EFFECTS OF ZILPATEROL HYDROCHLORIDE AND DAYS ON THE FINISHING DIET ON FEEDLOT PERFORMANCE, CARCASS CHARACTERISTICS, AND TENDERNESS IN BEEF HEIFERS

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Effects of zilpaterol hydrochloride and days on the finishing diet on feedlot performance, carcass characteristics, and tenderness in beef heifers[1]

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ABSTRACT: British × Continental heifers (n = 3,382; initial BW = 307 kg) were serially slaughtered to determine if increasing days on the finishing diet (DOF) mitigates negative consequences of zilpaterol HCl (ZH) on quality grade and tenderness of beef. A 2 × 3 factorial arrangement of treatments in a completely randomized block design (36 pens; 6 pens/treatment) was used. Zilpaterol HCl (8.33 mg/kg DM) was fed 0 and 20 to 22 d before slaughter plus a 3 to 5 d withdrawal to heifers spending 127, 148, and 167 DOF. Feedlot and carcass performance data were analyzed with pen as the experimental unit. Three hundred sixty carcasses (60 carcasses/treatment) were randomly subsampled, and strip loin steaks were aged for 7, 14, and 21 d for assessment of Warner-Bratzler shear force (WBSF) and slice shear force (SSF) with carcass serving as the experimental unit for analysis. No relevant ZH × DOF interactions were detected ($P > 0.05$). Feeding ZH during the treatment period increased ADG by 9.5%, G:F by 12.5%, carcass ADG by 33.6%, carcass G:F by 35.9%, carcass ADG:live ADG by 15.6%, HCW by 3.2% (345 vs. 356 kg), dressing percent by 1.5%, and LM area by 6.5% and decreased 12th-rib fat by 5.2% and yield grade (YG) by 0.27 units ($P < 0.01$). Feeding ZH tended to decrease marbling score (437 vs. 442 units; $P = 0.10$) and increased WBSF at 7 (4.25 vs. 3.47 kg; $P < 0.01$), 14 (3.57 vs. 3.05 kg; $P < 0.01$), and 21 d (3.50 vs. 3.03 kg; $P < 0.01$). Feeding ZH decreased empty body fat percentage (EBF; 29.7% vs. 30.3%; $P < 0.01$) and increased 28% EBF adjusted final BW (473.4 vs. 449.8 kg; $P < 0.01$). Analysis of interactive means indicated that the ZH × 148 DOF group had a similar percentage of USDA Prime, Premium Choice, Low Choice, and YG 1, 2, 3, 4, and 5 carcasses ($P > 0.10$) and decreased percentage of Select (30.4 vs. 36.6%; $P = 0.03$) and Standard (0.2 vs. 0.9%; $P = 0.05$) carcasses compared with the control × 127 DOF group. As a result of ZH shifting body composition, extending the DOF of beef heifers is an effective feeding strategy to equalize carcass grade distributions. This can be accomplished along with sustaining the ZH mediated advantages in feedlot and carcass weight gain.

Key words: beef heifers, beta agonist, days on feed, zilpaterol hydrochloride

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INTRODUCTION

Zilpaterol hydrochloride (**ZH**; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) is an exogenous β-adrenergic agonist that physiologically mimics the actions of naturally occurring catecholamines. Zilpaterol hydrochloride is approved by the U.S. Food and Drug Administration (New Animal Drug Application 141-258) to be fed to confined cattle at a rate of 8.3 mg/kg during the final 20 to 40 d before slaughter with a mandatory 3 d minimal withdrawal period. Numerous studies have documented the potent effects of ZH to promote skeletal muscle growth, thereby shifting compositional gain (Delmore et al., 2010). In turn, feedlot performance advantages in improvement of ADG and G:F are captured. Increases in dressing percentage, HCW, and cutability improving factors are realized in the carcass. The attributes of ZH that require more precise management are a resulting

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decrease in marbling score due presumably to a dilution effect of increased LM area (**LMA**) size and tenderness, as measured by shear force effect, due to skeletal muscle fiber hypertrophy (Kellermeier et al., 2009).

Many studies have focused on steers fed ZH, but only a few have reported data from beef heifers (Montgomery et al., 2009a; Robles-Estrada et al., 2009). Differences between sexes in ZH response would be expected due to their inherent differences in compositional growth. Also, investigations into feedlot management strategies that can mitigate the negative ZH effects have been limited to extension of the withdrawal period (Robles-Estrada et al., 2009; Shook et al., 2009; Holland et al., 2010), but more strategies should be considered. Consequently, the objectives of this study are 2-fold: 1) determine the impact of ZH and days on the finishing diet (**DOF**) in beef heifers on feedlot performance, carcass performance, carcass characteristics, and tenderness and 2) determine if extending DOF of heifers fed ZH alleviates negative consequences of ZH along with capturing the beneficial ZH advantages.

MATERIALS AND METHODS

Research procedures involving live cattle handling at Cactus Research Ltd. (Cactus, TX) abided by standards set forth by the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (Federation of Animal Science Societies, 1999).

Live Cattle Procedures

Cattle Procurement and Processing. A total of 3,857 heifers were sourced from stocker operations and sale barns originating in South Dakota, Kansas, Nebraska, Oklahoma, Missouri, Colorado, and Iowa. Phenotypically, heifers were predominately black-hided, appeared to be of British × Continental breeding, and were medium to large framed. Heifers were received at Cactus Research Ltd. from January 8 to January 11, 2008. Upon arrival, heifers were grouped by arrival date and seller and provided a 60% concentrate diet and limited quantities of chopped alfalfa hay until they were randomized to study pens. Heifers appearing to deviate drastically from the mean BW of the pen were culled from the study by pen riders before randomization while the heifers were still in their arrival pen. Initial processing procedures included recording of an individual BW, placement of a uniquely numbered ear tag, vaccination with a modified live virus vaccine (Vista 3 SQ; Intervet Schering Plough Animal Health), treatment with an internal (Safe-Guard Oral Suspension; Intervet Schering Plough Animal Health) and external (Ivomec Pour-On; Merial, Duluth, GA) parasiticide, administration of an antibiotic (Micotil; Elanco Animal Health, Greenfield, IN) to control bovine respiratory disease, and implanted with Revalor-IH (80 mg trenbolone acetate + 8 mg estradiol; Invervet Schering Plough Animal Health). Heifers were reimplanted with Revalor-H (140 mg trenbolone acetate + 14 mg estradiol; Invervet Schering Plough Animal Health) 76 to 78 d before slaughter.

Experimental Design. A completely randomized block design with 6 blocks and 6 treatments in a 2 × 3 factorial arrangement was used. Each block consisted of 6 adjacent pens of heifers with a similar arrival date and origin. The number of heifers randomly allotted to a pen (77 to 106) was adjusted to allow 24.1 cm of feed bunk space and at least 14.4 m^2 of pen space per heifer. Treatments were randomly assigned to pens (6 pens/treatment) within blocks. The treatments imposed were ZH (8.33 mg/kg of dietary DM; Zilmax, Intervet Schering Plough Animal Health) feeding (0 and 20 to 22 d directly before slaughter plus a 3 to 5 d withdrawal) and DOF (127, 148, and 167 d). After randomization and culling techniques were completed, a total of 3,382 heifers participated in the study.

