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The relationship between pre-harvest stress and the carcass characteristics of beef heifers that qualified for kosher designation

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ABSTRACT

Differences in pre-harvest stress measurements and carcass characteristics between kosher and not-qualified-as-kosher cattle were evaluated. Finished heifers ($n = 157$) were slaughtered by a shochet while held in an upright position using Glatt slaughter procedures. Stress measurements were collected prior to slaughter. Carcass data were collected, and 3.8-cm thick samples were taken from the loin at the 13th rib. Steaks from each sample were evaluated for mechanical tenderness and simulated retail display. Cattle with shorter times from gate to exsanguination and lower vocalization scores were more likely ($P < 0.01$) to qualify as kosher. Kosher carcasses had larger ($P = 0.02$) ribeye areas and higher ($P < 0.0001$) Warner–Bratzler shear values. At each day of simulated retail display, kosher steaks had lower ($P < 0.05$) L*, a*, and b* values. These data suggest that body composition and pre-harvest stress affect the likelihood of a beef animal qualifying as kosher and quality differences exist between kosher and non-kosher steaks.

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1. Introduction

Kosher food based on biblical origins grew into a $200 billion food industry in 2009 (Regenstein & Regenstein, 2012). The kosher slaughter process is performed by a trained religious slaughter man with no stunning of the animal prior to exsanguination. However, this procedure alone does not make an animal acceptable for kosher consumption. Internal organs, specifically the lungs, must be inspected for any defects. Lungs have been inspected since biblical times as a guard against disease. Pneumonia and other respiratory illnesses are among the most common causes of lung leisons today (Schneider, Tait, Busby, & Reecy, 2009). Lung adhesions are of primary concern and may result in an animal failing to qualify as kosher. We hypothesize that there are differences between cattle that qualify as kosher and those that do not, that pre-slaughter stress may affect carcass and meat quality of steers and heifers kosher slaughtered, and there may be differences in carcass and meat quality between kosher-qualified cattle and non-kosher-qualified cattle. The objective of this study was to determine if there are differences in pre-slaughter stress measurements and carcass characteristics between carcasses that qualified for kosher versus those that did not qualify as kosher.

2. Materials and methods

2.1. Data collection

Trained university personnel observed kosher beef slaughter of steers and heifers of mostly Angus genetics sourced from North Dakota and Minnesota, USA ($n = 162$) at a commercial abattoir in New Rockford, ND during three slaughter days in consecutive months (January through March). Slaughter facilities are typical of a modern beef slaughter facility, with cattle moving from lairage pens onto a v-belt restrainer that moved the cattle to the bleeding gate. All cattle were held in an upright position and the head restrained by a hydraulic device that presented the throat to the trained rabbi for bleeding. A single rabbi performed all of the bleeding, and all animal were presented for "Glatt" kosher slaughter. Pre-slaughter stress measurements recorded included number of animals per lairage pen, chute score, vocalization score, number of times electrical prods used, and time from entering the v-belt to exsanguination (GtE). Chute scores (1 = calm, no movement; 2 = slightly restless; 3 = squirming, occasionally shaking the chute; 4 = continuous, very vigorous movement and shaking of the chute; 5 = rearing, twisting of the body and struggling violently) were adapted from Grandin (1993) and Grandin (2010) and recorded in the holding chute prior to entering the v-belt restrainer. Vocalization scores (0 = no vocalization, 1 = low intensity, singular vocalization; 2 = mild intensity, one to two vocalizations; 3 = high intensity, two or more vocalizations) were observed on the v-belt restrainer. Time from exsanguination to insensibility (EtU) was recorded. Insensibility

