

The effect of zilpaterol hydrochloride on beef producer and processor revenue of calf-fed Holstein steers

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ABSTRACT: A serial harvest was conducted every 28 d from 254 to 534 days on feed (DOF) to quantify changes in growth and composition of calf-fed Holstein steers ($n = 110$, initial BW = 449.2 ± 19.9 kg). One-half were supplemented the β -2 adrenergic agonist zilpaterol hydrochloride (ZH; 8.33 mg/kg 100% DM basis), and the remainder fed a control (CON) ration during the final 20 d followed by a 3 d withdrawal prior to harvest. Cattle were randomly allocated to dietary treatment and harvest endpoint (254, 282, 310, 338, 366, 394, 422, 450, 478, 506, and 534 DOF) using a 2×11 factorial treatment structure and a completely randomized experimental design structure. The objective of this ad-hoc investigation was to quantify changes in value across multiple harvest endpoints and marketing strategies for cattle supplemented with ZH. Cattle-fed ZH had increased ($P < 0.01$) value when sold on a dressed basis (+\$82.64) or on a value-based formula (+\$75.59) compared with CON cattle. No differences

($P \geq 0.14$) were detected between ZH and CON carcasses for premiums and discounts related to HCW, yield grade, or quality grade. Moreover, no differences ($P = 0.98$) were detected for overall adjusted carcass value between ZH and CON carcasses. Fabrication values revealed that ZH carcasses had greater ($P < 0.01$) revenue than CON carcasses for primal round (+\$36.23), loin (+\$38.16), flank (+\$8.95), rib (+\$16.33), and chuck (+\$27.49) regardless of DOF. Increased primal values ultimately led to greater ($P < 0.01$) processor revenue (+\$138.94) and carcass value per 45.4 kg (+\$6.45) for cattle-fed ZH compared with CON cattle. Overall, increased carcass weight and improved fabrication yield led to greater revenue at all harvest endpoints for cattle-fed ZH. Linear increases in live and dressed values indicated the daily change in live value was \$3.48, which is less than an increase of \$3.77 daily for dressed carcass value. Greater beef processor margin and profitability are expected when this growth technology is used.

Key words: beef, economics, Holstein

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INTRODUCTION

Growth-promoting technologies known as beta-adrenergic agonists (β AA) are used to

strategically manage the composition of gain of fed cattle. The FDA-approved β AA utilized in the fed-cattle industry include ractopamine hydrochloride (commercially available as Optaflexx and Actogain from Elanco Animal Health and Zoetis LLC, respectively) and zilpaterol hydrochloride (ZH; commercially available as Zilmax

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from Merck Animal Health). Ractopamine was approved for use in 2003 with zilpaterol gaining approval in 2006 (Johnson et al., 2013). These supplements are added to the ration of finishing cattle during the last 20 to 42 d of the finishing period and are known to increase lean tissue accretion (Avendano-Reyes et al., 2006; Strydom et al., 2009; Scramlin et al., 2010).

Elam et al. (2009), Montgomery et al. (2009), and Rathmann et al. (2012) reported that feeding ZH (fed at 8.33 mg/kg of diet DM) to cattle during the last 20 to 40 d of the finishing period followed by a 3 d withdrawal increased ADG, final BW, HCW, dressed yield, and LM area concomitant with reduced USDA-calculated yield grade. With input costs rising year-over-year and cyclical feeder cattle supply, a retrospective look at carcass performance and processor margins at various finishing endpoints for calf-fed Holsteins is of interest to the industry. Through increased feeding and carcass performance, we theorize that increased value may be attributed to the utilization of ZH for all levels of production. This investigation focused on the effect of ZH on the revenue stream of beef producers and processors utilizing calf-fed Holsteins across multiple marketing scenarios and endpoints. In addition, utilization of feeding performance parameters such as ADG, DMI, BW, HCW, and ZH supplementation was evaluated for the ability to predict producer and processor revenue.

MATERIALS AND METHODS

Live Cattle and Carcass Procedures

Cattle were fed at Agri-Research Center, Inc. feedyard (Canyon, TX). All experimental procedures followed the guidelines described in the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (FASS, Savoy, IL). Institutional animal care and use guidelines were followed according to the West Texas A&M University cooperative research, education, and extension team directive.