Feeding Procedures. On d 0 of the study, each block of heifers was started on a 60% concentrate receiving diet and then systematically transitioned to an approximately 90% concentrate finishing diet by d 37. All pens within a block followed the same transition schedule. Feed was delivered to each pen 3 times daily (0600, 0900, and 1230 h) during the transition period and 2 times daily (0600 and 1230 h) during the finishing phase by trucks fitted with mixer boxes (Roto-Mix Mfg., Dodge City, KS) mounted on load cells. Feed delivery to the bunk was computerized (Read-N-Feed, Micro Beef Technologies, Amarillo, TX), and feeding amounts were recorded and maintained electronically. The feeding management strategy was to provide ad libitum feed access with the objective of having all feed consumed by the first morning feeding. Daily feed calls were based upon feed bunk inventory at 0530, 1800, and 2100 h and the behavior of the heifers at the first morning feeding. Feed samples were acquired from the bunk immediately after feed delivery after the morning feeding cycle. One subsample was dried in a forced-air oven at 100°C for DM determination, and another subsample was retained and frozen. Retained samples were composited monthly and submitted to Servi-Tech Laboratories (Amarillo, TX) for nutrient analysis. Diets were mixed in a horizontal paddle mixer, and microingredients were added using a microweigh machine (Micro Beef Technologies). Once the treatment period began for each serial slaughter group, 2 diets were fed: 1) a control diet (no ZH) and 2) a diet containing 8.33 mg/kg (DM basis) of ZH. Irrespective of the treatment diet assigned, the 90% concentrate finishing diet always contained monensin (Rumensin; Elanco Animal Health), tylosin (Tylan; Elanco Animal Health), and melengestrol acetate (MGA 500; Pfizer Animal Health, New York, NY) for the duration of the study. Zilpaterol hydrochloride was withdrawn from the treatment diet 5 d before slaughter in the 127 DOF slaughter group and 3 d before slaughter in the 148 and 167 DOF slaughter groups. Diets were formulated to meet or exceed NRC (1996) nutrient recommendations for growing and finishing heifers. Formulated diet composition and analyzed nutrient analysis of the finishing diets are presented in Table 1.

Weighing Procedures. Three different BW measurements (initial, interim, and final) were recorded during the actual study period. All BW measurements were based upon a group weight (2 or 3 drafts per pen) on a platform scale (readability ± 45.4 kg). The pen weight was then divided by the number of heifers in the pen to establish the BW of each heifer in the pen. The initial BW (d 0) was recorded within 1 to 3 d after initial processing of each block and was left unshrunk for analysis. The interim weights were recorded 29, 34, and 32 d before slaughter for the 127, 148, and 167 DOF slaughter groups, respectively. The final BW was recorded immediately before the shipment of heifers to Tyson Fresh Meats in Amarillo, TX. Heifers were fed at 25% of the quantity of feed fed the previous day at the morning feeding on the day of shipment. In all cases, every pen had consumed the entire amount fed before weighing on the final day. The interim and final BW measurements were multiplied by 0.96 to adjust for gastrointestinal fill (NRC, 1996).

Table 1. Formulated composition and analyzed chemical composition (DM basis) of the finishing diets

	Treatment[1]	
Item	Control	ZH
Ingredient		
Steam-flaked corn, %	73.31	73.29
Dried corn distillers grains, %	10.00	10.00
Corn silage, %	9.59	9.59
Animal fat, %	3.04	3.04
Finisher supplement,[2] %	4.04	4.04
Microingredients,[3] %	0.03	0.05
Chemical compostion		
DM, % as-fed	70.80	70.93
CP, %	13.68	14.23
NPN, CP equivalent, %	3.23	3.17
NDF, %	13.77	13.13
Fat, %	6.88	7.40
Ca, %	0.71	0.69
P, %	0.35	0.36
K, %	0.68	0.65
Mg, %	0.21	0.20

[1]The control diet represents the finishing diet fed for the duration of the study period, and the zilpaterol hydrochloride (ZH; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) diet represents the finishing diet fed to the appropriately prescribed treatment pens during the period in which ZH was included in the diet.

[2]The finisher supplement was formulated to contain (DM basis) 82.2% CP, 77.0% NPN, 11.52% Ca, 0.19% P, 4.8% K, and 6.9% salt.

[3]Microingredients were added to the diet using a microweigh machine (Micro Beef Technologies, Amarillo, TX). Monensin [Rumensin, Elanco, Greenfield, IN; 321 mg/(animal·d)], tylosin [Tylan, Elanco; 90 mg/(animal·d)], melengesterol acetate [MGA 500, Pfizer, New York, NY; 0.4 mg/(animal·d)], vitamin A [29,000 IU/(animal·d)], vitamin D [2,900 IU/(animal·d)], and vitamin E [100 IU/(animal·d)] were added into the control and ZH treatment diets. Only the ZH treatment diet contained ZH [73 mg/(animal·d)].

Carcass Procedures

Carcass Evaluation. Carcass measurements were obtained by personnel from the West Texas A&M University Beef Carcass Research Center at the Tyson Fresh Meats slaughtering facility in Amarillo, TX, after carcasses were chilled for 24 to 36 h postmortem and then ribbed at the 12th- and 13th-rib interface by plant personnel. Carcass measurements taken were HCW, LMA, estimated percentage of KPH, 12th-rib fat (based upon the adjusted preliminary yield grade), and marbling score. The marbling score was used to determine a USDA quality grade, and a calculated yield grade was determined according to standards set forth by the USDA (1997).

Tenderness Evaluation. Tenderness was assessed by both Warner-Bratzler Shear Force (**WBSF**) and slice shear force (**SSF**) analyses. Three-hundred and sixty carcasses (60 carcasses/treatment) were randomly selected for tenderness evaluation from 2 pens within each ZH × DOF treatment group. At 48 h postmortem, the left side of each of the randomly selected carcasses were followed through the plant fabrication floor, and the boneless strip loin (Institutional Meat Purchase Specifications, IMPS 180) was obtained, vacuum sealed, and sent to the Texas Tech University Gordon W. Davis Meat Science Laboratory for storage at 2°C to 4°C. At d 7 postmortem, six 2.54-cm-thick steaks from each boneless strip loin were cut. Two steaks per aging treatment (one for WBSF and one for SSF assessment) were randomly chosen to be aged for 7, 14, and 21 d at 4°C and then frozen at −20°C. At a later date, steaks were thawed for 24 h at 4°C and then cooked on a belt grill to a medium degree of doneness (internal temperature of 68°C to 71°C). Steaks were cooled at 4°C for 24 h before shearing. For WBSF evaluation, six 1.3-cm-diameter cores were taken from each steak parallel to the orientation of the muscle fibers. Each core was sheared perpendicular to the muscle fiber using a WBSF instrument (GR Electric Mfg., Manhattan, KS). The 6 subsample WBSF values were then averaged for statistical analysis. Slice shear force analysis was performed on 3 different locations across each steak, and an average SSF value was obtained. Slice shear force values were obtained by removing a 1-cm-thick, 5-cm-long slice from the lateral, middle, and medial ends of each steak and sheared using a United testing instrument (United Calibration Corporation and United Testing Systems Inc., Huntington Beach, CA) with a cross-head speed of 500 mm/min and a load cell of 50 kg.