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was defined by lack of corneal reflex. Approximately 30 s after exsanguination, a 2-mL blood sample was collected and analyzed immediately for blood lactate concentration using a Lactate Pro Meter (Arkray, USA Inc., Edina, MN). Hot carcass weight (HCW) was recorded, and carcasses were transported in refrigerated trailers to the North Dakota Natural Beef processing facility in Fargo, ND. The kosher data indicating if a carcass qualified for kosher, with all carcasses qualified for kosher designated as "Glatt," or were not kosher were obtained from North Dakota Natural Beef after the slaughter process was completed. The trained rabbis inspected the internal organs, and especially the lungs and carcasses for evidence of defects that would prevent the carcass from being classified as kosher. To inspect the lungs, a small hand-held air pump was used to inflate the lungs which were then evaluated for the lungs ability to hold air. If the lungs did not hold air, the carcass would not qualify as kosher. After a 24-h chill, 12th rib fat (BF), rib eye area (REA), kidney pelvic and heart fat percentage (KPH), final yield grade (FYG), marbling score (Marb), as well as the presence of beef quality defects were measured by trained university personnel. At the same time, an approximately 3.8-cm thick sample was obtained from the loin at the 13th rib, placed in a labeled bag inside a cooler, and transported immediately to the North Dakota State University's meats laboratory. Upon arrival, a subsample of loin (~2 g) was removed and frozen at −10 °C for up to 60 d for later analysis of sarcomere length and troponin-T degradation. Two steaks (2.54-cm and 1.25-cm thick) were cut from the remaining sample, vacuum packaged (Cryovac® vacuum packager, Duncan, SC) and aged at 4 °C for 14 d and 7 d respectively until further processing and analyses. It is important to note that the steak samples had not been subjected to "koshering" that is, the samples had not been salted or soaked.

2.2. Warner–Bratzler shear force (WBSF)

After aging for 14 d in darkness at 4 °C, the 2.54-cm steaks were frozen at −20 °C until analysis for tenderness by WBSF. All samples from the three collection periods were evaluated on the same day. Prior to cooking and shear force measurements, steaks were thawed overnight in a 4 °C-cooler and then allowed to come to room temperature (approximately 18 °C) before being weighed. A copper-constantan thermocouple was inserted (Omega Engineering Inc., Stamford, CT) into the geometric center of the steak. Steaks were cooked on clamshell-style grills (George Foreman grill Model No. GRP99, Columbia, MO) to an internal temperature of 71 °C and then removed from the grill and allowed to cool to room temperature (approximately 21 °C). Steaks were weighed again, and cook loss was calculated by dividing cooked weight by raw weight and subtracting the total from 100. Six, 1.27-cm cores were taken from each steak parallel to the muscle fibers and sheared once perpendicular to the muscle fibers for measurement of tenderness using a Warner–Bratzler shear force machine (G-R Manufacturing, Manhattan, KS) (AMSA, 1995).

2.3. Display life

After aging for 7 d in darkness, the 1.25-cm steaks were removed from vacuum packaging, individually placed in white foam trays with absorbent pads (4S Trays, Pactiv, Lake Forest, IL), overwrapped with clear cellophane, and placed in a 4 °C cooler under continuous fluorescent light (Sylvania, 32-watt, T-8 Cool White, Sylvania, Danvers, MA). L*, a*, and b* color were measured at three locations on the steak surface, with the values being averaged for each day, on each steak every 24 h for 10 d using a Minolta colorimeter using a D65 illuminant and calibrated using a white calibration tile (Konica Minolta, Toyko, Japan). Steaks were randomly moved daily to mimic movement found in a retail case and to account for slight variations in light intensity.