Cattle were fed and harvested (28-d intervals) over a period of 280 d starting at 254 d on feed (DOF) and ending at 534 DOF. Harvest endpoints included five cattle that received ZH, the last 20 d prior to harvest at a rate of 8.33 mg per kg of diet DM followed by a 3-d withdrawal period, and five cattle that received a control (CON) diet. Live animal growth data, diet composition, and feeding performance outcomes were reported previously by Walter et al. (2016). Harvest data and yields were

reported by May et al. (2016a). Carcasses were graded 36 h postmortem; quality and yield outcomes for United States, Canadian, and Japanese grading systems were reported in May et al. (2016b). Carcasses were separated into industry standard subprimals 48 h postmortem; cutout yields were reported in May et al. (2017).

Determination of Live Cattle Costs

To determine total breakeven value, initial cattle cost, and medicine costs (sum of processing fees, implant, vaccines, anthelmintics, prophylactic and/or metaphylactic therapy, ID costs), feed, yardage, and ZH supplementation costs were used (Table 1).

Initial cattle cost was determined by averaging reported values for Holstein steers in 408.2–498.9 kg weight range during the time period of 25 June 2012 through 30 April 2013 (USDAa, 2014). For the specified date range, all values were compiled and averaged to determine the fixed value of steers utilized in this investigation (\$80.45 per 45.4 kg).

Duff and Anderson (2007) summarized data collected from the southern plains of the United States in which 11,588 lots of Holstein steers were utilized. Using data reported for Holstein steers fed in Colorado, Kansas, Oklahoma, Texas, and Nebraska, the average medicine cost was calculated as \$15.09 per animal.

Previously described feeding performance data (Walter et al., 2016) were utilized to determine total feeding cost. Ration cost per 907.1 kg was determined using data reported by Hoelscher (2013), which indicated that during the month of May 2013, average fed-cattle rations for the southern plains ranged from \$370 to 380 per 907.1 kg of diet DM.

Yardage was set at \$0.40 daily per animal using data reported by Lardy (2013). The cost of ZH inclusion in the diet during the last 20 d on

Table 1. Feedlot capital costs for determination of breakeven of calf-fed Holsteins fed ZH for 0 or 20 d

Item	
Cattle cost, \$/45.4 kg	80.45
Medicine cost, \$/animal	15.09
Feed cost, \$/907.1 kg	375.00
Yardage, \$/d/animal	0.40
ZH feeding cost, \$/10kg	8,453.00
ZH feeding cost, \$/mg of active ingredient in a total mixed ration	0.017
ZH feeding cost, \$/kg of DM at label target 8.33 mg/kg of DM	0.142

trial followed by a 3-d withdrawal was calculated using feeding performance data of steers receiving the supplement. During the time period the investigation occurred, the average cost of ZH was \$8,453/10 kg of which 4.8% was the active ingredient (Merck Animal Health, 2013). Following the guidelines for supplementation (8.33 mg/kg diet DM), the relative cost was calculated at a rate of \$0.017 per mg of active ingredient contained in the total mixed finishing ration.

Determination of Revenue

Revenue of live cattle and carcasses was determined by compiling data from multiple reports, which are representative of pricing from July 24, 2012 to April 30, 2013, the study period. To determine pricing for sales of dairy-bred steers, the USDA market news report LM_CT145 “Five-area weekly direct slaughter cattle formula, grid, and contract purchases” was compiled and averaged across the study period (USDAb, 2014). Average pricing for live and dressed basis sales was used in this investigation. To calculate value-based formula pricing, the average-dressed basis price was used as the carcass base price, which was adjusted using individual discounts and premiums for each animal in the study.

The USDA report LM_CT169 “Five-area weekly slaughter cattle premiums and discounts” was used to determine premiums and discounts for HCW, quality grade, and yield grade (USDAc, 2014). Total value for each marketing method as well as value per 45.4 kg of HCW was calculated to determine adjusted value-based formula value. Carcasses were eligible to receive multiple discounts and/or premiums; no thresholds were set for premiums or discounts. For example, carcasses that exceeded 408.2 kg and graded USDA Prime, yield grade 2 would receive the simple average value discount from the base price for a heavy-weight carcass and receive premiums for quality- and yield-grading parameters.

To determine revenue of calf-fed Holsteins to the production system of beef processors, the fabrication value of each animal was calculated as well as the drop credit value and summed to determine total value. In addition to calculation of total value, carcass value was also calculated by dividing total value by HCW for each steer and multiplied by 100 to determine value per 45.4 kg of HCW.