Purge. On d 7 postmortem, each strip loin was weighed while still in the package. Afterward, each strip loin was removed from the vacuum package, blotted with a towel to remove surface moisture, and weighed to acquire the actual boneless strip loin weight. Each vacuum package was dried in an oven at 90°C for 2 h, after which the bag was weighed. Percent purge was calculated as the weight of the boneless strip loin in the vacuum packaging minus the total weight of the dried bag and boneless strip loin divided by the weight of the boneless strip loin in the vacuum packaging and multiplied by 100.

Statistical Analyses

Interim and final BW were multiplied by 0.96 for all analyses. All dead and removed cattle were excluded from analyses. Factors used to calculate carcass ADG, carcass F:G, and carcass ADG:live ADG were derived by applying a 58% standard dressing percent to the initial BW, and the interim shrunk BW was multiplied by the estimated interim dressing percent = 51.46522 + 0.02468 × DOF + 0.43775 × DMI. The estimated interim dressing percent prediction equation ($r^2 = 0.66$) was derived from the pens of heifers not fed ZH. Empty BW, empty body fat percentage, and final shrunk BW adjusted to a 28% empty body fat were calculated as outlined by Guiroy et al. (2002).

Feedlot performance, estimated carcass performance on a live basis, and carcass trait data were analyzed as a 2 × 3 completely randomized block design using the MIXED procedure (SAS Inst. Inc., Cary, NC) with pen serving as the experimental unit. The days on ZH, DOF, and ZH × DOF interaction were treated as fixed effects, whereas block was treated as a random effect in the model. Animal served as the experimental unit for analysis of SSF, WBSF, and purge data because strip loins were randomly subsampled at the time of slaughter. Frequency distributions of carcasses within specific quality and yield grade categories as well as WBSF tenderness categories (<3.0, 3.4, 4.0, 4.3, and 4.9 kg) were analyzed as binomial proportions using the GLIMMIX procedure of SAS.

RESULTS AND DISCUSSION

The objectives of the study were 2-fold: 1) determine the impact of ZH and DOF in beef heifers on feedlot performance, carcass performance, carcass characteristics, and tenderness and 2) determine if extending DOF of heifers fed ZH alleviates negative consequences of ZH along with capturing the beneficial ZH advantages. Consequently, results and discussion of the main effects will be presented to address the first objective, followed by the results and discussion of simple effects to address the second objective.

Main Effects

Feedlot Performance. Live performance data for the pretreatment period, treatment period, and entire trial period are displayed in Table 2. No ZH × DOF interactions were detected for any live performance parameters ($P \geq 0.17$), with the exception of a tendency for DMI during the treatment period ($P = 0.07$). During the pretreatment period, there were no differences noted between the control and ZH treatment groups for ADG, DMI, and G:F ($P \geq 0.94$), suggesting that there were no inherent live performance advantages favoring 1 group or the other before introduction of treatments. During the treatment period (29 to 34 d before harvest), ZH increased ADG by 9.5% (0.14 kg; $P < 0.01$), decreased DMI by 2.0% (0.18 kg; $P < 0.01$), and improved G:F by 12.5% (0.02; $P < 0.01$). During the entire trial period (pretreatment period plus the treatment period), heifers fed ZH achieved an increase in ADG by 2.5% (0.04 kg; $P < 0.01$), had no change in DMI ($P = 0.39$), and saw an improvement in G:F by 2.2% (0.004; $P < 0.01$). Ultimately, the final BW of the ZH-fed groups was increased by 0.8% (4.3 kg; $P = 0.02$).

Although the magnitude of the ZH response varies in beef cattle, it is clear that an increase in ADG and improvement in G:F is routinely achieved in both this study and others with either no change or a minimal decrease in DMI (Delmore et al., 2010). Large-pen steer studies have revealed ADG increases of 15.5% (Elam et al., 2009; 0 vs. 20 d ZH groups) and 13.8% (Montgomery et al., 2009b; 0 vs. 30 d ZH group) during the treatment period. Likewise, these studies documented an improvement in G:F by 16.2% and 18.4%, respectively. Montgomery et al. (2009b) detected a 3.4% decrease in DMI, but Elam et al. (2009) reported no difference. In another study, Montgomery et al. (2009a) reported performance results of both steers and heifers at similar sites (3 sites total) in small-pen experimental conditions. When comparing the control and 20 d ZH cattle during the treatment period, steers had increased ADG by 43.5% and heifers by 18.3%. Likewise, steers had improved G:F by 46.7% and heifers by 25.4%. Dry matter intake was reduced in both sexes (1.9% in steers and 5.7% in heifers). When considering these data and the results of the current study relative to large-pen steer studies, it would appear that although the ZH growth response is consistent in both sexes, it maybe more mod-

Table 2. Feedlot performance of beef heifers fed zilpaterol hydrochloride (ZH) over varied days on the finishing diet (DOF)

	Days on ZH[1]			DOF[2]				*P*-value		
Item	0	20	SEM[3]	127	148	167	SEM[3]	ZH	DOF	ZH × DOF
Initial BW, kg	307.3	306.7	3.42	305.3	307.2	308.5	3.46	0.59	0.07	0.26
Interim BW, kg	496.4	496.1	3.66	472.1[a]	490.8[b]	525.8[c]	3.80	0.86	<0.01	0.68
Final BW, kg	542.8	547.1	3.92	518.7[a]	547.5[b]	568.8[c]	4.02	0.02	<0.01	0.92
Pretreatment period										
ADG, kg	1.64	1.64	0.01	1.70[b]	1.61[a]	1.61[a]	0.02	0.97	<0.01	0.58
DMI, kg/d	8.61	8.61	0.06	8.51[a]	8.59[a]	8.73[b]	0.07	0.94	<0.01	0.72
G:F	0.191	0.191	0.001	0.200[b]	0.187[a]	0.184[a]	0.001	0.98	<0.01	0.21
Treatment period										
ADG, kg	1.47	1.61	0.03	1.61[b]	1.67[b]	1.34[a]	0.03	<0.01	<0.01	0.17
DMI, kg/d	9.15	8.97	0.04	9.31[c]	9.15[b]	8.72[a]	0.05	<0.01	<0.01	0.07
G:F	0.160	0.180	0.003	0.173[b]	0.183[c]	0.154[a]	0.003	<0.01	<0.01	0.18
Entire trial period										
ADG, kg	1.60	1.64	0.01	1.68[c]	1.62[b]	1.56[a]	0.01	<0.01	<0.01	0.40
DMI, kg/d	8.73	8.69	0.05	8.70	8.72	8.73	0.06	0.39	0.83	1.00
G:F	0.184	0.188	0.001	0.193[c]	0.186[b]	0.179[a]	0.001	<0.01	<0.01	0.34

[a–c]DOF means within a row without a common superscript differ ($P < 0.05$).

[1]Treatment diets were formulated to contain no ZH (0 d) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) for the final 20 d before slaughter.

[2]Heifers were finished for a period of 127, 148, and 167 d on the finishing diet before slaughter.

[3]Standard error of treatment means (days on ZH, n = 18 pens/main-effect mean; DOF, n = 12 pens/main-effect mean).

est in heifers. Physiologically, this would be a rational hypothesis given the inherent differences in live performance expected between steers and heifers independent of administration of any growth-enhancing agents.