2.4. Myofibril extraction and sarcomere length

Myofibrils were extracted using the method of Weaver, Bowker, and Gerrard (2009) from a subset of loin samples that were frozen 24-h post-mortem ($n = 53$) equally representing carcasses that qualified for kosher and those that did not. Briefly, an approximately 1 g sample was removed from the freezer, minced, and homogenized using a blender (Waring Laboratory Science, Torrington, CT) in 5 volumes of ice-cold rigor buffer [75 mM KCl, 10 mM imidazole, 2 mM $MgCl_2$, 2 mM ethylenediaminetetraacetic acid (EDTA), 1 mM NaN_3; pH 7.2; with 0.1 mM phenylethyl sulfonyl fluoride (PMSF)] using a Kinematica PT 10/35 Polytron homogenizer with PTA-10S generator (Brinkmann, Westbury, NY). After centrifugation at 20,000 ×*g* and 4 °C for 30 min, myofibrils were washed several times with rigor buffer and then resuspended in 5 volumes of rigor buffer and 5 volumes of glycerol and stored at −20 °C for approximately 2 months until further processing. To estimate sarcomere length, myofibrils were fixed on slides with 3% (*v*/*v*) formaldehyde in rigor buffer, mounted in media [75 mM KCl, 10 mM Tris (pH 8.5), 2 mM $MgCl_2$, 2 mM EDTA, 1 mM NaN_3, 1 mg/mL p-phenylenediamine, 75% (*v*/*v*) glycerol], and sealed under coverslips (Weaver, Bowker, & Gerrard, 2008). Five different microscopic field images were captured for each slide using the Zeiss Axio Imager M2 upright microscope equipped with high resolution AxioCamMRc3 camera and the A-Plan100x 1.25 oil Ph3 objective (Carl Zeiss Microscopy, LLC; Thornwood, NY). The first 20 myofibrils observed that were positioned in a straight-line orientation and at least 5 full sarcomeres in length were measured using Image-Pro Plus 5.0 software (Media Cybernetics, Bethesda, MD). The average sarcomere length for each slide (loin sample) was recorded.

2.5. Whole muscle protein extraction, SDS-PAGE electrophoresis, and troponin-T immunoblotting

Whole muscle protein was extracted from frozen 24-h subset ($n = 53$) of loin subsamples as described by Huff-Lonergan, Mitsuhashi, Parrish, and Robson (1996). Briefly, 0.5 g of muscle tissue was minced and then homogenized in 5 mL of extraction buffer [10 m*M* sodium phosphate, pH 7.0; 2% (*w*/*v*) sodium dodecyl sulfate (SDS)] with a serrated pestle attached to a mechanical homogenizer (Eberbach Corporation, Ann Arbor, MI) at room temperature until well ground. The homogenate was clarified by centrifugation (1500 ×*g*) for 15 min at room temperature. The protein concentration of each cleared extract was determined using DC Protein Assay Reagents (BioRad Laboratories, Hercules, CA) based on Lowry, Rosebrough, Farr, and Randall (1951). Protein extracts were diluted with water to a final concentration of

Table 1
Least squares means and standard errors for pre-harvest characteristics of heifers that qualified and did not qualify as kosher.

Trait	Non-kosher ($n = 85$)	SEM	Kosher ($n = 72$)	SEM	*P*-value
Animal number/pen	10.6	0.35	10.3	0.37	0.53
Chute score[a]	2.97	0.15	2.85	0.16	0.60
Blood lactate, mmol/L	7.48	0.60	7.78	0.63	0.73
GtE[b], s	53.7	1.92	46.5	1.99	0.01
EtU[c], s	78.1	2.75	83.2	2.88	0.20
Vocalization score[d]	1.09	0.15	0.47	0.16	0.01
EP[e]	1.03	0.16	0.92	0.17	0.64

[a] Chute score where 1 = calm, no movement; 2 = slightly restless; 3 = squirming, occasionally shaking the chute; 4 = continuous, very vigorous movement and shaking of the chute; and 5 = rearing, twisting of the body and struggling violently.
[b] Gate to exsanguination, time from gate (v-belt) to exsanguination.
[c] Exsanguination to insensibility, time from exsanguination to insensibility as defined by lack of corneal reflex.
[d] Vocalization score where 0 = no vocalization; 1 = low intensity, singular vocalization; 2 = mild intensity, one to two vocalizations; and 3 = high intensity, two or more vocalizations.
[e] Number of times the electrical prod was used.