For determination of drop credit value, the USDA report NW_LS441 “USDA by-product drop value (steer) freight on buyer central United States”

was compiled across the study period and averaged (USDAd, 2014). To calculate fabrication value of carcasses, the weighed subprimals and trim from each carcass (May et al., 2017) were captured and valued using mandatory price reporting values for subprimals from Prime (USDA report LM_XB456; “national weekly boxed beef cuts-prime product”; USD Ae, 2014), Choice and Select (USDA report LM_XB459; “national weekly boxed beef cutout and boxed beef cuts”; USD Af, 2014), and Standard (USDA report LM_XB462; “national weekly boxed beef cuts-ungraded product”; USD Ag, 2014) USDA quality grade carcasses. Five subprimals (blade meat [NAMP 109B], pectoral meat [NAMP 115D], outside skirt [NAMP 121C], inside skirt [NAMP 121D], and beef back ribs [NAMP 124]) were priced using the USDA report LM_XB 459 (USD Af, 2014) regardless of USDA quality grade. For determination of trim value, the USDA report LM_XB459 was used for 81% and 90% trim levels (USD Af, 2014). In addition, three cuts (hanging tender [NAMP 140], heel [NAMP 171F], and shank meat [NAMP 117]) fabricated in the study were not listed on pricing reports by grade and therefore were priced as 90% trim. For the prediction of producer and processor margin \$/45.4 kg, reported shrunk body weight (SBW) and predicted HCW (PHCW; $PHCW = -41.44 + (0.6637 \times SBW) + (12.974 \times ZH)$) were determined following the procedures developed by McEvers (2014). This method was used to highlight the ability for a producer to weigh live cattle and estimate HCW and potential economic viability of marketing cattle on a carcass vs. live basis.

Statistical Analysis

A completely randomized experimental design was utilized with a 2×11 factorial treatment arrangement. The MIXED procedure of SAS (SAS 9.3, SAS Institute, Cary, NC) was utilized to model the fixed effects of ZH supplementation, DOF, and ZH \times DOF interaction were calculated with feed-yard pen and harvest facility used as random effects. When calculating means, the LSMEANS option was utilized to calculate all comparison estimates. Differences were determined when probability values were less than the preset alpha of 0.05 using the Scheffe adjustment to control for family-wise error rate. Linear and quadratic relationships were constructed using CONTRAST statements to evaluate differences across DOF for each item of interest. Moreover, using the CORR procedure, simple r values were calculated between dependent and

predictive variables. The REG procedure was used to model dependent variables using the STEPWISE method of selection.

RESULTS AND DISCUSSION

Producer Feeding Cost and Breakeven Analysis

For the calculation of cattle costs inherent to beef producers, no ZH \times DOF interactions occurred ($P \geq 0.12$; Table 2). No ZH treatment differences were observed for initial cattle cost, feed cost, or breakeven \$/45.4 kg ($P \geq 0.44$). However, cattle-fed ZH had greater total breakeven \$/animal ($P = 0.03$; +\$41.13) compared with controls, due to increased feed costs and ZH supplementation. The average cost of feeding the supplement was \$28.06 per steer, which accounts for 68.2% of the increase in total breakeven reported.

Initial cattle cost differed ($P = 0.02$) across DOF; this is directly related to differences in placement weight of the cattle due to randomization. Feed cost accumulated ($P < 0.01$) at \$4.34 per day, whereas total breakeven \$/animal accumulated ($P < 0.01$) at \$4.90 per day. Thus, breakeven value of the live animal increased ($P < 0.01$) at \$0.12/45.4 kg per day.

Live, Dressed, and Value-Based Formula Pricing of Cattle

No ZH \times DOF interactions were detected ($P \geq 0.16$) for live or carcass values (Table 3). Live value, HCW adjustment, yield grade adjustment, quality grade adjustment, and final adjusted value per 45.4 kg did not differ between dietary treatments ($P \geq 0.13$). However, cattle-fed ZH had 4.8% more dressed value revenue ($P < 0.01$; +\$82.64) and total formula value ($P < 0.01$; +\$75.59) than CON steers. The increase in value of cattle-fed ZH regardless of DOF illustrated how improvements in dressed carcass yield directly increased value. In previous literature, Schroeder and Tonsor (2011) indicated that average net profits for beef producers feeding ZH were approximately \$21.08/animal and that return included the cost of the supplement, which during the tenure of their investigation averaged \$18.00/animal. Nevertheless, the use of growth technologies such as ZH had a positive effect on increasing value of calf-fed Holsteins sold on a dressed carcass or value-based formula basis.