Estimated Carcass Performance on a Live Basis. Estimated carcass performance data for the pretreatment period, treatment period, and entire trial period are displayed in Table 3. No ZH × DOF interactions were detected for any carcass performance traits ($P \geq 0.18$). During the pretreatment period, there was no difference between the control and ZH groups for carcass ADG, carcass G:F, and the proportion of live ADG which is carcass ADG ($P \geq 0.97$), implying that no inherent differences existed in estimated carcass performance before the initiation of treatments. During the treatment period, heifers fed ZH had increased carcass ADG by 33.6% (0.36 kg; $P < 0.01$), improved carcass G:F by 35.9% (0.042; $P < 0.01$), and increased carcass ADG as a proportion of live ADG by a margin of 15.6% ($P < 0.01$). Over the entire trial period (pretreatment period plus the treatment period), the ZH-fed heifers maintained an increase in carcass ADG by 6.1% (0.07 kg; $P < 0.01$), an improvement in carcass G:F by 7.7% (0.01; $P < 0.01$), and increased carcass ADG as a proportion of live ADG by a margin of 3.3% ($P < 0.01$). By the end of the trial, heifers that had been fed ZH had reduced empty body fat percentage by 0.57% when compared with control groups with an equivalent number of DOF ($P < 0.01$), which resulted in a 28% (23.6 kg; $P < 0.01$) heavier adjusted final BW.

In a review of ZH-related trials, Delmore et al. (2010) concluded that, on average, ZH-fed steers documented a 9 kg heavier BW but uniquely captured a greater increase in HCW of 15 kg. In the current study, heifers reported a heavier BW by 4.3 kg and a heavier HCW by 11.1 kg. Independent of sex, it is clear that ZH impacts carcass tissue gain to a greater degree than total BW tissue growth. Dramatic improvements in carcass cutout yields have consistently demonstrated this point (Hilton et al., 2009; Kellermeier et al., 2009; Rathmann et al., 2009; Shook et al., 2009). From a practical standpoint, it would consequently be more critical to be aware of changes in carcass performance on a live basis then routinely measured live BW performance variables before slaughter. Using similar calculations to the current study, Leheska et al. (2009) reported nearly identical results in that heifers fed ZH for 20 d had a reduced empty body fat percentage by 0.62% and a 28% heavier adjusted final BW by 26 kg. Steers fed ZH 20 d had a reduced empty body fat percentage by 1.04% and a 28% heavier adjusted final BW by 35 kg (Leheska et al., 2009). It is apparent that because ZH shifts body composition, associated benefits are achieved in carcass F:G. Moreover, the current study is the first to highlight the dramatic ZH-induced increase in the proportion of carcass ADG as a proportion of live ADG at the conclusion of the feeding period. Collectively, these observations would appear to lend flexibility to extending DOF in ZH-fed cattle without immediate worries of diminishing efficiency ratios, especially from a carcass weight gain standpoint.

Table 3. Estimated carcass performance on a live basis of beef heifers fed zilpaterol hydrochloride (ZH) over varied days on the finishing diet (DOF)[1]

	Days on ZH[2]			DOF[3]				*P*-value		
Item	0	20	SEM[4]	127	148	167	SEM[4]	ZH	DOF	ZH × DOF
Pretreatment period										
Carcass ADG, kg	1.15	1.15	0.01	1.19[b]	1.13[a]	1.14[a]	0.01	0.97	<0.01	0.74
Carcass G:F	0.134	0.134	0.001	0.139[b]	0.132[a]	0.130[a]	0.001	0.99	<0.01	0.27
Carcass ADG:live ADG, %	70.2	70.2	0.17	69.6[a]	70.2[b]	70.6[c]	0.18	0.99	<0.01	0.28
Treatment period										
Carcass ADG, kg	1.07	1.43	0.02	1.29[b]	1.35[b]	1.10[a]	0.03	<0.01	<0.01	0.66
Carcass G:F	0.117	0.159	0.002	0.139[b]	0.150[c]	0.127[a]	0.003	<0.01	<0.01	0.62
Carcass ADG:live ADG, %	73.1	88.7	1.20	80.4	80.5	81.7	1.34	<0.01	0.61	0.18
Entire Trial Period										
Carcass ADG, kg	1.14	1.21	0.01	1.21[c]	1.18[b]	1.13[a]	0.01	<0.01	<0.01	0.96
Carcass G:F	0.130	0.140	0.001	0.139[c]	0.136[b]	0.130[a]	0.001	<0.01	<0.01	0.94
Carcass ADG:live ADG, %	70.8	74.1	0.28	72.0	72.7	72.5	0.31	<0.01	0.09	0.34
Empty body fat,[5] %	30.28	29.71	0.22	28.75[a]	30.22[b]	31.00[c]	0.23	<0.01	<0.01	0.27
EBW,[6] kg	486.2	500.8	3.52	467.5[a]	496.7[b]	516.25[c]	3.66	<0.01	<0.01	0.95
28% adjusted final BW,[7] kg	449.8	473.4	3.22	455.4[a]	461.1[a]	468.3[b]	3.43	<0.01	<0.01	0.19

[a–c]DOF means within a row without a common superscript differ ($P < 0.05$).

[1]Factors used to calculate carcass ADG, carcass F:G, and carcass ADG:live ADG were derived by applying a 58% standard dressing percent to the initial BW, and the interim shrunk BW was multiplied by the estimated interim dressing percent = 51.46522 + 0.02468 × DOF + 0.43775 × DMI. The estimated interim dressing percent prediction equation ($r^2 = 0.66$) was derived from the pens of heifers not fed ZH.

[2]Treatment diets were formulated to contain no ZH (0 d) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) for the final 20 d before slaughter.

[3]Heifers were finished for a period of 127, 148, and 167 d on the finishing diet before slaughter.

[4]Standard error of treatment means (days on ZH, n = 18 pens/main-effect mean; DOF, n = 12 pens/main-effect mean).

[5]Empty body fat (%) = 17.76207 + (4.68142 × 12th-rib fat) + (0.01945 × HCW) + (0.81855 × quality grade) − (0.06754 × LM area). The numerical quality grade value was assigned on the basis of the marbling score quality grade such that Standard = 3 to 4, Select = 4 to 5, low Choice = 5 to 6, average Choice = 6 to 7, high Choice = 7 to 8, low Prime = 8 to 9, and average Prime = 9 to 10; Guiroy et al. (2002).

[6]Empty BW = (1.316 × HCW) + 32.29; Guiroy et al. (2002).

[7]Shrunk BW adjusted to a 28% empty body fat = empty BW + [(28 – empty body fat) × 14.26]/0.891; Guiroy et al. (2002).

Carcass Traits. A summary of the carcass characteristics data is presented in Table 4. No ZH × DOF interactions were detected for any of the analyzed carcass traits ($P \geq 0.35$); however, there was a tendency for a 12th-rib fat ZH × DOF interaction ($P = 0.09$). Heifers fed ZH had increased HCW by 3.2% (11.1 kg; $P < 0.01$), increased dressing percentage by a margin of 1.52% ($P < 0.01$), increased LMA by 6.5% (5.6 cm^2; $P < 0.01$), increased LMA per 45.4 kg of HCW by 3.2% (0.36 cm^2/45.4 kg HCW; $P < 0.01$), decreased 12th-rib fat by 5.2% (0.08 cm; $P < 0.01$), decreased percentage of KPH by a margin of 0.03% ($P = 0.05$), and a decreased numerical calculated yield grade by 0.27 units ($P < 0.01$). Heifers fed ZH had a tendency for marbling score to be decreased by 1.2% (5.2 units; $P = 0.10$).

