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Effects of zilpaterol hydrochloride supplementation on growth performance, carcass characteristics and production economics of steers differing in breed composition[1]

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SUMMARY

The β–adrenergic agonist zilpaterol hydrochloride (ZH) affects skeletal muscle growth, but little is known if this response is influenced by differences in genetic background of cattle. The objective of this study was to determine the effects of ZH on growth, carcass characteristics and production economic responses of Angus-sired (ANG) and SimAngus-sired (SIMANG) steers. Pens within each block × breed composition were randomly assigned to either ZH (8.3 ppm of DM; fed for the final 20 d before slaughter) or control (CON; 0 ppm ZH). Steers were ultrasounded before ZH inclusion and following withdrawal to determine the influence of ZH on change in ribeye area (REA), fat thickness and percent intramuscular fat (IMF). Carcass and feedlot performance data were collected and used to determine breed composition and ZH effects on economic responses. The interaction of breed composition × ZH had no influence on measured responses. Breed composition did not influence change in ultrasound measurements during the ZH feeding period or feedlot performance. Carcasses from SIMANG steers had larger REA and improved YG, while ANG steers had increased marbling scores. SimAngus-sired steers produced a greater percentage of YG 2 and a lower percentage of YG 3 carcasses than ANG steers. A greater proportion of ANG carcasses were classified as upper 2/3 Choice while a greater proportion of SIMANG carcasses were included in the lower 1/3 Choice designation. Carcass value per cwt was greater for ANG compared to SIMANG carcasses while other economic responses were similar. Feeding ZH improved ADG, YG, and REA and resulted in increased YG 2 carcasses. Total carcass value was greater for ZH compared to CON. While CON had increased IMF during ZH feeding, this did not manifest into differences in QG. Breed composition influenced carcass grid premiums, but not overall carcass value. Feeding ZH improved carcass value by increasing HCW. Responses among breed composition were as expected for ANG vs SIMANG cattle types. The resultant economic effect was that grid premiums for higher-grading ANG cattle were offset by larger HCW for SIMANG, leading to similar overall carcass values. Finally, the influence of ZH on growth and carcass traits was as expected with increased carcass value being realized through heavier HCW.

INTRODUCTION

Inclusion of the β–adrenergic agonist zilpaterol hydrochloride (ZH, Zilmax®, Merck Animal Health, Summit, NJ) in beef finishing diets has been shown to have dramatic effects on skeletal muscle growth. This shifts the composition of gain and results in improvements in ADG and F:G in the feedlot, as well as increases in dressing percentage, HCW and cutability of the carcass (Delmore et al., 2010). Much work

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has focused on the effects of feeding ZH to a single 'type' of cattle but our understanding of feeding ZH to cattle with differing breed compositions commonly used in the Northern Plains (Angus (ANG) and SimAngus (SIMANG) is limited.

Angus and SIMANG cattle have inherent differences in muscle and adipose composition that could result in differential responses to ZH. Therefore, the objective of this study was to determine the effect of ZH on growth performance, carcass characteristics and production economics of feedlot cattle with varied breed composition.

