kg (400 g/ton) chlortetracycline fed from days 7 to 20 and days 49 to 62.

fed TIACTC had fewer ($P < 0.05$) overall diarrhea treatments than controls, but this difference was minute and practically irrelevant, and likely due to chance and little to no variability observed in the TIACTC treatment. Compared to controls, the number of individual animal treatments for lameness were significantly less ($P < 0.05$) in the TIACTC treatment group during the first TIACTC feeding period (days 7 to 20), the immediate 28-d follow-up period, and the second TIACTC feeding period. Pigs fed TIACTC had a 56% reduction ($P < 0.05$) in the overall number of treatments for lameness during the study compared to controls.

To the author's knowledge, there have been no studies examining the effects of TIACTC on incidence of cough or diarrhea in a commercial field setting. In this study, there were minimal differences over the course of the study, but collectively, TIACTC-fed pigs tended to exhibit less cough or diarrhea during the study period. There have been a large number of experimental challenge studies

demonstrating effectiveness of TIACTC against various respiratory and enteric pathogens (Hsu et al., 1983; Schwartz et al., 1999; Stipkovits et al., 2001; Walter et al., 2001), where coughing and diarrhea parameters were measured and improved. The relatively low incidence of respiratory disease was somewhat surprising in this group of pigs, as they had a known history of respiratory disease and diagnostic samples taken during the study showed presence of *P. multocida*, *A. suis*, and *H. parasuis*, among others. There was a marked increase in the incidence of coughing between the second TIACTC feeding period (days 49 to 62) and the second follow-up period (days 63 to 89). Diagnostic sampling during this period showed positive presence of influenza in the study population.

The relatively low level of diarrhea was not as surprising given that animals had been vaccinated for *L. intracellularis* as well as *Salmonella sp.* before the start of this study. *Lawsonia* was detected during diagnostic sampling during the study, but not

Table 3. Effects of TIACTC¹ on the incidence of individual animal antibiotic treatments in growing-finish-ing pigs

Item	Treatment		SEM	P value
	Control	TIACTC ¹		
No. of pens	23	23	—	—
Respiratory treatments, total no./pen				
Days 0–6	0.00	0.00	—	—
Days 7–20 (first feeding period)	0.00	0.00	—	—
Days 21–48	0.35	0.35	0.123	1.00
Days 49–62 (second feeding period)	0.17	0.09	0.082	0.43
Days 63–89	0.30	0.22	0.116	0.57
Day 90 to end	0.00	0.00	—	—
Overall (start to end)	0.83	0.65	0.179	0.50
Diarrhea treatments, total no./pen				
Days 0–6	0.00	0.00	—	—
Days 7–20 (first feeding period)	0.00	0.00	—	—
Days 21–48	0.13	0.00	0.003	<0.001
Days 49–62 (second feeding period)	0.00	0.00	—	—
Days 63–89	0.00	0.00	—	—
Day 90 to end	0.00	0.00	—	—
Overall (start to end)	0.13	0.00	0.003	<0.001
Lameness treatments, total no./pen				
Days 0–6	0.83	0.39	0.210	0.08
Days 7–20 (first feeding period)	6.26	1.26	0.586	<0.001
Days 21–48	9.26	3.48	1.011	<0.001
Days 49–62 (second feeding period)	3.48	1.74	0.435	0.002
Days 63–89	3.52	3.48	0.517	0.94
Day 90 to end	0.00	0.00	—	—
Overall (start to end)	23.35	10.35	2.244	<0.001
Morbidity and mortality				
Number of pigs	12	9	—	—
Percentage of pigs	2.09	1.56	0.490	0.41

¹TIACTC = 39 mg/kg (35 g/ton) tiamulin + 441 mg/kg (400 g/ton) chlortetracycline fed from days 7 to 20 and days 49 to 62.

before day 89. Thus, pigs likely did not experience a great enteric challenge and this could explain the relatively low incidence of diarrhea. Nonetheless, feeding TIACTC tended to lower both coughing and diarrhea levels during the study period.

Of particular interest in this study was the marked effect that feeding TIACTC had on incidence levels of lameness as well as subsequent antibiotic treatments. In this study, experimental treatments were housed in adjacent pens, and TIACTC-fed pigs had nose-to-nose contact with nonmedicated controls. This may, in theory, have presented a situation where TIACTC-fed pigs were facing a continuous challenge and lessened the magnitude of observed results. Nonetheless, feeding TIACTC dramatically reduced lameness observations as well as lameness treatments early in the growth period. Brumm et al. (2012) evaluated a single 14-d feeding period of TIACTC for lameness and reported an initial reduction in lameness for TIACTC-fed pigs followed by similar incidence levels between treatments later in the growth period. In theory, as the animals move further away from the time of medical intervention, the levels of disease and performance for the two treatments should approach similar levels. These results generally align with those of the current study.