The most consistent biological effect of ZH has been a corresponding increase in skeletal muscle tissue, which accounts for many of the documented carcass trait changes (Johnson, 2004). Two large-pen steer studies reported a ZH-induced dressing percentage increase of 1.3% (Elam et al., 2009; 0 vs. 20 d ZH groups) and 1.2% (Montgomery et al., 2009b; 0 vs. 30 d ZH group), an increase in LMA by 9.1% and 8.7%, a decrease in 12th-rib fat by 6.5% and 8.2%, a decrease in the percentage of KPH by 0.03% and 0.08%, and a decrease in calculated yield grade by 0.37 and 0.29 units. Both Elam et al. (2009) and Montgomery et al (2009b) detected a decrease in marbling score of 14 and 17 units. In a small-pen study, Montgomery et al. (2009a) reported carcass traits from both steers and heifers at similar sites. Steers and heifers demonstrated a ZH response for increases in HCW (3.7% and 3.4%; steers and heifers, respectively), dressing percentage (1.3% and 1.5%), LMA (9.4% and 5.8%), and decreased calculated yield grade (0.38 and 0.28 units). Steers had decreased marbling scores by 29 units, but heifers fed ZH for only 20 d did not differ. The 40-d ZH-fed heifers did experience a decline in marbling score by 33 units. When considering these results and the results of the study herein, it would appear that heifers respond to ZH as strongly or even stronger in regard to a boost in dressing percentage but more modestly for increases in LMA, reduced 12th-rib fat, reduced KPH, and reduced numerical calculated yield grade. However, it appears that if ZH is only fed for 20 d, the losses in marbling score are substantially less than in ZH-fed steers to the point that in some instances there may be no detectable difference between ZH-fed heifers and non-ZH-fed heifers.

Table 4. Carcass traits of beef heifers fed zilpaterol hydrochloride (ZH) over varied days on the finishing diet (DOF)

	Days on ZH[1]			DOF[2]				*P*-value		
Item	0	20	SEM[3]	127	148	167	SEM[3]	ZH	DOF	ZH × DOF
Carcass weight, kg	344.9	356.0	2.67	330.7[a]	352.9[b]	367.8[c]	2.78	<0.01	<0.01	0.95
Dressing percentage	63.53	65.05	0.10	63.75[a]	64.46[b]	64.65[b]	0.11	<0.01	<0.01	0.81
LM area, cm^2	86.16	91.76	0.82	86.76[a]	90.50[b]	89.62[b]	0.89	<0.01	<0.01	0.62
LM area, cm^2/45.4 kg HCW	11.35	11.71	0.12	11.90[c]	11.63[b]	11.06[a]	0.13	<0.01	<0.01	0.70
12th-rib fat, cm	1.54	1.46	0.04	1.31[a]	1.55[b]	1.63[c]	0.04	<0.01	<0.01	0.09
KPH, %	1.93	1.90	0.01	1.88[a]	1.93[b]	1.93[b]	0.02	0.05	0.03	0.35
Calculated yield grade	2.96	2.69	0.07	2.58[a]	2.83[b]	3.07[c]	0.07	<0.01	<0.01	0.75
Marbling score[4]	441.8	436.6	2.42	423.6[a]	442.2[b]	451.8[c]	2.88	0.10	<0.01	0.55

[a–c]DOF means within a row without a common superscript differ ($P < 0.05$).

[1]Treatment diets were formulated to contain no ZH (0 d) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) for the final 20 d before slaughter.

[2]Heifers were finished for a period of 127, 148, and 167 d on the finishing diet before slaughter.

[3]Standard error of treatment means (days on ZH, n = 18 pens/main-effect mean; DOF, n = 12 pens/main-effect mean).

[4]300 = Slight[00], 400 = Small[00].

Carcass Grade Distributions. The calculated quality and yield grade distribution data are displayed in Table 5. No ZH × DOF interactions were detected for any grade category evaluated ($P \geq 0.17$). From a yield grade standpoint, heifers administered ZH had a greater percentage of yield grade 1 carcasses (6.3%; $P < 0.01$), a greater percentage of yield grade 2 carcasses (6.5%; $P < 0.01$), a lesser percentage of yield grade 3 carcasses (7.1%; $P < 0.01$), and a lesser percentage of yield grade 4 carcasses (4.8%; $P < 0.01$). There was a tendency for ZH supplemented heifers to have a lesser percentage of yield grade 5 carcasses (0.9%; $P = 0.08$). From a quality grade standpoint, there was no difference in the percentage of carcasses grading Prime, Premium Choice (High Choice and Average Choice combined), or Standard ($P \geq$ 0.26). However, heifers fed ZH had a lesser percentage of carcasses grading Choice (High Choice, Average Choice, and Low Choice combined; 6.2%; $P < 0.01$) because of a lesser percentage of Low Choice carcasses (6.2%; $P < 0.01$). Likewise, ZH-fed heifers had a greater percentage of carcasses grading Select (6.2%; $P < 0.01$).

Montgomery et al. (2009a) reported that there were no ZH effects (control vs. 20 and 40 d ZH duration combined) on shifts in the proportion of carcasses achieving any specific USDA quality grade. In fact, there was actually a tendency ($P = 0.08$) for non-ZH-fed heifers to have a greater proportion of No Roll carcasses. In general, ZH heifers demonstrated an improvement in USDA yield grade 1 and 2 categories. In the same trials, steers fed ZH graded Choice (High, Average, or

Table 5. Carcass grade distribution of beef heifers fed zilpaterol hydrochloride (ZH) over varied days on the finishing diet (DOF)

	Days on ZH[1]			DOF[2]				*P*-value		
Item	0	20	SEM[3]	127	148	167	SEM[3]	ZH	DOF	ZH × DOF
USDA quality grade, %										
Prime	2.3	1.8	0.29	1.3[a]	2.3[a,b]	2.6[b]	0.35	0.26	0.04	0.24
Premium Choice	19.5	19.8	1.11	15.1[a]	18.9[a]	25.0[b]	1.35	0.84	<0.01	0.79
Low Choice	50.1	43.9	1.06	43.0[a]	51.6[b]	46.3[a]	1.30	<0.01	<0.01	0.40
Choice[4]	69.6	63.7	1.09	58.1[a]	70.6[b]	71.3[b]	1.34	<0.01	<0.01	0.82
Select	27.8	34.0	1.09	39.9[b]	27.0[a]	25.8[a]	1.34	<0.01	<0.01	0.93
Standard	0.4	0.4	0.16	0.7[b]	0.1[a]	0.4[a,b]	0.19	0.74	0.04	0.35
USDA yield grade, %										
Yield grade 1	11.9	18.2	2.31	20.4[c]	14.4[b]	10.3[a]	2.43	<0.01	<0.01	0.98
Yield grade 2	37.5	44.0	1.50	47.0[b]	42.2[b]	33.1[a]	1.84	<0.01	<0.01	0.84
Yield grade 3	38.4	31.3	1.71	28.9[a]	35.1[b]	40.7[c]	2.00	<0.01	<0.01	0.70
Yield grade 4	10.6	5.8	1.16	3.6[a]	6.9[a]	14.1[b]	1.42	<0.01	<0.01	0.60
Yield grade 5	1.6	0.7	0.35	0.2[a]	1.5[b]	1.9[b]	0.43	0.08	0.02	0.17

[a–c]DOF means within a row without a common superscript differ ($P < 0.05$).