MATERIALS AND METHODS

Animals and Basal Diet

The South Dakota State University (SDSU) Institutional Animal Care and Use Committee approved all procedures involving animals. Cows at the SDSU Cottonwood and Antelope Research stations, of primarily Angus genetics, were artificially inseminated to 1 of 2 bulls. Bulls were either 100% Angus or 50% Angus × 50% Simmental from a common Angus sire (GAR Predestined, American Angus Association Registration Number 13395344). Purebred Angus clean-up bulls from the same sire were used to complete a 60-d breeding season. Steer progeny (n = 133) were transported post-weaning to the University of Nebraska Panhandle Research Center feedlot. Steers were fed a common 60% roughage:40% concentrate (DM basis) backgrounding diet for 45 d prior to the start of the project. At the start of the experiment, steers were fed a 45% roughage:55% concentrate diet and were adapted using 3 diets over a 63-d period to reach the final diet of 16% roughage:84% concentrate. Steers remained on this diet until marketed (97 d or 126 d). Diet ingredients were alfalfa hay, corn silage, wet distillers grains plus solubles (WDGS), dry rolled corn (DRC), and a supplement (supplement was formulated to include 0.3% urea and to provide a dietary DM inclusion of 0.3% salt, 60 ppm of Fe, 40 ppm of Mg, 25 ppm of Mn, 10 ppm of Cu, 1 ppm of I, 0.15 ppm of Se, 1.5 IU/g of vitamin A, 0.15 IU of vitamin D, 8.81 IU/kg of vitamin E. Monensin (Rumensin®, Elanco Animal Health, Indianapolis, IN) and tylosin (Tylan®, Elanco Animal Health) were fed at 360 and 90 $mg \cdot hd^{-1} \cdot d^{-1}$, respectively. Varying combinations of these ingredients were used to formulate least cost diets throughout the feeding period. All steers were implanted with 36 mg zeranol (Ralgro®, Merck Animal Health, Summit, NJ) at d -2 of trial initiation. Steers were re-implanted at 70 d with 200 mg trenbolone acetate and 40 mg estradiol (Revalor®-XS, Merck Animal Health, Summit, NJ).

Experimental Design and Treatments

Angus-sired (n=76) and SIMANG-sired (n=57) steers were allocated to a randomized incomplete block design with 4 blocks of ANG and 3 blocks of SIMANG. Treatments were arranged as a 2 × 2 factorial of sire breed and finishing diets fed with (ZH) or without (CON) ZH (8.3 ppm of DM) for 20 d prior to slaughter. Initial BW of 598.8 ± 41.6 lb and 610.1 ± 41.6 lb (least squares means ± SEM) for ANG and SIMANG, respectively, tended to differ (P = 0.082). Using initial BW as the blocking factor, steers were stratified by initial BW into blocks of four pens (9 or 10 steers per pen) with ZH treatment randomly assigned within each breed composition x block combination. The experimental design resulted in 4 BW blocks (3 complete and 1 incomplete with only 2 pens of ANG represented), 7 pen replicates per ZH treatment, 8 pen replicates of ANG, 6 pen replicates of SIMANG, 4 pen replicates of each ZH x ANG treatment combination, and 3 pen replicates of each ZH x SIMANG combination. Following a 3 d withdrawal from ZH, steers were marketed in 2 groups (153 d and 182 d on feed) when they were visually estimated to average 0.4 inch of 12th rib backfat thickness. The first group was the heaviest 2 blocks and the second group was the lightest 2 blocks, so all treatments were equally represented at each harvest date.

Ultrasound measurements

Real-time ultrasound measurements were collected and analyzed to determine 12th rib subcutaneous fat thickness, percent intramuscular fat (IMF) and ribeye area (REA) of each steer using an Aloka 500V instrument (Aloka, Wallingford, CT). Initial ultrasound measurements were collected 4 d prior to ZH inclusion and final measurements on the morning of harvest. Body weights were also collected at these time points. Differences (final – initial) in fat thickness, IMF, and REA were calculated to evaluate change in carcass composition during the ZH feeding period.

Slaughter and Carcass Data Collection

Final BW was measured when steers were ultrasounded on the morning of slaughter (final BW was adjusted by 4% to represent a standard shrink). Steers were transported approximately 123 miles to a commercial packing plant (Cargill, Fort Morgan, CO) where they were slaughtered under standard, humane harvest procedures. Carcasses were tracked through the harvest floor to maintain animal identification. Individual HCW were recorded at slaughter. Ribeye area, 12th rib backfat, and percentage KPH were recorded by university-trained personnel. Marbling score and QG were assigned by a USDA grader. Hot carcass weight, REA, 12th rib backfat, and KPH were then used to calculate USDA YG for each individual carcass.