As a whole, morbidity and mortality did not differ among treatments in this study, although incidence levels were relatively low. This is in line with studies evaluating TIACTC in studies with relatively low (<5%) morbidity and mortality levels (Hammer and Dau, 2010; Hammer et al., 2011; Brumm et al., 2012). However, in a study with greater levels (>5%), Erlandson et al. (2012) reported a 3.0% and 2.6% unit reduction in morbidity and mortality levels, respectively.

Growth Performance

Pigs fed TIACTC were heavier (0.6 kg; $P < 0.05$) at the end of the first TIACTC feeding period, and had greater ($P < 0.05$) ADG (4.1%) and ADFI (3.8%) during the first feeding period compared to nonmedicated controls (Table 4). Interestingly, pigs fed TIACTC had greater ($P < 0.05$) ADG (2.1%) and ADFI (2.0%) during the first 28-d follow-up period, when all pigs received a common control diet. As such, TIACTC-fed pigs were 1.1 kg heavier ($P < 0.05$) than nonmedicated controls at day 49 of study. The second TIACTC feeding period produced similar results as the first, with TIACTC-fed pigs having 4.3% greater ($P < 0.05$) ADG and

3.0% greater ADFI than controls during the second 14-d feeding period. Pigs fed TIACTC were 1.7 kg heavier ($P < 0.05$) at the end of the second feeding period (day 61). There was no difference ($P > 0.05$) between treatments on subsequent ADG or ADFI, and there was no difference ($P > 0.05$) in G:F at any point during the study period. Pigs fed TIACTC were 1.3 kg heavier ($P < 0.05$) than nonmedicated controls at the start of the marketing period, and were 1.6 kg heavier ($P < 0.05$) overall at marketing (Table 4). Of particular interest, the BW advantage of TIACTC-fed pigs over nonmedicated controls increased with marketing group (Figure 1). In marketing group 1, TIACTC-fed pigs were 1.0 kg heavier than controls, followed by 1.1 kg in marketing group 2, 1.5 kg in marketing group 3, and 3.3 kg in marketing group 4.

There have been six previous studies evaluating the growth performance of pigs fed TIACTC in the grow-finish period (Hammer and Dau, 2010; Hammer et al., 2011; Konz et al., 2011; Brumm et al., 2012; Erlandson et al., 2012; Nitikanchana et al., 2012). However, these studies differ in start and end weights and overall study length compared to this study, and this makes comparison of overall growth performance difficult. Nonetheless, all six of these studies have reported greater growth rate for TIACTC-fed pigs compared to nonmedicated controls during the TIACTC feeding period, with improvements ranging from 3.5% (Erlandson et al., 2012) to as much as 11.2% (Nitikanchana et al., 2012). In this study, feeding TIACTC increased growth rate by 4.1% and 4.3% for the first and second TIACTC feeding periods, respectively, results within the range previously observed. In this study, the increase in growth rate appeared to be a result of an increase in feed intake. However, in the six studies mentioned previously, there was no effect of TIACTC on feed intake. In addition, feed conversion did not differ between TIACTC-fed pigs and controls in the current study, results which are in stark contrast to the studies mentioned previously, which report improvements in feed conversion ranging from 3.2% (Erlandson et al., 2012) to as much as 11.5% (Nitikanchana et al., 2012). Reasons for the differences between past studies and this study for ADFI and G:F are not clear, but it is important to note that ADFI during the second TIACTC feeding period in this study was much higher than expected, and this could have impacted overall results.

In addition to greater growth rates observed during the TIACTC feeding period, TIACTC-fed pigs appeared to have a carryover advantage compared

Table 4. Effects of TIACTC¹ on the growth performance of growing-finishing pigs

Item	Treatment		SEM	P value
	Control	TIACTC ¹		
No. of pens	23	23	—	—
BW, kg				
Start (day 0)	34.1	34.0	0.41	0.30
Start of first feeding period (day 7)	39.5	39.5	0.43	0.76
End of first feeding period (day 21)	53.5	54.1	0.52	0.02
Start of second feeding period (day 49)	84.2	85.3	0.75	<0.001
End of second feeding period (day 61)	98.2	99.9	0.84	<0.001
Start of marketing (day 89)	125.9	127.2	0.97	0.04
Overall market weight	141.0	142.5	1.18	0.02
ADG, kg/d				
Days 0–7	0.78	0.78	0.011	0.80
Days 7–21 (first feeding period)	1.00	1.04	0.014	0.003
Days 21–49	1.09	1.12	0.012	0.03
Days 49–61 (second feeding period)	1.17	1.22	0.013	0.001
Days 61–89	0.99	0.98	0.013	0.38
Days 0–89	1.02	1.04	0.009	0.02
Day 89 to end	0.85	0.88	0.023	0.40
Overall (start to end)	1.00	1.02	0.010	0.01
ADFI, kg/d				
Days 0–7	1.60	1.61	0.018	0.46
Days 7–21 (first feeding period)	2.02	2.10	0.032	0.003
Days 21–49	2.68	2.73	0.047	0.01
Days 49–61 (second feeding period)	3.19	3.28	0.059	<0.001
Days 61–89	3.15	3.17	0.042	0.40
Days 0–89	2.71	2.76	0.040	0.005
Day 89 to end	3.32	3.38	0.065	0.21
Overall (start to end)	2.80	2.86	0.042	0.005
G:F				
Days 0–7	0.490	0.488	0.0058	0.83
Days 7–21 (first feeding period)	0.494	0.496	0.0041	0.69
Days 21–49	0.408	0.408	0.0033	0.87
Days 49–61 (second feeding period)	0.368	0.372	0.0048	0.14
Days 61–89	0.315	0.307	0.0042	0.09
Days 0–89	0.380	0.378	0.0033	0.46
Day 89 to end	0.257	0.258	0.0042	0.80
Overall (start to end)	0.358	0.357	0.0027	0.49

