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Feeding performance, carcass characteristics, and tenderness attributes of steers sorted by the Igenity tenderness panel and fed zilpaterol hydrochloride

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ABSTRACT: Steers (n = 560; initial BW = 420 ± 26 kg) were selected from a pool of 1,040, using the IGENITY Profile DNA test for tenderness, sorted into 1 of 4 tenderness genotype (TG) groups [140 tough (TUF), 140 intermediate (INT), 140 tender (TEND), or 140 mixed (MXD)], and subsequently allocated into 56 pens at random, of which one-half (28 pens, 7 pens from each TG) were supplemented the β-adrenergic agonist zilpaterol hydrochloride (ZH) and the balance fed a control ration. No TG × ZH interaction ($P \geq 0.15$) occurred for any measured trait. Cattle from INT TG had less ($P < 0.05$) DMI during pretreatment (d 0 to 118) and entire trial (d 0 to 143) periods than other TG. Cattle fed ZH had greater ($P < 0.01$) ADG and G:F, and decreased ($P < 0.01$) DMI during the treatment period (d 119 to 143). Cattle from the TEND group had greater ($P < 0.01$) marbling scores, increased ($P < 0.02$) calculated USDA yield grades (YG), and more ($P < 0.02$) calculated empty body fat (EBF) than TUF cattle. Cattle receiving ZH during the treatment period had increased ($P < 0.01$) HCW, dressed yield, and LM area. Additionally, cattle fed ZH exhibited decreased ($P < 0.01$) EBF, marbling, KPH, and calculated USDA YG. No difference ($P > 0.06$) in YG distributions were detected among TG, yet TEND cattle were represented by a greater ($P < 0.01$) proportion of Prime and premium Choice carcasses. Cattle fed ZH exhibited increased ($P < 0.01$) frequencies of YG 2 carcasses and fewer ($P < 0.01$) YG 3, 4, and 5 carcasses concurrent with an increase ($P < 0.04$) in the percentage of Select carcasses. Longissimus steaks from TUF cattle had greater ($P < 0.03$) Warner-Bratzler Shear Force (WBSF) values at 7 and 14 d postmortem than steaks from INT or TEND cattle. Furthermore, ZH-fed cattle had increased ($P < 0.01$) WBSF values for all aging periods compared with control cattle. Frequency of steaks with WBSF values <3.9 kg (certified tender) were less ($P < 0.05$) for the TUF group. Feeding ZH resulted in fewer longissimus steaks ($P < 0.01$) with WBSF values <3.0 kg (guaranteed tender) across all aging periods; however, no difference in the frequency of steaks with WBSF values <3.9 kg was found after 21 d of aging. Igenity Profile tenderness scores were correlated ($P < 0.05$) to carcass finish attributes and WBSF values. Commercially available tenderness panels may have the potential to allow for antemortem sorting of cattle into expected tenderness groupings, which could augment feeding management strategies and ultimately lead to increased marketing value for the beef system.

Key words: beef, DNA, tenderness, zilpaterol hydrochloride

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INTRODUCTION

Advancements in knowledge and use of information from the beef genome have provided additional tools to producers wanting to improve breeding and marketing of animals. Identification of SNP markers tied to economically important factors associated with finished beef have been the focus of previous studies (Kononoff et al., 2005; Marques et al., 2009). DeVuyst et al. (2011) reported genotypic correlations between Igenity Profile scores and economically important traits of ADG, LM area, marbling, and USDA YG in a population of fed steers and heifers were significant but rather weak.

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The 3 SNP associated with Igenity Profile tenderness technology included the calpastatin SNP UoG-CAST1, as well as the calpain SNP CAPN316 and CAPN4751. The SNP UoG-CAST1 was developed by the University of Guelph (Ontario, Canada) and released in 2005 (Schenkel et al, 2006). The CAPN316 and CAPN4751 SNP were identified by the USDA Meat Animal Research Center in Clay Center, NE, and released in 2003 and 2005, respectively (Page et al. 2002; White et al. 2005).