[1]Treatment diets were formulated to contain no ZH (0 d) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) for the final 20 d before slaughter.

[2]Heifers were finished for a period of 127, 148, and 167 d on the finishing diet before slaughter.

[3]Standard error of treatment means (days on ZH, n = 18 pens/main-effect mean; DOF, n = 12 pens/main-effect mean).

[4]Choice = Premium Choice + Low Choice.

Table 6. Tenderness and strip loin purge loss of beef heifers fed zilpaterol hydrochloride (ZH) over varied days on the finishing diet (DOF)

	Days on ZH[1]			DOF[2]				*P*-value		
Item	0	20	SEM[3]	127	148	167	SEM[3]	ZH	DOF	ZH × DOF
SSF,[4] kg										
7 d	14.16	17.71	0.56	14.31[a]	16.29[b]	17.20[b]	0.76	<0.01	<0.01	0.12
14 d	12.45	14.74	0.26	13.22	13.94	13.63	0.30	<0.01	0.20	0.13
21 d	12.01	13.68	0.26	13.06	12.91	12.56	0.30	<0.01	0.42	0.44
WBSF,[5] kg										
7 d	3.47	4.25	0.07	3.48[a]	3.87[b]	4.23[c]	0.08	<0.01	<0.01	0.33
14 d	3.05	3.57	0.05	2.97[a]	3.31[b]	3.65[c]	0.06	<0.01	<0.01	0.79
21 d	3.03	3.50	0.05	3.34[b]	3.10[a]	3.35[b]	0.06	<0.01	<0.01	0.18
Strip loin purge,[6] %	0.92	1.19	0.06	1.22[b]	1.23[b]	0.72[a]	0.09	<0.01	<0.01	0.13

[a–c]DOF means within a row without a common superscript differ ($P < 0.05$).

[1]Treatment diets were formulated to contain no ZH (0 d) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) for the final 20 d before slaughter.

[2]Heifers were finished for a period of 127, 148, and 167 d on the finishing diet before slaughter.

[3]Standard error of treatment means (days on ZH, n = 180 carcasses/main-effect mean; DOF, n = 120 carcasses/main-effect mean).

[4]SSF = slice shear force. SSF estimates of 2.54-cm-thick steaks from the boneless strip loin (Institutional Meat Purchase Specifications, IMPS 180) were assessed after aging for 7, 14, and 21 d postmortem.

[5]WBSF = Warner-Bratzler shear force. WBSF estimates of 2.54-cm-thick steaks from the boneless strip loin (IMPS 180) were assessed after aging for 7, 14, and 21 d postmortem.

[6]Purge was calculated as the weight of the strip loin in vacuum packaging minus the total weight of the dried bag and towel dried strip loin divided by the weight of the strip loin in vacuum packaging and multiplied by 100.

Low Choice) 12.6% less often and graded Select 12.2% more often when compared with control steers. In general, ZH steers demonstrated a stronger improvement in USDA yield grade 1 and 2 categories. Collectively, it would appear that ZH heifers do not suffer the same quality grading shifts as is observed in steers fed ZH. Interestingly, heifers still simultaneously capture advantageous shifts in yield grade, although to a more modest degree than when compared with steers.

Tenderness and Purge. Slice shear force, WBSF, and strip loin purge loss data are presented in Table 6. No ZH × DOF interactions were noted for any of the parameters evaluated ($P \geq 0.12$). From a SSF standpoint, strip loins from heifers that had been supplemented ZH were increased at 7, 14, and 21 d of aging ($P < 0.01$), with the magnitude of difference between control and ZH steaks being 3.55, 2.29, and 1.67 kg, respectively. Similar results were seen for WBSF analyses. The ZH steaks were increased at 7, 14, and 21 d of aging ($P < 0.01$), with the margin of difference between control and ZH steaks being 0.78, 0.52, and 0.47 kg, respectively. The toughening effect of ZH and the decline in the margin of difference between control steers and ZH steers as aging times increase has been reported previously for multiple muscles in both steers and heifers (Brooks et al., 2009; Holmer et al., 2009; Rathmann et al., 2009; Garmyn et al., 2011). Extending the postmortem aging time of ZH-fed cattle appears to be a sound practice to limit increased shear force effects brought about by the hypertrophic effect of ZH on muscle fiber diameter (Kellermeier et al., 2009). No direct comparisons of the influence of ZH on WBSF between steers and heifers has been documented, although Brooks et al. (2009) pooled and analyzed tenderness data from 5 trials, including both steer studies and heifer studies, claiming that the response was similar.

Miller et al. (2001) established that *longissimus lumborum* steaks with WBSF values < 3.0, 3.4, 4.0, 4.3, and 4.9 kg had consumer tenderness acceptability ratings of 100%, 99%, 94%, 86%, and 59%, respectively. Figure 1 demonstrates the distribution of strip loin steaks aged for 7, 14, and 21 d meeting the thresholds outlined by Miller et al. (2001). There was a ZH × DOF interaction or tendency for an interaction for the 7-d-aged steaks with a WBSF < 4.0 (P = 0.02), and < 4.3 (P = 0.05); for the 14-d-aged steaks with a WBSF <3.0 (P = 0.01), < 3.4 (P = 0.05), < 4.0 (P = 0.06), and < 4.3 (P = 0.07); and for the 21-d-aged steaks with a WBSF < 3.0 (P = 0.01).However, evaluation of the interactive means indicated that the nature of the interactions did not appear relevant. There was a ZH effect ($P \leq 0.02$) for every comparison, in that the control group had a significantly greater proportion of steaks in the given WBSF × postmortem aging category.

Strip loin purge loss was greater for ZH strip loins by a margin of 0.27% when compared with the control ($P < 0.01$). Kellermeier et al. (2009) reported a strip loin purge loss of 0.39% in ZH steers. Rathmann et al. (2009) reported a strip loin purge loss of 0.14%. All of these results are consistent with the fact that ZH increases the proportion of carcass moisture because of an increase in the proportion of carcass protein and simultaneous decrease in carcass fat (Kellermeier et al., 2009; Rathmann et al., 2009).

