Growth Response to Carbadox in Pigs with a High or Low Genetic Capacity for Lean Tissue Growth

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Summary and Implications

The impact of feeding carbadox from 12 to 75 pounds bodyweight on the rate, efficiency, and composition of growth in pigs with a high and low genetic capacity for lean tissue growth (LG) was evaluated. The high LG pigs gained bodyweight and muscle tissue faster and utilized feed more efficiently than low LG pigs. High LG pigs also had carcasses with more dissectible muscle and less dissectible fat. The pigs' responses to carbadox feeding were dependent on the LG genotype. Feeding carbadox from 13 to 75 pounds bodyweight resulted in improved body growth and efficiency of feed utilization, but the magnitude of the responses were greater in the high LG pigs. Dietary carbadox additions from 13 to 75 pounds also resulted in greater muscle growth rates and carcass muscle content at 75 and 250 pounds in the high but not the low LG genotypes. Based on these data, the value of dietary agents such as carbadox that control or destroy antigens in the body need to be based on the impact of the agent on carcass composition as well as rate and efficiency of body growth. Furthermore, the value of the agent will be increased as pigs' genetic capacity for lean tissue growth is increased.

Introduction

Feeding certain antimicrobial agents has been shown to reduce intestinal concentrations of growth inhibiting cytokines in chicks (Roura et al., 1992) as well as increase the ability of pig sera to enhance proliferation of muscle cells in vitro (Hathaway et al., 1990). In previous research conducted at our station (Stahly et al., 1995), feeding subtherapeutic levels of carbadox from 13 to 75 pounds bodyweight has been shown to increase muscle growth and carcass muscle content in pigs experiencing either a low or high level of chronic antigen exposure. The magnitude of the responses was greater in pigs experiencing a high level of antigen exposure.

The improvement in muscle growth as a result of carbadox feeding is hypothesized to be associated with the production of a growth-promoting factor and/or the reduction of some inhibitory factor (i.e., cytokines) via its ability to contain and/or destroy foreign antigens. For example, lowering cytokine release results in greater release of the anabolic hormones somatotropin and IGF-I. Pigs with a high genetic capacity for muscle growth generally possess more muscle cells, thus anabolic compounds that enhance protein synthesis in muscle should elicit the greatest response in these animals. Furthermore, genetically lean pigs should utilize any additional energy resulting from feeding an antimicrobial agent largely for muscle growth, whereas genetically fat pigs likely would utilize the energy more for fat tissue deposition.

Thus, the objective of the study was to evaluate the impact of dietary carbadox addition on the rate, efficiency, and composition of growth in pigs with a high or low genetic capacity for lean tissue growth.

Materials and Methods

Pigs from genetic strains with a high and low genetic capacity for lean tissue growth (LG) were utilized. Pigs were derived using a segregated early weaning scheme to create pigs with a low level of antigen exposure, thus immune system activation. Within each genetic strain, nine litters of five littermate barrows were utilized. Four barrows in each litter were individually penned and allocated to one of two dietary carbadox (C, 0 or 55 ppm) regimens from 13 to 75 pounds bodyweight. Currently, the Food and Drug Administration (FDA) requires that carbadox be withdrawn from the diet at 75 pounds bodyweight or 10 weeks before the pigs are marketed. Consequently, one-half of the pigs fed 0 or 55 ppm carbadox were killed at 75 pounds in order to determine body composition of the pigs up to the point that carbadox feeding was discontinued. The remaining one-half of the pigs originally fed 0 or 55 ppm were placed on the control diet (0 ppm carbadox) from 75 to 250 pounds bodyweight. The fifth barrow in the litter was killed at 13 pounds bodyweight for determination of initial body composition.

Pigs were penned individually in 1.2 by 3.3 foot pens from 10 to 60 pounds and then in 2 by 7.5 foot pens from 60 to 250 pounds bodyweight. The thermal environments were maintained at an average of 78 and 70˚F for pigs weighing 10 to 60 pounds and 60 to 250 pounds, respectively. The dietary regimens used in the experiment are shown in Table 1. The diets were formulated to meet or exceed the estimated nutrient needs of the high LG group (Williams et al., 1994). The carbadox levels were achieved by adding .1 percent of carrier or carrier containing 25 grams of carbadox per pound. Diets were sampled and analyzed for carbadox content.

When pigs reached the desired slaughter weight (75 or 250 pounds), they were transported to the Iowa State University Meats Laboratory, electrically stunned, and killed by exsanguination. Viscera weights (head and heart plus lungs, liver, kidneys, reproductive tract, G.I. tract, leaf fat, and thymus) and hot carcass weights were recorded.