Miller et al. (2001) indicated consumer tenderness acceptability reached 100% when WBSF values were ≤3.0 kg; furthermore, steaks weighing ≤3.0 kg were deemed "guaranteed tender" and authors postulated those animals worthy of premiums over tougher steaks. Use of genomic markers to identify cattle with superior palatability attributes may lead to increased beef value (Weaber and Lusk, 2010). Recent evaluations of beef tenderness reported by Garmyn et al. (2011) examined the distributions of cattle with WBSF values <4.6 kg fed zilpaterol hydrochloride (**ZH**) for 0 or 20 d; as aging time increased, the proportion of longissimus lumborum steaks with WBSF values <4.6 kg increased to 100% after aging for 28 d.

The objective of this study was to quantify feeding and carcass performance, and objective tenderness traits of cattle sorted by the Igenity Profile tenderness panel into groups differing in eating quality before being fed ZH for 0 or 20 d.

MATERIALS AND METHODS

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).

Live Cattle Procedures

Cattle Processing. In the spring of 2010, 1,040 British and British × Continental beef steers were processed at Boise Valley Feeders, Parma, ID. Cattle were sampled using the Igenity tagging system for obtaining ear tissue samples and tagged with a unique identification ear tag, as well as an electronic identification button. Animals were vaccinated against *Clostridium spp*., using Vision 8 with SPUR (Merck Animal Health, Summit, NJ), and infectious bovine rhinotracheitis and bovine viral diarrhea, using Titanium 3 (AgriLabs, St. Joseph, MO). Furthermore, animals were dewormed with oral fenbendazole (Safe-Guard, Merck Animal Health), along with injectable moxidectin (Cydectin, Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO). During processing, steers were also implanted with a growth promotant containing 40 mg of estradiol and 200 mg of trenbolone acetate (Revalor-XS; Merck Animal Health).

Tenderness Genotype Determination. Ear tissue samples were subsequently sent to Igenity in Lincoln, NE (Igenity, 2011), where individual genotypes for calpain and calpastatin were determined, and molecular breeding values (**MBV**) calculated. Molecular breeding values were then used to rank cattle on an ordinal tenderness genotype (**TG**) scale from 1 to 10, where a score of 10 was most likely to exhibit tender phenotypic characteristics and a 1 least likely. Cattle placed in the tender (**TEND**; 7+ to 10) category had MBV values ranging from –2.60 to –4.49; those in the intermediate (**INT**; 6 to 7–) category, ranged from –1.45 to –2.05; and those in the tough (**TUF**; 2 to 5) category, ranged from –0.44 to 2.24. A fourth group, which contained a representative distribution of each TG range, was identified as the mixed study group (**MXD**). A total of 560 steers (182 TEND, 196 INT, 182 TUF) were selected, weighed, and transported to Johnson Research, LLC, Parma, ID. Upon arrival, cattle were individually weighed (initial BW = 420 ± 26 kg), blocked by BW, then assigned to a pen based on TG (14 pens TEND, 14 pens INT, 14 pens TUF, 14 pens MXD) and ZH (Merck Animal Health, Summit, NJ; 28 pens, 0 d; 28 pens, 20 d) treatment (Table 1).

Feeding Procedures. Cattle were housed in outdoor pens 7.6 m wide × 21.3 m long in groups of 10, allowing for 16.2 m^2 of space for each animal. Animals were allowed to consume water ad libitum, using fenceline water tanks shared by adjacent pens. Cattle were fed ad libitum a total mixed ration that met or exceeded NRC requirements, and transitioned using a step-up diet, followed by a traditional finishing diet (Table 2). Cattle that received ZH were fed a finishing ration that contained 8.33 mg/kg of dietary DM for 20 d before slaughter with a 3-d withdrawal. Zilpaterol hydrochloride was introduced into the ration of selected treatment pens, using a formulated premix delivered by a third-party cattle supplement company. The premix included in the finishing ration of control cattle had identical ingredients, with the exception of ZH inclusion. Bunks were managed to prevent slicking, if possible, so that 2.3 kg per animal of residual feed remained before the next day's ration allocation. Eleven cattle were removed from the study before completion due to mortality or chronic morbidity.