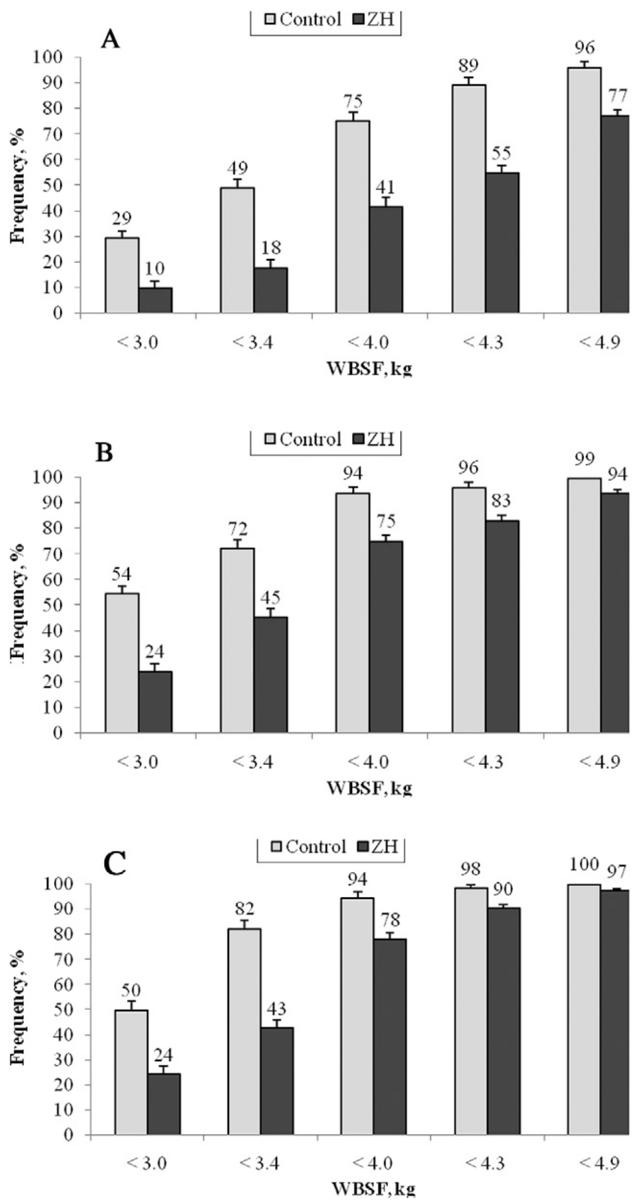

Figure 1. The frequency distribution of carcasses recording a Warner-Bratzler shear force (WBSF) value < 3.0, 3.4, 4.0, 4.3, and 4.9 kg at each aging period: A) 7 d postmortem, B)14 d postmortem, and C) 21 d postmortem. Heifers were either not fed zilpaterol hydrochloride (control) or fed zilpaterol hydrochloride (ZH; 8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS). After slaughter, a strip loin steak was removed from the left side of each carcass and aged appropriately. Miller et al. (2001) established that New York strip steaks with WBSF values < 3.0, 3.4, 4.0, 4.3, and 4.9 kg had consumer tenderness acceptability ratings of 100%, 99%, 94%, 86%, and 59%, respectively. There was a ZH × DOF interaction or tendency for an interaction for the 7-d-aged steaks with a WBSF < 4.0 (P = 0.02), and < 4.3 (P = 0.05); for the 14-d-aged steaks with a WBSF <3.0 (P = 0.01), < 3.4 (P = 0.05), < 4.0 (P = 0.06), and < 4.3 (P = 0.07); and for the 21-d-aged steaks with a WBSF < 3.0 (P = 0.01). There was a ZH effect ($P \leq 0.02$) for every comparison, in that the control group had a significantly greater proportion of steaks in the given WBSF × postmortem aging category. The SE of the treatment means (n = 177 carcasses/control main-effect mean; n = 172 carcasses/ZH main-effect mean) is denoted by the upward error bars in each panel.

Simple Effects

Shifts in Empty Body Composition. It is strongly apparent that ZH alters the composition of the animal.

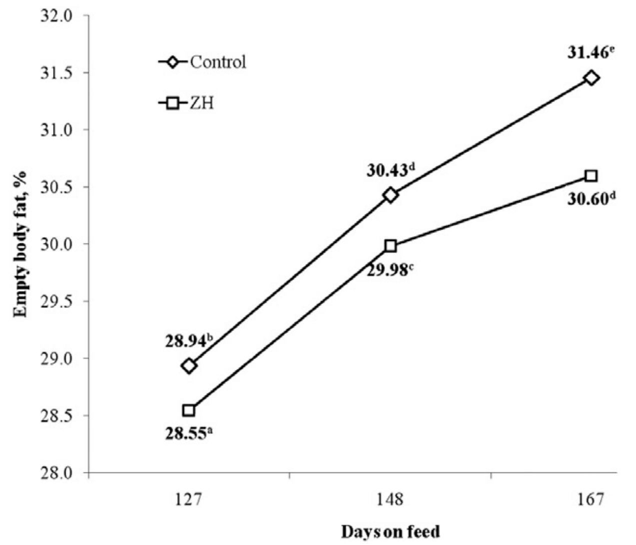

Figure 2. Simple effects of zilpaterol hydrochloride (ZH) and days on the finishing diet on empty body fat percentage. Heifers were serially slaughtered after 127, 148, and 167 d on the finishing diet and exposure to a treatment diet containing no ZH (control) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS). Data labels without a common superscript differ (*P* < 0.05).

Consequently, if the objective of finishing cattle is to harvest them at a specific empty body fat percentage, then it is logical that an increased number of days may be required when cattle are fed ZH. Figure 2 presents the empty body fat percentage by ZH × DOF treatment group. When comparing heifers with an equivalent number of DOF, the control cattle were always fatter than the ZH cattle (*P* < 0.05). Nevertheless, ZH heifers with 148 DOF were fatter than the control heifers with 127 DOF (*P* < 0.05), but there was no difference (*P* = 0.37) in empty body fat percentage between ZH heifers with 167 DOF and control heifers with 148 DOF (*P* = 0.37). In general, it would appear that an increase in DOF when supplementing ZH is necessary to achieve a similar empty body fat percentage when compared with not feeding ZH. The exact number of extra DOF required will likely fluctuate depending on the sex of the cattle, their biological type and physiological maturity pattern, and the physical and chemical composition of the finishing diet.

Estimated Carcass Performance on a Live Basis. Table 7 presents the interactive means of estimated carcass performance on a live basis during the treatment period (29 to 34 d period immediately before slaughter when treatment diets were fed). Irrespective of DOF, every ZH-fed group recorded increased carcass ADG, increased G:F, and increased carcass ADG:live ADG vs. any of the control groups (*P* < 0.05). Among the ZH groups, there was no difference between the ZH × 127 DOF groups and ZH × 148 DOF groups for carcass ADG (*P* = 0.11), but the ZH × 167 DOF groups had decreased carcass ADG when compared with either of these groups (*P* < 0.05). When comparing the ZH groups relative to carcass G:F, there was no difference between the ZH ×

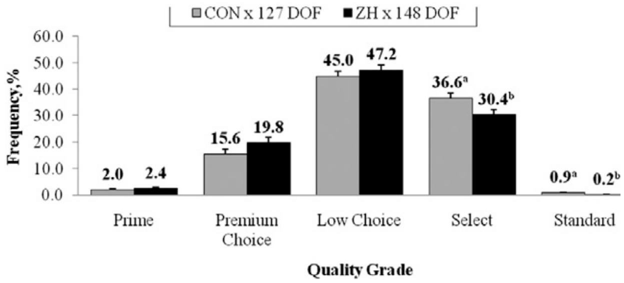

Figure 3. The interactive least-squares means comparison between the control × 127 days on the finishing diet (DOF) group and the zilpaterol hydrochloride (ZH) × 148 DOF group for distribution of quality grades. Heifers were serially slaughtered after 127, 148, and 167 d on the finishing diet and exposure to a treatment diet containing no ZH (control) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS). The SE of the treatment means (n = 6 pens/treatment) is denoted by the upward error bars. Data labels without a common superscript differ ($P < 0.05$).