¹TIACTC = 39 mg/kg (35 g/ton) tiamulin + 441 mg/kg (400 g/ton) chlortetracycline fed from days 7 to 20 and days 49 to 62.

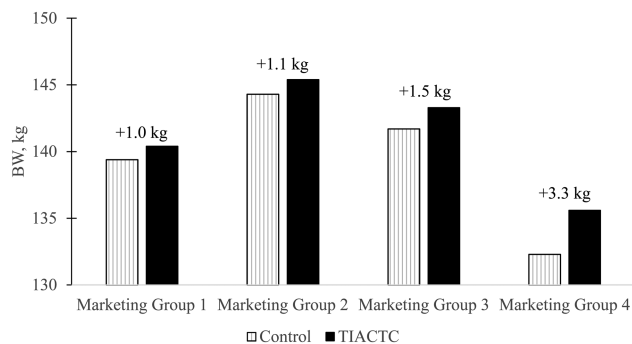


Figure 1. Effects of TIACTC on marketing group BW. Marketing group 1 = heaviest 12% of pen (i.e., 3 pigs) removed; marketing group 2 = next heaviest 24% or 28% of pen (i.e., 6 or 7 pigs) removed; marketing group 3 = next heaviest 48% or 52% of pen (i.e., 12 or 13 pigs) removed; marketing group 4 = lightest 12% of pen (i.e., 3 pigs) removed.

to nonmedicated controls, with greater growth rate in the first follow-up period (although not in the second). This carryover effect has been inconsistent in previous studies. Brumm et al. (2012) reported an increase in growth rate for TIACTC-fed pigs of 3.3% following the TIACTC feeding period, which is similar to this study (Table 4). However, other studies have not observed increased performance of TIACTC-fed pigs in the follow-up period (Konz et al., 2011; Nitikanchana et al., 2012).

Furthermore, in this study, the BW advantage of TIACTC-fed pigs vs. nonmedicated controls increased with each marketing group, reaching as much as 3.3 kg in marketing group 4 (Figure 1). This is the first study in grow-finish pigs to send

Table 5. Effects of TIACTC¹ on carcass characteristics of growing-finishing pigs

Item	Treatment		SEM	P value
	Control	TIACTC ¹		
No. of pens	23	23	—	—
Marketing group 1 (day 90)				
Final farm live weight, kg	139.4	140.4	1.28	0.41
Hot carcass weight, kg	105.3	105.1	1.03	0.91
Carcass yield, %	75.5	74.9	0.36	0.17
Marketing group 2 (day 104)				
Final farm live weight, kg	144.3	145.4	1.25	0.25
Hot carcass weight, kg	110.4	111.1	0.94	0.41
Carcass yield, %	76.4	76.4	0.26	0.86
Marketing group 3 (days 110–111)				
Final farm live weight, kg	141.7	143.3	1.25	0.04
Hot carcass weight, kg	107.1	108.3	0.96	0.03
Carcass yield, %	75.6	75.6	0.19	0.96
Marketing group 4 (day 118)				
Final farm live weight, kg	132.3	135.6	1.71	0.12
Hot carcass weight, kg	99.3	102.0	1.98	0.35
Carcass yield, %	75.6	75.7	0.71	0.92
Overall				
Final farm live weight, kg	141.0	142.5	1.18	0.02
Hot carcass weight, kg	107.3	108.4	0.89	0.05
Carcass yield, %	76.2	76.0	0.18	0.55

¹TIACTC = 39 mg/kg (35 g/ton) tiamulin + 441 mg/kg (400 g/ton) chlortetracycline fed from days 7 to 20 and days 49 to 62.

pigs for slaughter using this marketing strategy, and as such, this is the first study to potentially show a marked improvement in the lightest pigs (and those last sent for slaughter) in the facility.

Carcass Characteristics

This is the first study that reports BW for each specific marketing group and is the first study to report carcass characteristics (HCW and yield) for pigs fed TIACTC. Overall, pigs fed TIACTC were heavier ($P < 0.05$) than controls at the time of marketing, but this difference was not statistically significant for each marketing group (Table 5). In addition, HCW differences generally increased with marketing group, ranging from -0.2 kg less than controls in marketing group 1 to 1.0 kg greater than controls in marketing group 4 (Table 5). There were no differences ($P > 0.05$) in carcass yield in any of the marketing groups or when the marketing groups were combined.

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