Carcass Procedures

Carcass Data Collection. Cattle were harvested in a commercial beef processing facility in Washington, using typical industry methods and allowed to chill for 36 h. Personnel from the West Texas A&M University-Beef Carcass Research Center were present at harvest to identify and evaluate individual animals. Data collected at

Table 1. Final counts of cattle per tenderness genotype and zilpaterol hydrochloride[1] feeding

	Fed zilpaterol hydrochloride for 20 d				Not fed zilpaterol hydrochloride			
	Igenity Profile tenderness grouping							
Block	Tough	Intermediate	Tender	Mixed	Tough	Intermediate	Tender	Mixed
1	1 pen (10 steers)	1 pen (9 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)
2	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (8 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)
3	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)
4	1 pen (10 steers)	1 pen (8 steers)	1 pen (9 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (9 steers)	1 pen (9 steers)	1 pen (10 steers)
5	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)
6	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (9 steers)	1 pen (10 steers)	1 pen (10 steers)
7	1 pen (10 steers)	1 pen (8 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)	1 pen (10 steers)
Total	70 steers	65 steers	69 Steers	70 Steers	68 Steers	68 Steers	69 Steers	70 Steers

[1]Merck Animal Health, Summit, NJ.

harvest included individual animal ear tag, liver abnormality score, HCW, and corresponding beef processor identification numbers. Carcass performance data collected in the cooler included LM area (cm^2), subcutaneous fat thickness (cm), estimated percentage KPH (%), estimated marbling score (10 = practically devoid, 20 = traces, 30 = slight, 40 = small, 50 = modest, 60 = moderate, 70 = slightly abundant, 80 = moderately abundant, 90 = abundant), as well as stamped USDA yield and quality grades. Carcasses were then tracked through the fabrication floor of the beef processing facility and 1 strip loin (Institutional Meat Purchase Specifications (IMPS) 180; 0 cm × 2.54 cm tail) was collected from each carcass.

Table 2. Formulated composition of diets allocated during the feeding period

	Ration		
Item	Step-up	Finishing[1]	Treatment[2]
Ingredients (as fed)			
Alfalfa hay, %	13.6	3.7	3.7
Rolled corn, %	12.0	11.5	11.5
Dry distillers grain, %	3.0	4.5	4.5
Whey, %	14.0	14.0	14.0
Liquid supplement, %	4.8	4.8	4.8
Wheat, %	16.0	17.5	17.5
Cobbage, %	36.6	44.0	44.0
Chemical composition (DM basis)			
DM. %	68.07	66.55	66.55
NE_m, Mcal / kg	1.92	1.96	2.01
NE_g, Mcal / kg	1.28	1.23	1.26
Fat, %	3.08	3.43	3.58
ADF, %	11.82	7.68	7.07
NDF, %	22.89	16.23	14.09
CP, %	13.60	13.37	13.07
Calcium, %	1.19	0.88	0.95
Phosphorus, %	0.41	0.39	0.38
Potassium, %	1.12	0.71	0.77
Magnesium, %	0.20	0.15	0.16
Time period fed	Apr. 29 to May 3, 2010	May 4 to Sept. 20, 2010	Aug. 28 to Sept. 16, 2010

[1]Finishing ration for cattle fed post zilpaterol hydrochloride (ZH; Merck Animal Health, Summit, NJ) and cattle not fed ZH during the feeding period.

[2]Finishing ration fed to cattle containing ZH during the feeding period.

Warner-Bratzler Shear Force. Strip loins collected from each carcass were transported under refrigeration via commercial freight carrier to the West Texas A&M University meat laboratory where three 2.54-cm-thick steaks were cut from the cranial end of the subprimal. The steaks were randomly allocated to 1 of 3 aging (7, 14, and 21 d) periods and then frozen at –28ºC until further analysis. Steaks were thawed at 1°C for 24 h before cooking. Steaks were cooked in a forced-air convection oven (Blodgett, model CTB/R, G.S. Blodgett Co., Burlington, VT), set at 177°C, until an internal endpoint temperature of 70°C was reached. The internal temperature of each steak was monitored through a copper-constantan thermocouple wire (Omega Engineering, Stamford, VT), positioned in the geometric center and connected to a temperature-monitoring device (Omega Engineering, Stamford, VT). Steaks were wrapped in cellophane and chilled for 24 h at 1°C. After chilling, six, 1.27-cm cores were randomly removed, parallel to the muscle fiber orientation, from each steak. The cores were immediately sheared using a V-shaped blade on a Warner-Bratzler shear force machine (G-R Manufacturing, Manhattan, KS). The peak shear force value was displayed on a Mecmesin BNG-500 Shear Force Gauge (Newton House, UK). The peak shear force was manually recorded. Overall WBSF value for each steak was calculated using the mean WBSF value from the 6 cores sheared. For each aging period, WBSF values were evaluated against 2 thresholds [≤3.0 kg (guaranteed tender, Miller et al. 2001) and ≤3.9 kg (certified very tender, ASTM, 2011)].