The effect of DOF followed expected trends in that as DOF accumulated, revenue increased for live, dressed, and formula values. Live value increased at a rate of \$3.48 per day, whereas dressed value increased

Table 2. Feedlot capitol cost and breakeven of calf-fed Holsteins fed ZH for 0 or 20 d

Item	<i>n</i>	Cattle cost, \$	Medicine cost, \$	Yardage, \$	Feed cost, \$	ZH Feeding cost, \$	Breakeven, \$/animal	Breakeven, \$/45.4 kg
Diet treatment								
CON	55	829.37	15.09	67.20	687.76	0.00	1599.42	105.45
ZH	55	830.79	15.09	67.20	699.41	28.06	1640.55	106.13
SEM	–	4.78	–	–	10.77	0.27	12.81	0.70
Harvest endpoint								
254	10	859.61	15.09	11.20	90.24	22.41	987.35	88.03
282	10	820.51	15.09	22.40	198.20	24.24	1068.32	92.27
310	10	808.92	15.09	33.60	308.84	24.13	1178.52	95.47
338	10	812.22	15.09	44.80	436.57	27.46	1322.41	99.02
366	10	811.90	15.09	56.00	539.64	28.56	1436.91	102.72
394	10	833.70	15.09	67.20	711.96	30.36	1643.13	108.15
422	10	818.18	15.09	78.40	805.66	28.36	1731.51	108.81
450	10	845.69	15.09	89.60	957.37	29.71	1922.61	114.08
478	10	842.07	15.09	100.80	1085.41	30.71	2058.72	113.56
506	10	848.67	15.09	112.00	1200.21	30.80	2191.37	117.06
534	10	829.36	15.09	123.20	1235.39	31.92	2279.00	124.52
SEM	–	11.20	–	–	25.25	0.89	30.04	1.64
<i>P</i> value								
ZH*	–	0.83	–	–	0.44	–	0.03	0.50
DOF	–	0.02	–	–	<0.01	–	<0.01	<0.01
ZH \times DOF	–	0.81	–	–	0.12	–	0.21	0.73
Linear	–	0.26	–	–	<0.01	–	<0.01	<0.01
Quadratic	–	0.03	–	–	0.80	–	0.31	0.55

*Zilpaterol Hydrochloride (Merck Animal Health, Summit, NJ).

Table 3. Expected sales revenue of calf-fed Holstein steers fed ZH for 0 or 20 d priced at historical live, dressed, and formula sales values during the years 2012–2013

Item	<i>n</i>	Live value, \$	Dressed value, \$	Carcass base price, \$/45.4 kg	HCW adjustment, \$/45.4 kg	Yield grade adjustment, \$/45.4 kg	Quality grade adjustment, \$/45.4 kg	Adjusted value, \$/45.4 kg	Formula value, \$
Diet treatment									
CON	55	1765.56	1726.78	191.50	(6.91)	(3.81)	(5.36)	175.42	1565.45
ZH	55	1796.02	1809.42	191.50	(8.28)	(2.68)	(5.16)	175.38	1641.04
SEM	–	14.19	17.38	–	0.80	0.53	0.81	1.29	16.21
Harvest endpoint									
254	10	1325.81	1249.54	191.50	0.00	2.15	(16.33)	177.32	1156.50
282	10	1368.46	1343.85	191.50	0.00	0.84	(13.49)	178.85	1255.19
310	10	1460.79	1405.80	191.50	0.00	1.27	(7.81)	184.96	1357.65
338	10	1580.79	1541.19	191.50	(0.02)	0.85	(5.33)	187.00	1506.20
366	10	1653.95	1603.24	191.50	(0.02)	1.52	(4.26)	188.73	1581.16
394	10	1795.62	1762.93	191.50	(0.44)	(2.50)	(4.26)	184.30	1698.51
422	10	1883.52	1990.86	191.50	(9.94)	(3.62)	(1.07)	176.88	1830.07
450	10	1992.41	2027.07	191.50	(10.26)	(7.87)	(4.26)	169.11	1781.97
478	10	2142.81	2137.51	191.50	(21.07)	(8.77)	(1.07)	160.60	1791.16
506	10	2213.02	2242.20	191.50	(23.05)	(9.77)	0.00	158.68	1858.11
534	10	2171.50	2144.90	191.50	(18.76)	(9.77)	(0.01)	162.96	1819.21
SEM	–	33.29	40.77	–	1.87	1.25	1.89	3.01	38.01
<i>P</i> value									
ZH*	–	0.13	<0.01	–	0.23	0.14	0.87	0.98	<0.01
DOF	–	<0.01	<0.01	–	<0.01	<0.01	<0.01	<0.01	<0.01
ZH × DOF	–	0.16	0.54	–	0.77	0.57	0.79	0.82	0.21
Linear	–	<0.01	<0.01	–	<0.01	<0.01	<0.01	<0.01	<0.01
Quadratic	–	0.37	0.04	–	<0.01	0.05	<0.01	<0.01	<0.01