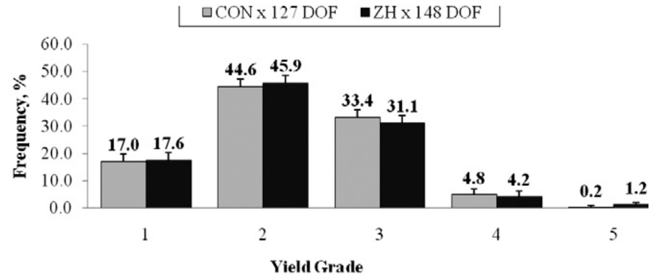

Figure 4. The interactive least-squares means comparison between the control × 127 d on the finishing diet (DOF) group and the zilpaterol hydrochloride (ZH) × 148 DOF group for distribution of yield grades. Heifers were serially slaughtered after 127, 148, and 167 d on the finishing diet and exposure to a treatment diet containing no ZH (control) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS). The SE of the treatment means (n = 6 pens/treatment) is denoted by the upward error bars. No differences existed between treatment groups within each yield grade ($P > 0.22$).

127 DOF groups and ZH × 167 DOF groups ($P = 0.06$); however, the ZH × 148 DOF groups had an increased G:F over both other ZH groups ($P < 0.05$). There was no difference among any ZH groups for the proportion of carcass ADG that is live ADG. When approached from an estimated carcass weight gain standpoint, it would collectively appear that ZH allows the length of the finishing period to be extended without ill effects on cost of gain generally noted toward the end of the feeding period.

Carcass Grade Distributions. The most realistic comparison to ascertain if extending DOF would be beneficial to equalizing carcass grade distributions was to compare the control × 127 DOF group with the ZH × 148 DOF group. Figure 3 displays the quality grade frequency distributions between these treatments. The proportion of USDA Prime, Premium Choice, and Low Choice carcasses did not differ between these treatments ($P > 0.10$). Actually, the ZH × 148 DOF group had a decreased percentage of Select (30.4% vs. 36.6%; $P = 0.03$) and Standard (0.2% vs. 0.9%; $P = 0.05$) carcasses compared with the control × 127 DOF group. Figure 4 presents the yield grade distribution differences. There was no difference ($P = 0.22$) in the proportion of yield grade 1, 2, 3, 4, or 5 carcasses between the control × 127 DOF group and the ZH × 148 DOF group.

Tenderness. Figure 5 depicts the WBSF least-squares means between the control × 127 DOF group and the ZH × 148 DOF group. The ZH × 148 DOF group was increased over the control × 127 DOF group at 7 (4.32 vs. 3.18 kg; $P < 0.01$), 14 (3.59 vs. 2.74 kg; $P < 0.01$), and 21 d (3.39 vs. 3.09 kg; $P = 0.01$). Extending the DOF of the ZH-fed heifers by 21 d reduced the range in WBSF between control and ZH heifers when compared with the range when comparing cattle fed an equivalent number of DOF (0.39 kg vs. 0.47 kg).

Implications

The magnitude of the ZH response is not dependent on the number of days heifers spend on the finishing diet. Zilpaterol hydrochloride causes improvements in live feedlot performance, but to a greater extent on live estimated carcass weight gain and efficiency. Zilpaterol hydrochloride has minimal effects on shifting quality grade distributions but does still adversely affect shear force in

Table 7. Simple effects of zilpaterol hydrochloride (ZH) by days on the finishing diet (DOF) on estimated carcass performance on a live basis in beef heifers during the treatment period[1]

	DOF[3]						
	127		148		167		
Item[2]	Control[5]	ZH[5]	Control	ZH	Control	ZH	SEM[4]
Carcass ADG, kg	1.14[b]	1.45[d]	1.16[b]	1.54[d]	0.92[a]	1.28[c]	0.04
Carcass G:F	0.120[b]	0.159[c]	0.125[b]	0.171[d]	0.106[a]	0.147[c]	0.004
Carcass ADG:live ADG, %	72.03[a]	88.85[b]	74.27[a]	86.76[b]	72.94[a]	90.51[b]	1.68

[a–d]Interactive means within a row without a common superscript differ ($P < 0.05$).

[1]The treatment period consisted of the final 29, 34, and 32 d immediately before slaughter for the 127, 148, and 167 DOF treatment groups, respectively.

[2]Factors used to calculate carcass ADG, carcass F:G, and carcass ADG:live ADG were derived by applying a 58% standard dressing percent to the initial BW, and the interim shrunk BW was multiplied by the estimated interim dressing percent = 51.46522 + 0.02468 × DOF + 0.43775 × DMI. The estimated interim dressing percent prediction equation ($r^2 = 0.66$) was derived from the pens of heifers not fed ZH.

[3]Heifers were finished for a period of 127, 148, and 167 d on the finishing diet before slaughter.

[4]Standard error of treatment means (n = 6 pens/simple-effect mean).

[5]Treatment diets were formulated to contain no ZH (0 d) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS) for the final 20 d before slaughter.

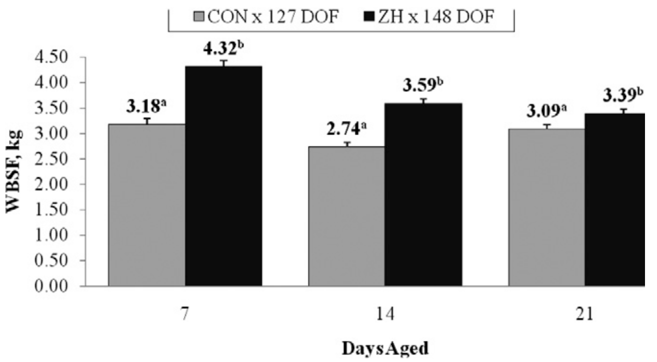

Figure 5. The interactive least-squares means comparison between the control × 127 d on the finishing diet group and the zilpaterol hydrochloride (ZH) × 148 DOF group for Warner-Bratzler shear force (WBSF). Heifers were serially slaughtered after 127, 148, and 167 d on the finishing diet and exposure to a treatment diet containing no ZH (control) or ZH (8.33 mg/kg, DM basis; Zilmax, Intervet Schering Plough Animal Health, De Soto, KS). The SE of the treatment means (n = 6 pens/treatment) is denoted by the upward error bars. Data labels without a common superscript differ ($P < 0.05$).

heifers. An apparent postponement of adipose accretion and increase in muscle accretion results in a 28% heavier empty body fat adjusted final body weight for ZH-fed heifers. Given this shift in body composition, extending the DOF of ZH-fed heifers results in a comparable quality grade and yield grade distribution when compared with control heifers slaughtered 21 d before. This, in consideration with the fact that ZH causes drastic improvements in carcass feed efficiency and carcass retention, makes extending DOF a practical management strategy to minimize adverse effects of ZH without compromising cost of BW gain at the end of the feeding period.

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