Statistical Analysis

A 2 × 4 factorial treatment arrangement was used in a randomized complete block experimental design. Each block consisted of 8 pens; 2 replicate pens represented

Table 3. Live performance data within genotypic tenderness assignment for cattle fed ZH[1] for 0 or 20 d

	Tenderness genotype					ZH			*P*-value		
Item	Tough	Intermediate	Tender	Mixed	SEM	No	Yes	SEM	Tenderness genotype	ZH	Tenderness genotype × ZH
Pens	14	14	14	14	-	28	28	-	-	-	-
Animals[2]	138	133	138	140	-	275	274	-	-	-	-
Initial BW, kg	420.6	419.5	421.4	421.6	1.781	420.6	420.9	1.259	0.6387	0.7262	0.6437
D 119 BW, kg	624.0	624.7	629.4	627.0	3.209	626.8	625.7	2.269	0.3396	0.6337	0.6456
Final BW, kg	673.1	670.3	676.2	671.9	4.113	670.3	675.5	2.908	0.5244	0.0815	0.9892
Pretreatment period (d 0 to 118)											
ADG, kg	1.72	1.74	1.76	1.74	0.026	1.75	1.74	0.018	0.5225	0.4820	0.2941
DMI, kg/d	10.37[ab]	10.02[b]	10.63[a]	10.68[a]	0.246	10.39	10.46	0.174	0.0424	0.6689	0.3912
G:F	0.167	0.175	0.166	0.163	0.004	0.169	0.167	0.003	0.0903	0.4714	0.7178
ZH treatment period (d 119 to 143)											
ADG, kg	1.96	1.82	1.87	1.79	0.091	1.74	1.99	0.064	0.2766	0.0003	0.2318
DMI, kg/d	10.43	10.31	10.65	10.59	0.169	10.76	10.23	0.119	0.1887	0.0001	0.9073
G:F	0.188	0.177	0.177	0.170	0.008	0.162	0.194	0.006	0.2170	0.0001	0.2266
Entire trial period (d 0 to 143)											
ADG, kg	1.77	1.75	1.78	1.75	0.027	1.75	1.78	0.019	0.6245	0.0892	0.9373
DMI, kg/d	10.38[ab]	10.08[b]	10.64[a]	10.66[a]	0.219	10.46	10.42	0.155	0.0367	0.8186	0.4870
G:F	0.171	0.175	0.168	0.164	0.004	0.168	0.171	0.003	0.0670	0.2112	0.5045

[a,b]Means without a common superscript differ ($P < 0.05$).

[1]ZH = zilpaterol hydrochloride (Merck Animal Health, Summit, NJ).

[2]Final total number of cattle on day of harvest.

each TG and were either fed ZH for 0 or 20 d at the end of the feeding period. Initial BW was not shrunk and d 119 and 143 BW were multiplied by 0.96 for all analyses. All removed and dead cattle were not used in the final analysis. A total of 549 steers were evaluated at the beef processing facility, with 1 steer being condemned by USDA Food Safety and Inspection Service personnel during harvest. Empty BW, empty body fat (**EBF**), and shrunk BW adjusted to a 28% EBF was calculated using the methodology outlined by Guiroy et al. (2002). Live, carcass, and WBSF data were analyzed using the MIXED procedure (SAS Inst. Inc., Cary, NC); pen was the experimental unit. Igenity Profile derived TG, ZH treatment, and TG × ZH interactions were used as fixed effects in the model with the random effect of block. Least squares means were generated using the LSMEANS option and separated when significant using the PDIFF option. Spearman correlation analysis of ordinal Igenity Profile scores and individual carcass data variables were analyzed using the CORR procedure with the spearman option. Frequency distributions for USDA yield and quality grade, as well as WBSF thresholds, were analyzed using the GENMOD procedure with TG, ZH, TG × ZH, and block effects. The LOGISTIC procedure was used to estimate the probability of longissimus lumborum steaks being measured as guaranteed tender (WBSF ≤3.0 kg) as a function of Igenity Profile scores across a composite of the 3 aging times.