*Zilpaterol Hydrochloride (Merck Animal Health, Summit, NJ).

at a rate of \$3.77 per day. Difference between live and dressed value is directly associated to increased carcass transfer of nutrients as the cattle increased in physiological finish across DOF. It is worth noting that the maximization of revenue utilizing these methods of marketing will only be hindered by size and weight restrictions placed on producers by beef packers and the determination of marginal rates of return based on feeding performance characteristics.

Comparing components of the value-based formula, discounts for HCW increased ($P < 0.01$) by \$0.09 per 45.4 kg per day during the study. The increase in discounts concomitant with accumulating DOF was expected due to heavier carcasses receiving discounts in an effort to improve boxed-beef uniformity. Adjustments for calculated yield grade decreased ($P < 0.01$) across DOF at a rate of $-\$0.05$ per 45.4 kg per day with the greatest premiums ($+\$2.15/45.4$ kg) awarded during the initial harvest (day 254) and the greatest discounts ($-\$9.77/45.4$ kg) assessed during the 506 and 534 DOF harvests. In contrast to yield grade, adjustments based on quality-grading characteristics increased ($P < 0.01$) across DOF at a rate \$0.05 per 45.4 kg per day. The 254 DOF endpoint received the largest discount ($-\$16.33/45.4$ kg) due to inferior quality, whereas the

506 DOF harvest endpoint received no adjustment. Adjusted carcass value per 45.4 kg across DOF followed a quadratic function ($P < 0.01$) and peaked at 366 DOF. Total formula value increased ($P < 0.01$) across DOF at a rate \$2.54 per 45.4 kg per day, which was primarily a function of increased HCW. With additional DOF, discounts related to increased HCW and calculated yield grade may lead to reduced value per 45.4 kg. However, due to the increase in HCW over time, total value was maximized at 506 DOF. These data suggest that producers who sell on a value-based formula would observe the greatest carcass value per 45.4 kg at 366 DOF. The beef system quandary then becomes what value to maximize (live, dressed carcass, value-based carcass, or fabrication) and how overall profitability on a per animal basis is affected by marketing day. We believe that the time at which carcass value is optimized may be a better metric than total formula value due to economic restraints related to input costs.

Beef Processor Drop Credit, Fabrication, and Revenue of Cattle

Revenue derived from carcass fabrication for beef processors did not reveal ZH × DOF interactions (P

≥ 0.16); however, a tendency for interaction ($P = 0.06$) occurred when calculating the total value of the plate subprimal (Table 4). This tendency is likely due to cutting error related to separation of the primal rib from the primal plate and loin or from switching harvest facilities during the trial. No differences ($P = 0.13$) were discovered among calculated drop credit between the two dietary treatments. Conversely, cattle-fed ZH had increased ($P < 0.01$) value of round (+\$36.23), loin (+\$38.16), flank (+\$8.95), rib (+\$16.33), chuck (+\$27.49), and brisket (+5.14) primals as compared with CON steers.

For cattle-fed ZH, overall fabrication revenue was \$135.46 greater ($P < 0.01$) than that of CON steers. Total processor revenue was \$138.94 greater ($P < 0.01$) for cattle-supplemented ZH than for CON steers. Moreover, cattle-fed ZH exhibited increased ($P < 0.01$) processor carcass value of \$6.45 per 45.4 kg as compared with CON steers. The significant increase in fabrication value coupled with a numeric increase in drop credit resulted in increased total revenue and carcass value of calf-fed Holstein steers supplemented ZH. Previous

literature reported an average return for beef processors of \$31.68 per animal (Schroeder and Tonsor, 2011).