After chilling for 24 hours at 33˚F, standard carcass measurements of cold carcass weight, midline backfat thickness at the first rib, last rib, and last lumbar vertebrae, backfat thickness 2 inches off midline at the tenth rib, and the tenth rib longissimus muscle area were recorded. The right side of each carcass was separated into wholesale cuts (jowl, shoulder, ribs, belly, loin, and ham) and their weights were recorded. Each wholesale cut was then physically dissected into individual tissues (muscle, bone, skin, and fat) and their weights were recorded.

In order to quantify the level of antigen exposure, thus immune system activation, pigs were bled at 13, 75, and 250 pounds bodyweight. The presence of serological titers for mycoplasma hyopneumonia (MP), actinobacillus pleuropneumoniae (APP), porcine reproductive and respiratory syndrome (PRRS), transmissible gastroenteritis (TGE), swine influenza virus (SIV), and for serum concentrations of the acute phase protein, alpha-1 acyl glycoprotein (AGP) were determined. The lungs of pigs killed at 75 and 250 pounds bodyweight also were evaluated for the presence and severity of lesions (Table 2).

Pigs were free of antibody titers for each of the common antigens except for SIV in the low LG genotype animals during the latter part of the study. The presence of mild lung lesions in the low LG pigs at 250 pounds body weight likely relates to the exposure of these animals to SIV even though all pigs in both LG groups were housed in the same building.

Data were analyzed as a split-plot experimental design with LG genotype considered the whole plot and dietary carbadox level considered the subplot treatment. The pig was considered the experimental unit. Carcass data were adjusted for differences in pig weight at slaughter. Least squares means are reported.

Results and Discussion

Genotype Effects

The impact of LG genotype on rate, efficiency, and composition of growth is shown in Table 3. As expected, the high LG pigs gained more muscle daily than the low LG pigs. Furthermore, the high LG pigs gained bodyweight faster and required less feed per unit of bodyweight gain. At a market weight of 250 pounds, the high LG pigs also produced carcasses with more dissectible muscle and less fat (both backfat and dissectible fat) than the low LG pigs.

Carbadox and Genotype x Carbadox Effects

Responses to carbadox were dependent on LG genotype. Pigs fed carbadox from 13 to 75 pounds bodyweight gained weight faster and required less feed per unit of gain from 13 to 75 pounds (Table 4), but the magnitude of the improvement was greater in the high LG genotype. Carbadox feeding resulted in greater muscle growth, expressed as gain per day or percentage of the carcass, in the high but not the low LG pigs. Similarly, carbadox reduced dissectible fat in the high but not the low LG pigs.

In pigs reared to a market weight of 250 pounds, carbadox feeding from 13 to 75 pounds bodyweight resulted in faster bodyweight and muscle tissue gains and lower quantities of feed per unit of gain in the high but not the low LG pigs. Furthermore, carcass muscle percentage was increased and carcass backfat and dissectible fat content were lowered in the high but not the low LG pigs. In contrast, carbadox feeding from 13 to 75 pounds in the low LG pigs tended to result in more body fat being deposited in the carcass. These responses in tissue growth from 13 to 250 pounds bodyweight occurred even though carbadox feeding was discontinued at 75 pounds bodyweight.

Based on these and previous data (Stahly et al., 1995), feeding a subtherapeutic level of the antimicrobial agent carbadox influences body composition as well as the rate and efficiency of growth in pigs experiencing low levels of antigen exposure. Furthermore, the responses are dependent on the pig's genetic capacity for muscle growth as well as its level of antigen exposure. Consequently, the biological and economic value of an antimicrobial agent as a subtherapeutic growth promotant should reflect its impact on composition of growth as well as the rate and efficiency of growth.

References

Hathaway, M., et al. 1990. J. Anim. Sci. 68:3190.
Roura, E.J., et al. 1992. J. Nutr. 122:2383.
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Table 1. Composition of basal diets.

Ingredient	Pig growth stage, lb of body wt. 13 to 75	75 to 250
Corn	28.20	62.70
Soybean meal, 48%	42.80	34.10
Dried whey	20.00	-
Dried skim milk	5.00	-
D,L-methionine	0.16	-
Dicalcium phosphate	1.46	1.56
Calcium carbonate	.61	.70
Salt	.25	.40
Trace mineral mix[a]	.12	.12
Vitamin mix[a]	.43	.43
Carrier	1.00	-

[a]Carbadox added to carrier to provide a dietary carbadox concentration of 55 ppm.

Table 2. Serological titers for prevalent antigens and lung lesions in high and low LG pigs.