RESULTS AND DISCUSSION

Live Cattle Performance

No TG ×ZH interaction ($P \geq 0.23$) existed for any live performance variable (Table 3). No differences in BW ($P \geq 0.34$) or ADG ($P \geq 0.28$) were detected among TG. Cattle in the INT category had less ($P \leq 0.05$) DMI than cattle in the TEND or MXD categories, during both the pretreatment and entire trial period; TUF cattle were intermediate in DMI. Depressed DMI and similar ADG of the INT group led to a tendency ($P = 0.06$) for improved G:F as compared with other TG.

Final BW of ZH-fed cattle tended ($P = 0.08$) to be greater than non-ZH fed cattle. Greater ADG (0.25 kg; $P < 0.01$) and G:F (0.032; $P < 0.01$), concurrent with less DMI (0.53 kg; $P < 0.01$), was observed for ZH-fed cattle during the treatment period.

The results in this investigation suggest a 14.4% and 19.8% improvement for ADG and G:F, corresponding to a 5.2% decrease in DMI and are supportive of earlier studies that indicated enhanced feeding performance of cattle fed ZH (Plascencia et al. 1999; Avendano-Reyes et al. 2006; Vasconcelos et al. 2008; Elam et al. 2009).

Carcass Characteristics

Carcass performance data (Table 4) did not reveal any TG × ZH interaction ($P \geq 0.24$). Cattle in the TUF category were leaner ($P < 0.02$) than all other TG, as measured by calculated EBF and yield grade. Moreover, TUF cattle had lower ($P < 0.02$) marbling scores than TEND or MXD groups. Cattle in the TEND group, as indicated by EBF data, likely reach a marketable endpoint in fewer days as compared with the TUF group. The use of tenderness panel sorting of the steers fed in this investigation illustrates the possibilities for producers to enhance feeding duration management of cattle based on TG. Furthermore, the differences observed among TG for the outcomes of calculated EBF, marbling score, and calculated USDA yield grade suggest that Igenity Profile tenderness scores are also associated with rate of achieving a physiological endpoint.

Cattle fed ZH had heavier HCW (14.1 kg; $P < 0.01$), increased dressed carcass yield (1.61%; $P < 0.01$), increased empty BW (19.2 kg; $P < 0.01$), greater 28% adjusted final BW (29.9 kg; $P < 0.01$), and greater LM area (6.3 cm^2; $P < 0.01$). Likewise, feeding ZH resulted in lower marbling scores (24 degrees; $P < 0.01$), less calculated EBF (0.53%; $P < 0.02$), less estimated KPH (0.08%; $P < 0.01$), and lower USDA calculated yield grades (0.24; $P < 0.01$). No differences ($P \geq 0.29$) were detected for lean color scores or subcutaneous 12th rib fat depth as a result of ZH feeding.

Evaluating the carcass performance parameters that were measured, cattle administered ZH possessed carcass traits similar to earlier investigations. Elam et al. (2009) investigated ZH use in beef cattle and determined that the administration of this beta adrenergic agonist significantly increased HCW, dressed yield, and LM area, concurrent with decreased marbling score, estimated KPH, and calculated USDA yield grade.

No TG × ZH interactions ($P \geq 0.41$) were observed for yield or quality grade distributions (Table 5). Cattle in the MXD group tended ($P = 0.06$) to have fewer yield grade 3 cattle than those in the TEND group. When comparing the frequency of USDA yield grading characteristics between ZH-fed cattle and control animals, cattle fed ZH had a greater proportion of USDA yield grade 2 (51.77 vs. 36.07%; $P < 0.01$) carcasses. Subsequently, fewer carcasses were assigned yield grades of 3 (33.40 vs. 44.17%; $P < 0.01$) or 4 and 5 (4.04 vs. 12.74%; $P < 0.01$). This distribution shift in carcass yield grading is indicative of the effects of ZH supplementation in the finishing diet of beef cattle.