Economic Analysis

Economic data were collected and analyzed to determine treatment differences in $/cwt carcass value, total carcass value per steer ($/steer), feed cost of gain (FCOG, $/lb), and return on feed ($/steer). Individual carcasses were priced on the Fort Morgan Angus America Marketing Agreement grid in place during the period these cattle were harvested. Carcass values ($/cwt and $/steer) were taken directly from closeout sheets for individual animals based on HCW, carcass quality and YG. Actual daily feed costs were determined and used to calculate FCOG, which was calculated as the pen mean of actual pen feed cost·head^{-1}·day^{-1}· divided by ADG. Feed costs make up the largest cost for finishing cattle; therefore the return on feed was used as a baseline net return comparison. Return on feed per head was calculated by subtracting total feed cost from total carcass value.

Statistical Analysis

One animal died during the treatment period and was excluded from the dataset. Continuous response variables, including growth, measured carcass traits, and economic responses were analyzed as a 2 × 2 factorial treatment structure in a randomized incomplete block design using the MIXED procedure of SAS (SAS Inst.Inc., Cary, NC). Pen served as the experimental unit and was included as a random effect. Breed composition, ZH treatment, and their interaction were included as fixed effects. The Kenward-Roger option was used to calculate denominator degrees of freedom. Least squares means were calculated, and because the ZH × breed composition interaction was never significant ($P > 0.05$), were separated by the F-tests of fixed effects. Because the QG and YG classifications of each carcass conform to binomial distributions, the proportion (number graded in the class divided by number in the pen) of carcasses in each grade classification were analyzed as binomial distributions in the GLIMMIX procedure of SAS using the same model as above.

RESULTS AND DISCUSSION

Zilpaterol hydrochloride is a potent beta-adrenergic agonist that elicits a compositional change by increasing muscle synthesis and decreasing adiposity of growing animals (Mersmann, 1998). Previous research has investigated the impact of ZH on performance and carcass characteristics within cattle of similar breed composition such as calf-fed Holsteins (Beckett et al., 2009); however, it is unknown whether cattle of different genetic backgrounds will respond differently to ZH. Therefore, the objective of this study was to determine whether cattle of different breed compositions common to the Northern Great Plains would have a differential response to ZH supplementation.

The ZH × breed composition interaction did not influence ($P > 0.05$) any of the feedlot performance, carcass, or economic traits evaluated in this study, therefore only the main effects of ZH treatment and breed composition are presented. Gruber et al. (2007) investigated the effects of ractopamine hydrochloride on feedlot steers of varying genetic backgrounds and reported no interaction between treatment and breed composition. Ractopamine hydrochloride functions to increase protein synthesis while ZH has been shown to both increase protein synthesis and decrease degradation resulting in increased REA, decreased fat thickness and higher yielding carcasses (Scramlin et al., 2010). The lack of interaction in the present study indicated that even though the steers differed in genetic background, they responded similarly to ZH.

Breed composition did not affect ($P > 0.05$) cumulative ADG, final BW, DMI, or F:G of steers (Table 1). Changes in ultrasound fat thickness, REA, percent IMF, and ADG during the ZH feeding period were not different ($P > 0.05$) between the breed compositions of cattle investigated in this study. These results indicate ANG and SIMANG cattle responded similarly in regard to deposition of the muscle and fat tissues evaluated over the ZH treatment period. Carcass evaluation revealed no difference ($P > 0.05$) in HCW between breed compositions; however, SIMANG had a larger ($P < 0.05$) REA and improved ($P < 0.05$) YG compared with ANG carcasses. Carcasses produced by SIMANG steers also tended to have reduced ($P < 0.10$) fat thickness. Marbling score was greater ($P < 0.01$) in ANG carcasses compared with SIMANG. SimAngus-sired steers produced a greater proportion ($P < 0.05$) of YG 2 and lower proportion of YG 3 ($P < 0.05$) carcasses than ANG steers (Table 2). A greater proportion ($P < 0.05$) of ANG carcasses were classified as upper 2/3 Choice and there was a trend for a greater proportion ($P < 0.15$) of ANG carcasses grading Prime. There was no difference ($P > 0.05$) in the number of carcasses grading Select. However, there was an increase ($P < 0.05$) in the proportion of SIMANG carcasses classified in the lower 1/3 of the Choice grade compared with ANG. Carcass value per cwt was greater for ANG than SIMANG ($P < 0.01$) because of premiums on the grid for higher quality-grading carcasses. However, overall carcass value per head was similar ($P = 0.61$) as a result of greater value per cwt for ANG carcasses multiplied by numerically lower HCW for ANG than SIMANG carcasses. Feed cost of gain and return on feed were not ($P > 0.44$) influenced by breed composition.