Beef processors that source calf-fed Holstein steers fed ZH may realize an increase in revenue compared with harvesting and fabricating cattle not fed ZH. The increase in value to the beef-marketing channel for Holstein steers fed ZH credited to the processor is 168.1% of the value returned to beef producers selling on a dressed basis, and 183.8% of the value returned to those producers selling on a value-based formula. The risk: return ratio for the two segments is skewed; however, the overall contribution to the beef system is positive and results in increased protein availability for today's consumer.

Value of all major fabricated primals (round, loin, flank, rib, plate, chuck, and brisket) increased as DOF accumulated. Value of the round primal was least at day 254 and greatest at day 506, increasing at a rate of \$0.45 per day. Value of the loin primal was least during the beginning harvest endpoint and greatest at the last harvest endpoint, increasing at a rate of \$0.85 per day. The value of

Table 4. Expected fabrication revenue of calf-fed Holsteins steers fed ZH for 0 or 20 d priced using drop credit, sub-primal, and grind data coupled with reported values by United States Department of Agriculture quality grade during the years 2012–2013 across DOF

Diet treatment													
CON	55	320.52	348.36	74.67	181.87	112.00	326.62	87.92	1451.96	201.88	1653.85	184.25	
ZH [§]	55	356.75	386.52	83.62	198.20	115.14	354.11	93.06	1587.42	205.37	1792.79	190.70	
SEM	–	3.50	5.41	1.22	3.99	1.67	3.86	1.86	16.18	1.62	17.47	1.07	
Harvest endpoint													
254	10	267.17	251.12	57.54	111.20	78.44	243.90	71.69	1081.07	151.60	1232.67	189.00	
282	10	283.24	262.30	57.58	130.21	89.54	259.70	79.85	1162.41	156.48	1318.89	187.94	
310	10	301.71	300.97	64.15	155.36	110.5	292.21	78.08	1302.98	160.04	1470.02	200.28	
338	10	320.65	321.75	68.30	172.25	110.72	308.39	83.64	1385.71	180.76	1566.47	194.53	
366	10	315.45	344.35	70.95	186.12	98.68	313.43	82.14	1411.12	189.12	1600.24	190.77	
394	10	348.70	367.62	81.25	198.41	111.97	338.11	88.18	1534.23	205.32	1739.55	188.67	
422	10	364.98	392.78	82.90	214.48	118.62	363.75	93.65	1631.15	215.37	1846.52	178.36	
450	10	359.07	410.30	82.65	201.53	125.91	374.48	95.01	1648.96	227.82	1876.78	177.72	
478	10	389.37	445.80	103.63	232.32	125.05	403.36	103.67	1803.18	245.02	2048.20	183.43	
506	10	398.23	472.20	105.24	247.77	140.87	438.06	115.79	1918.17	253.05	2171.22	185.31	
534	10	376.43	472.66	96.42	240.74	139.00	408.63	103.73	1837.61	248.30	2085.92	186.17	
SEM	–	8.20	12.69	2.87	9.35	3.92	9.05	4.36	37.93	3.81	40.96	2.51	
P value													
ZH	–	<0.01	<0.01	<0.01	<0.01	0.19	<0.01	0.05	<0.01	0.13	<0.01	<0.01	
DOF	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
ZH × DOF	–	0.21	0.58	0.66	0.47	0.06	0.71	0.38	0.25	0.16	0.22	0.86	
Linear	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Quadratic	–	<0.01	<0.01	0.62	0.85	0.02	0.45	0.27	0.49	0.11	0.37	0.12	

*Total fabrication value.

[†]Drop credit calculated from USDA voluntary reported values, July 2012 to May 2013.

[‡]Processor revenue from by-product drop and fabrication value.

[§]Processor carcass value \$/45.4 kg derived from drop credit and fabrication value.

[¶]Zilpaterol Hydrochloride (Merck Animal Health, Summit, NJ).

the flank subprimal fit a linear function ($P < 0.01$) and increased at a rate of \$0.18 per day. Rib primal value fit a linear function ($P \leq 0.01$) and increased at a rate of \$0.47 per day. Plate subprimal value increased ($P < 0.01$) at a rate of \$0.20 per day from a low of \$78.44 at 254 DOF to \$140.87 at 506 DOF. Value of the chuck subprimal increased ($P < 0.01$) at a rate of \$0.67 per day from \$243.90 at day 254 to a maximum value of \$438.06 at day 506. Brisket subprimal value increased ($P < 0.01$) at the rate of \$0.13 per day from \$71.69 to 115.79 during the study period.