Cattle designated as TEND were represented by a greater proportion ($P < 0.01$) of carcasses with quality grades of Prime and premium Choice than other TG. Likewise, TEND cattle tended ($P = 0.09$) to have fewer commodity Choice carcasses than remaining groupings. Cattle fed ZH were represented by more ($P < 0.04$) Select carcasses and tended ($P = 0.06$) to exhibit fewer Prime and premium Choice carcasses.

Warner-Bratzler Shear Force

Warner-Bratzler shear force data (Table 6) of longissimus lumborum steaks did not reveal any TG × ZH

Table 4. Carcass performance data within genotypic tenderness assignment for cattle fed ZH[1] for 0 or 20 d

	Tenderness genotype					ZH			*P*-value		
Item	Tough	Intermediate	Tender	Mixed	SEM	No	Yes	SEM	Tenderness genotype	ZH	Tenderness genotype × ZH
HCW, kg	418.1	417.0	419.6	418.6	2.699	411.3	425.4	1.909	0.8119	0.0001	0.8912
Dressed yield, %	62.11	62.21	62.05	62.29	0.194	61.36	62.97	0.137	0.5970	0.0001	0.2459
Empty body fat[2], %	29.75^b	30.35^a	30.68^a	30.44^a	0.278	30.57	30.04	0.197	0.0128	0.0103	0.6790
Empty BW[3], kg	582.4	581.3	584.7	583.3	3.472	573.3	592.5	2.455	0.7963	0.0001	0.8659
28% adjusted final BW[4], kg	625.6	614.8	613.4	615.6	5.814	602.4	632.3	4.111	0.1519	0.0001	0.6425
Marbling	45.31^c	46.59^{bc}	49.74^a	47.59^{ab}	1.099	48.49	46.13	0.777	0.0021	0.0041	0.3947
Lean Color[5]	5.76	5.65	5.65	5.67	0.072	5.69	5.68	0.051	0.3454	0.9447	0.4743
S.C. fat thickness, cm	1.53	1.65	1.62	1.61	0.050	1.62	1.58	0.035	0.1109	0.2889	0.8120
LM area,cm^2	102.12	100.09	99.17	99.95	1.198	97.19	103.48	0.847	0.1015	0.0001	0.6281
KPH, %	1.96	2.00	1.98	1.99	0.029	2.02	1.94	0.021	0.5032	0.0006	0.5910
Calculated yield grade[6]	2.83^b	3.05^a	3.08^a	3.03^a	0.079	3.12	2.88	0.056	0.0140	0.0001	0.7918

$^{a–c}$Means without a common superscript differ ($P < 0.05$).

[1]ZH = zilpaterol hydrochloride (Merck Animal Health, Summit, NJ).

[2]Empty body fat, % = 17.76207 + (4.68142 × subcutaneous fat thickness, cm) + (0.01945 × HCW, kg) + (0.81855 × quality grade) – (0.06754 × LM area, cm^2). Numerical quality grade values were assigned based on the marbling score-derived 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).

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

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

[5]Lean color evaluation scores adapted from Herschler et al. (1995).

[6]USDA calculated yield grade.

Table 5. Carcass grading distributions within genotypic tenderness assignment for cattle fed ZH[1] for 0 or 20 d

	Tenderness genotype				ZH		P-value		
Item	Tough	Intermediate	Tender	Mixed	No	Yes	Tenderness genotype	ZH	Tenderness genotype × ZH
USDA YG1,[1] %	8.42	4.54	5.32	4.77	4.37	7.14	0.5755	0.1950	0.4624
USDA YG2, %	46.13	40.09	39.75	49.25	36.07	51.77	0.3155	0.0002	0.6787
USDA YG1,[1] %	36.76	42.24	44.30	31.77	44.17	33.40	0.0631	0.0030	0.6477
USDA YG4 and YG5, %	3.80	9.18	6.96	11.22	12.74	4.04	0.1791	0.0004	0.4162
Prime and premium Choice, %	18.74[b]	21.30[b]	39.09[a]	26.02[b]	30.07	21.63	0.0067	0.0581	0.7908
Low Choice, %	64.76	65.41	49.52	64.14	60.36	61.86	0.0860	0.7712	0.9524
Select, %	15.61	10.20	9.44	8.84	7.76	14.77	0.4622	0.0339	0.4256

[a, b]Means without a common superscript differ ($P < 0.05$).