Supplementation with ZH for 20 d prior to slaughter improved ($P < 0.05$) ADG during the ZH feeding period, did not affect ($P > 0.05$) overall ADG or DMI over the entire feeding period, but tended to improve ($P = 0.07$) overall F:G (Table 1). Supplementation with ZH had no effect ($P > 0.05$) on final BW. The difference between ultrasound measurements taken 4 d prior to ZH supplementation and on the day of slaughter revealed ZH treated cattle tended ($P < 0.10$) to gain more REA during the treatment period compared with CON while CON cattle accumulated more ($P < 0.01$) intramuscular fat than ZH. Fat thickness between the initial and final ultrasound was not different ($P > 0.05$) between treatments. Carcasses from ZH treated steers tended to have heavier ($P < 0.10$) HCW than CON steers as well as increased ($P < 0.001$) REA and improved ($P < 0.05$) YG. Despite greater accretion of IMF during the ZH feeding period, CON carcasses had similar ($P > 0.10$) marbling scores to ZH carcasses. In agreement with similar change between treatments in ultrasound fat thickness during the ZH feeding period, carcass backfat thickness was similar ($P > 0.10$) between ANG and SIMANG. Additionally steers supplemented with ZH produced a greater ($P < 0.05$) percentage of YG 2 carcasses and tended to produce fewer ($P < 0.10$) YG 3 than CON fed steers (Table 2). Supplementation with ZH did not affect ($P = 0.58$) distribution of QG compared to CON carcasses. Steers supplemented with ZH produced carcasses with increased total value ($P < 0.05$) compared to CON; however, there were no differences ($P > 0.10$) between treatments for price per cwt, FCOG, or return on feed.

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Table 1. Least squares means and SEM for performance trait responses to main effects of cattle breed composition and zilpaterol hydrochloride (ZH)[1] supplementation[2]