Fabrication value of carcasses increased ($P < 0.01$) at a rate of \$2.94 per day, following a linear function. Drop credit value is a function of live weight gain and increased ($P < 0.01$) at a rate of \$0.40 per day. Total processor revenue reflected the sum of drop credit and fabrication value and increased ($P < 0.01$) at a rate of \$3.34 per day. Although the value of the animals included in this investigation was maximized at day 506, we felt it necessary to reflect total revenue as a proportion of 45.4 kg of HCW. Processor carcass value was different ($P < 0.01$) across DOF; however, the maximum HCW value \$/45.4 kg was realized upon day 310 on feed due to maximization of fabrication yield. These results allow for an in-depth analysis of processor margin compared with data reported in earlier tables of this manuscript.

Correlation Analysis

Correlation coefficients calculated among variables utilized in the prediction of producer and processor net margins per 45.4 kg are reported in Table 5. Dependent variables of interest included producer and processor net margins per 45.4 kg for cattle bought and sold on a live, dressed, or formula basis. Independent variables included DOF, DMI, predicted HCW, and SBW. DOF had the strongest ($P < 0.05$) relationships with producer live ($r = -0.79$), dressed ($r = -0.80$), and formula ($r = -0.81$) sales. Processor net value for live

purchases was only correlated to DMI ($r = 0.26$), whereas SBW, DOF, and predicted HCW were similarly correlated ($P < 0.05$) with processor dressed ($r = -0.22$ to -0.28) and formula purchases ($r = 0.24$ to 0.32).

Although previous literature is scarce regarding correlation of DMI, SBW, DOF, or carcass parameters for economic analysis, one may postulate how each parameter may affect margin. As SBW increases, margins for producers decrease for cattle sold via the historically traditional methods of live sales. This result may be associated with SBW increasing linearly across DOF coupled to reductions in feeding performance. In addition, the investment cost of feed increased linearly, therefore increasing breakeven over time. Moreover, as SBW increased, HCW also increased which led to greater HCW discounts for heavy-weight carcasses. This may be why DOF and predicted HCW also have a similar relationship to dependent variables such as SBW. Alternatively, as SBW increased, processor margin for cattle purchased via value-based grid increased due to heavy-weight discounts assessed to the producer. Contrary to formula margin, dressed sales margin decreased, which is likely due to producers not receiving carcass premiums and discounts when selling cattle on a dressed basis. DOF and predicted HCW followed similar trends as SBW because the three variables are highly related. DMI had negative effects on producer margins for all three sales methods with positive effects for processor margin when buying via live purchase. We postulate that the effect of DMI on producer margins may be misleading. As DMI increases, SBW and HCW should also increase. For beef processors, the influence of DMI on margin of live bought cattle is more than likely a function of overall caloric consumption leading to increased-USDA quality-grading characteristics.

As the beef industry begins to meet the challenges of supplying protein to a growing world economy, the use of growth technologies will be a vital strategy to

Table 5. Simple r values among dependent and predictive variables

Item	Dependent variables of interest					
	Producer net value \$/45.4 kg			Processor net value \$/45.4 kg		
	Live sales	Dressed sales	Formula sales	Live purchase	Dressed purchase	Formula purchase
Shrunk BW, kg	-0.67***	-0.69***	-0.75***	0.12	-0.24**	0.31**
DOF	-0.79***	-0.80***	-0.81***	0.10	-0.28**	0.24*
DMI, kg/d	-0.25**	-0.51***	-0.34**	0.26**	-0.04	-0.10
Predicted HCW, kg [†]	-0.66***	-0.68***	-0.73***	0.16	-0.22*	0.32**

[†]HCW prediction from McEvers (2018) ($HCW = -41.44 + [0.6637 \times SBW] + [12.974 \times ZH]$).

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.0001$.

increase efficiency and maintain competitive pricing to the end consumer. During feeder cattle shortages, increased value will be placed on utilization of dairy-bred steers in the fed-cattle industry. This investigation indicates the use of the growing technology ZH and the effect on economic viability and revenue with respect to the beef processor. Increasing value, margin, and volume of fresh beef should be a top concern of any player in the beef industry.

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