[1]ZH = zilpaterol hydrochloride (Merck Animal Health, Summit, NJ); YG = yield grade.

interactions ($P \geq 0.22$). Cattle designated as TUF had greater ($P < 0.03$) 7- and 14-d WBSF values than INT or TEND categories; however, no TG differences ($P = 0.55$) in WBSF were detected 21 d postmortem. Cattle fed ZH for 20 d had greater ($P < 0.01$) WBSF values at 7, 14, and 21 d postmortem (0.74, 0.53, 0.34 kg, respectively) than non-ZH fed animals.

No TG × ZH interaction ($P > 0.19$; Table 7) was detected for the percentage of longissimus lumborum steaks less than the 3.0-kg threshold (guaranteed tender; Miller et al., 2001). No interaction ($P > 0.49$) was observed for percentage of steaks below the 3.9-kg threshold (certified very tender; ASTM, 2011) at 7 or 14 d aging. Cattle in the TEND group tended ($P = 0.08$) to have a greater percentage of steaks less than the guaranteed tender threshold than other TG. Cattle in the TUF group had fewer ($P < 0.05$) longissimus lumborum steaks with WBSF values ≤3.9 kg when comparing the 7-d aging period. Cattle fed ZH were represented by fewer ($P < 0.01$) guaranteed tender steaks for all aging periods and fewer ($P < 0.01$) certified very tender steaks at 7- and 14-d aging. Because virtually all (≥99.85%) longissimus lumborum steaks were less than the certified very tender threshold after 21 d postmortem, P-values were unreliable.

Comparing the effect of ZH on tenderness with previous work, several investigations (Brooks et al. 2009; Kellermeier et al. 2009; Leheska et al. 2009; Garmyn et al. 2011) have confirmed the differences found for WBSF values of cattle fed ZH. However, Garmyn et al. (2011) were unable to detect differences between control animals and cattle fed ZH when comparing the frequency of steaks with WBSF values <4.6 kg. Moreover, Hilton et al. (2009) indicated consumers were unable to detect differences in tenderness or overall acceptability of LM steaks from cattle fed ZH and those that were not. Similarly, Mehaffey et al. (2009) indicated that consumers found LM steaks similar in tenderness, juiciness, flavor, and overall palatability after 21 d aging, regardless of ZH feeding for 0 or 20 d. Comparing the tenderness thresholds (≤3.9 and ≤3.0) used in this investigation to previous research detailing consumer acceptability, Miller et al. (2001) reported that longissimus lumborum steaks with WBSF values of 4.0 kg resulted in a consumer acceptability rating of 94%, whereas steaks with WBSF values of 3.0 kg resulted in a rating of 100%.

The percentage and 95% upper and lower confidence limits of LM steaks estimated as guaranteed tender (WBSF ≤3.0 kg) across Igenity Profile tenderness scores (Figure 1) illustrates a prominent increase in probability of a guaranteed tender result as score increased from 2 to 10. At an Igenity Profile tenderness score of 2, 29% of LM, steaks were estimated as guaranteed tender, whereas at a score of 10, 69% of carcasses were estimated as guaranteed tender. When discussing the relative usefulness of the Igenity Profile tenderness panel, Van Eenennaam et al. (2007) noted that the potential improvement from selecting cattle based on the most tender genotype

Table 6. Warner-Bratzler shear force performance analysis for 7-, 14-, and 21-d aged beef short loins within genotypic tenderness assignment for cattle fed ZH[1] for 0 or 20 d

	Tenderness Genotype					ZH			P-value		
Item	Tough	Intermediate	Tender	Mixed	SEM	No	Yes	SEM	Tenderness genotype	ZH	Tenderness Genotype × ZH
7 d, kg	3.75[a]	3.42[b]	3.46[b]	3.53[b]	0.110	3.17	3.91	0.078	0.0224	0.0001	0.8636
14 d, kg	3.11[a]	2.93[b,c]	2.87[c]	3.07[a,b]	0.082	2.73	3.26	0.058	0.0176	0.0001	0.9585
21 d, kg	2.78	2.74	2.69	2.76	0.067	2.57	2.91	0.047	0.5525	0.0001	0.2187

[a–c]Means without a common superscript differ ($P < 0.05$).