Item	Breed Composition		ZH, ppm of DM				
	Angus	SimAng	0	8.3	SEM	*P* > F[3]	*P* > F[4]
ADG, initial-final, lb	3.83 ± 0.165[5]	3.87 ± 0.180	3.76	3.94	0.172	0.790	0.198
Final BW, lb[6]	1224.7 ± 28.8	1241.9 ± 31.0	1221.4	1245.0	29.7	0.451	0.281
DMI, $lb \cdot steer^{-1} \cdot d^{-1}$	21.91 ± 1.274	22.13 ± 1.285	22.15	21.89	1.278	0.574	0.423
F:G, $lb \cdot lb^{-1}$	5.81 ± 0.520	5.72 ± 0.532	5.98	5.55	0.524	0.705	0.071
Fat change[7], in	0.04 ± 0.015	0.03 ± 0.017	0.04	0.03	0.016	0.677	0.490
REA change[7], cm^2	1.1 ± 0.46	0.7 ± 0.49	0.6	1.2	0.47	0.298	0.092
IMF change[7], %	0.29 ± 0.188	0.39 ± 0.207	0.61	0.07	0.195	0.583	0.010
ADG, ZH feeding period, lb	2.31 ± 0.191	2.44 ± 0.233	1.96	2.79	0.209	0.674	0.017
HCW, lb	787.2 ± 17.8	796.6± 18.9	778.4	805.4	18.3	0.475	0.052
REA, cm^2	13.7 ± 0.28	14.3 ± 0.30	13.4	14.6	0.29	0.028	0.001
Yield grade	2.95 ± 0.079	2.62 ± 0.091	2.96	2.60	0.086	0.020	0.014
Fat thickness, in	0.58 ± 0.025	0.51 ± 0.02	0.57	0.53	0.027	0.093	0.369
Marbling score[8]	592.5 ± 22.4	486.2 ± 24.4	544.4	534.4	23.1	0.001	0.581
$/cwt[9]	210.43 ± 2.47	207.69 ± 2.50	209.03	209.09	2.48	0.009	0.938
Carcass Value, $/steer	1672.81 ± 50.50	1658.65 ± 52.30	1633.32	1698.13	51.19	0.617	0.038
Feed COG[10], $/lb	0.199 ± 0.017	0.194 ± 0.017	0.197	0.196	0.017	0.443	0.922
Return on feed, $/steer	1043.32 ± 43.22	1047.73 ± 46.37	1029.44	1061.61	44.39	0.896	0.322

[1] Zilpaterol hydrochloride was administered during the final 20 d of the finishing period.

[2] The breed composition × ZH interaction did not affect (*P* > 0.05) any performance traits.

[3] Probability of a greater F value for the main effect of breed composition.

[4] Probability of a greater F value for the main effect of ZH treatment.

[5] LS mean ± SEM

[6] Final BW were adjusted by 4% as per standard industry shrink.

[7] Change in ultrasound backfat thickness (FT), ribeye area (REA), and intramuscular fat (IMF) during the 20-d ZH feeding period.

[8] 400 = Slight^0; 500 = Small^0; 600 = Modest^0

[9] Weighted mean grid price per cwt of HCW.

[10] Feed cost of gain

Table 2. Least squares means and SEM for proportion of carcasses in each USDA YG and QG in response to main effects of breed composition and zilpaterol hydrochloride (ZH)[1] supplementation[2]

	Breed Composition		**ZH, ppm of DM**			
Item	**Angus**	**SimAngus**	**0**	**8.3**	***P* > F[3]**	***P* > F[4]**
Calculated USDA YG[5]						
2	0.2785 ± 0.060	0.5726 ± 0.074	0.3015 ± 0.066	0.5450 ± 0.070	0.016	0.034
3	0.6872 ± 0.074	0.4020 ± 0.062	0.6501 ± 0.081	0.4429 ± 0.085	0.019	0.059
USDA QG[6]						
Prime	0.1224 ± 0.039	0.0351 ± 0.024	0.0837 ± 0.042	0.0526 ± 0.029	0.140	0.558
Upper ⅔ Choice	0.6843 ± 0.053	0.3308 ± 0.063	0.5151 ± 0.064	0.5023 ± 0.069	0.006	0.895
Lower ⅓ Choice	0.1292 ± 0.039	0.5297 ± 0.068	0.2527 ± 0.062	0.3308 ± 0.066	0.002	0.413
Select	0.0496 ± 0.029	0.1232 ± 0.061	0.0789 ± 0.042	0.0788 ± 0.042	0.208	0.998

[1] ZH was administered during the final 20 d of the finishing period.

[2] The breed composition × ZH interaction did not affect ($P > 0.05$) USDA yield and quality grades.

[3] Probability of a greater F value for the main effect of breed composition.

[4] Probability of a greater F value for the main effect of ZH treatment.

[5] Only YG 2 and 3 are reported herein because none of the carcasses graded YG 1 or 5, and only 2 Angus carcasses that did not receive ZH graded YG 4.

[6] None of the carcasses graded Standard or lower.