Criteria	LG Genotype	Pig weight, lb 13	75	250
Serological titers				
MP, APP, PRRS, and TGE	High	-	-	-
	Low	-	-	-
SIV	High	-	-	-
	Low	-	-	+
Lung lesions, % of pigs				
No lesions	High		100	100
	Low		100	47
With lesions	High		0	0
	Low		0	53

Table 3. Impact of LG genotype on growth and carcass traits of pigs from 13 to 250 pounds bodyweight.[a]

Item	Stage of growth, lb	LG Genotype High	Low	Unit Change
Body growth and feed utilization				
Feed, lb/day[b]	13 to 250	4.92	5.09	-.17
Gain, lb/day[b]	13 to 250	1.72	1.60	+.12
Feed/Gain[b]	13 to 250	2.86	3.18	-.32
Tissue growth				
Muscle, lb/day[b]	13 to 250	.69	.51	+.18
Fat, lb/day[c]	13 to 250	.35	.44	-.09
Muscle/fat[b]	13 to 250	1.97	1.16	+.81
Carcass traits				
Carc. yield, %	250	72.6	72.6	0
Backfat, in[b]	250	1.02	1.49	-.47
LEA, in^2[b]	250	5.44	4.50	+.94
Dissectible tissue content				
Muscle, %[b]	250	55.3	45.8	+9.5
Fat, %[b]	250	28.0	37.8	-9.8

[a]Means of pigs pooled across dietary carbadox levels.
[b]LG genotype effect, P<.01.
[c]LG genotype effect, P<.10.

Table 4. Impact of LG genotype and dietary carbadox on growth and carcass traits of pigs from 13 to 75 pounds bodyweight.

Criteri[a]	LG Genotype	Carbadox, ppm 0	55	Unit change
No. of pens	High	17	18	
	Low	16	17	
Pig weight, lb				
Initial	High	13	13	
	Low	14	14	
75 lb	High	77	79	
	Low	77	78	
Body growth and feed utilization				
Feed, lb/day[a]	High	2.15	2.26	+.11
	Low	2.43	2.42	-.01
Gain, lb/day[a]	High	1.16	1.34	+.18
	Low	1.23	1.26	+.03
Feed/Gain[b]	High	1.85	1.69	-.16
	Low	1.98	1.92	-.06
Tissue growth[e]				
Muscle, lb/day[a]	High	.42	.54	+.12
	Low	.42	.41	-.01
Fat, lb/day[c]	High	.10	.10	0
	Low	.15	.15	0
Muscle/fat[b]	High	4.20	5.40	+1.20
	Low	2.79	2.71	-.08
Carcass traits[e]				
Backfat, in[cd]	High	.31	.27	-.04
	Low	.63	.59	-.04
LEA, in2[ab]	High	2.40	2.67	+.27
	Low	2.05	2.11	+.06
Dissectible carcass tissue contente				
Muscle, %[f]	High	59.5	62.3	+2.8
	Low	55.3	53.8	-1.5
Fat, %[f]	High	14.8	12.5	-2.3
	Low	20.2	20.1	-0.1

[a]LG genotype x carbadox effect, P<.01.
[b]LG genotype x carbadox effect, P<.13.
[c]LG genotype effect, P<.01.
[d]Carbadox effect, P<.13
[e]Carcass data on one-half of the pigs.
[f]LG genotype x carbadox effect, P<.10.

Table 5. Impact of LG genotype and dietary carbadox (from 13 to 75 lb.) on growth and carcass traits of pigs from 13 to 250 pounds bodyweight.

Criteria	LG Genotype	Carbadox, ppm[a] 0-0	55-0[a]	Unit change
No. of pens	High	9	9	
	Low	8	9	
Pig weight, lb				
Initial	High	13	13	
	Low	14	14	
Final	High	253	256	
	Low	251	255	
Body growth and feed utilization				
Feed, lb/day[b]	High	4.90	4.92	+.02
	Low	5.09	5.09	+0
Gain, lb/day[b]	High	1.68	1.77	+.09
	Low	1.61	1.60	-.01
Feed/Gain[bc]	High	2.92	2.78	-.14
	Low	3.16	3.18	+.02
Tissue Growth				
Muscle, lb/day[d]	High	.65	.71	+.06
	Low	.51	.51	0
Fat, lb/day[b]	High	.36	.35	-.01
	Low	.43	.45	+.02
Muscle/fat[d]	High	1.80	2.03	+.23
	Low	1.19	1.13	-.06
Carcass traits				
Carc. yield, %	High	73.1	72.0	-1.1
	Low	72.1	73.0	+.9
Tenth rib, in[d]	High	1.08	.96	-.12
	Low	1.42	1.56	+.14
LEA, in[2d]	High	5.19	5.70	+.51
	Low	4.63	4.37	-.26
Dissectible tissue content				
Muscle, %[d]	High	54.4	56.2	+1.8
	Low	45.9	45.6	-.3
Fat, %[d]	High	29.1	27.0	-2.1
	Low	37.1	38.5	+1.4

[a]Pigs received carbadox from 13 to 75 pounds and then were placed in the control diet (o ppm carbadox) from 75 to 250 pounds bodyweight.
[b]LG genotype effect, P<.01.
[c]LG genotype x carbadox effect, P<.16
[d]LG genotype x carbadox effect, P<.09.