[1]ZH = zilpaterol hydrochloride (Merck Animal Health, Summit, NJ).

Table 7. Frequency analysis of WBSF for 7, 14, and 21 d aged beef short loins within genotypic tenderness assignment for cattle fed ZH[1] for 0 or 20 d

	Tenderness genotypes				ZH		*P*-values		
Item	Tough	Intermediate	Tender	Mixed	No	Yes	Tenderness genotype	ZH	Tenderness genotype × ZH
WBSF ≤3.0 kg (guaranteed tender)[2]									
7 d aging, %	20.72	28.09	28.61	22.37	42.69	12.73	0.5303	0.0001	0.9179
14 d aging, %	45.21	55.69	58.89	47.48	69.62	33.58	0.1843	0.0001	0.6616
21 d aging, %	66.20	69.09	81.47	70.49	84.12	56.15	0.0751	0.0001	0.1910
WBSF ≤ 3.9 kg (certified very tender)[3]									
7 d aging, %	61.55[b]	80.41[a]	73.79[a]	71.21[a]	85.79	52.96	*0.0422*	0.0001	0.4960
14 d aging, %	89.58	95.31	94.28	91.44	97.28	83.08	0.3735	0.0001	0.8472
21 d aging, %	99.94	99.93	100.00	100.00	100.00	99.85	---	---	---

[a,b]Means without a common superscript differ ($P < 0.05$).

[1]ZH = zilpaterol hydrochloride (Merck Animal Health, Summit, NJ).

[2]Miller et al., 2001.

[3]ASTM, 2011.

(UoG-CAST1-CC, CAPN316-CC, and CAPN4751-CC) resulted in a 1-kg reduction in WBSF compared with the toughest genotype combination (UoG-CAST1-GG, CAPN316-GG, and CAPN4751-TT). The differences between the TUF and TEND groups were less than the theoretical maximum difference potential observed among animals with the most extreme genotype combinations, which reflect the fact that the groups in this study consisted of animals with a range of tenderness scores within each of the 3 group categories (bottom third, middle third, and top third) and thus do not reflect the potential extreme values.

The results of this investigation confirm previous research (DeVuyst et al. 2011), which suggested that carcass variables of LM area, calculated USDA yield grade, and USDA quality grade are minimally correlated to Igenity Profile tenderness score. In contrast to DeVuyst et al. (2011), who indicated a moderate correlation between HCW and tenderness score, the current investigation differed.

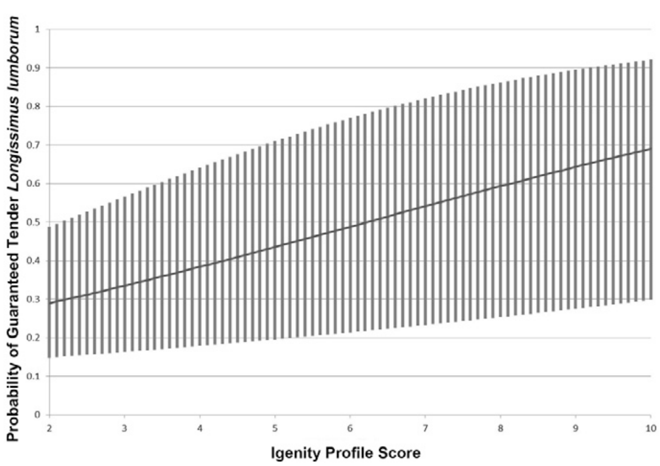

Figure 1. Probability and 95% confidence limits of LM steaks being measured as guaranteed tender (WBSF ≤3.0 kg) across Igenity Profile scores.

Use of available genotypic tenderness panels in the beef industry is a viable option to increase the value of beef. By selecting cattle of known markers associated with tenderness, producers may have the ability to influence the consistency of beef products. Certified tender programs could be enhanced by sorting and selecting for desired allele combinations or discounting undesirable combinations. Additional implications could include improved feeding duration management of cattle with allele combinations that are associated with earlier attainment of physiological finish. Further research is needed to validate this technology among various genotypes, including *Bos indicus*, and feeding duration schedules.

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