Project Summary

Attenuation of Stress-Induced Beef Quality and Tenderness Problems

Principal Investigators: P. D. Bass, J. D. Tatum, K. E. Belk, S. L. Archibeque, T. E. Engle, & G. C. Smith, Colorado State University

Study Completed
May 2009

BEEF ®

Funded by The Beef Checkoff

Attenuation of Stress-Induced Beef Quality and Tenderness Problems: Project Summary

Background

Exposure of cattle to pre-harvest stress (either psychological or physical) increases the incidence of meat quality defects. Stress stimulates release of catecholamines (epinephrine and norepinephrine) into the animal's circulatory system, causing a number of physiological responses including increased heart and respiration rates, elevated body temperature, decreased protein degradation and increased breakdown of liver and muscle glycogen reserves. Short-term pre-harvest stress, accompanied by elevated blood epinephrine concentrations, reduces beef tenderness without affecting final muscle pH (normal pH = 5.4 to 5.5) or lean color. Longer-term, sustained stress depletes muscle glycogen reserves, resulting in high-pH (≥ 5.8), dark-cutting beef. A high frequency of meat toughness problems usually coincides with final muscle pH values from 5.8 to 6.0. The inability to completely avoid stress during pre-harvest shipment and handling of livestock has prompted investigation of strategies for lessening the effects of stress on glycogen depletion and meat tenderness. Research conducted in swine and sheep suggests that dietary magnesium (Mg) supplementation may counteract some of the detrimental effects of stress on meat quality by reducing catecholamine secretion; however, this approach has not been investigated in cattle.

The objectives of this study were to compare stress responses of heifers and steers and evaluate the efficacy of short-term dietary Mg supplementation for attenuating effects of pre-harvest stress on beef quality characteristics.

Methodology

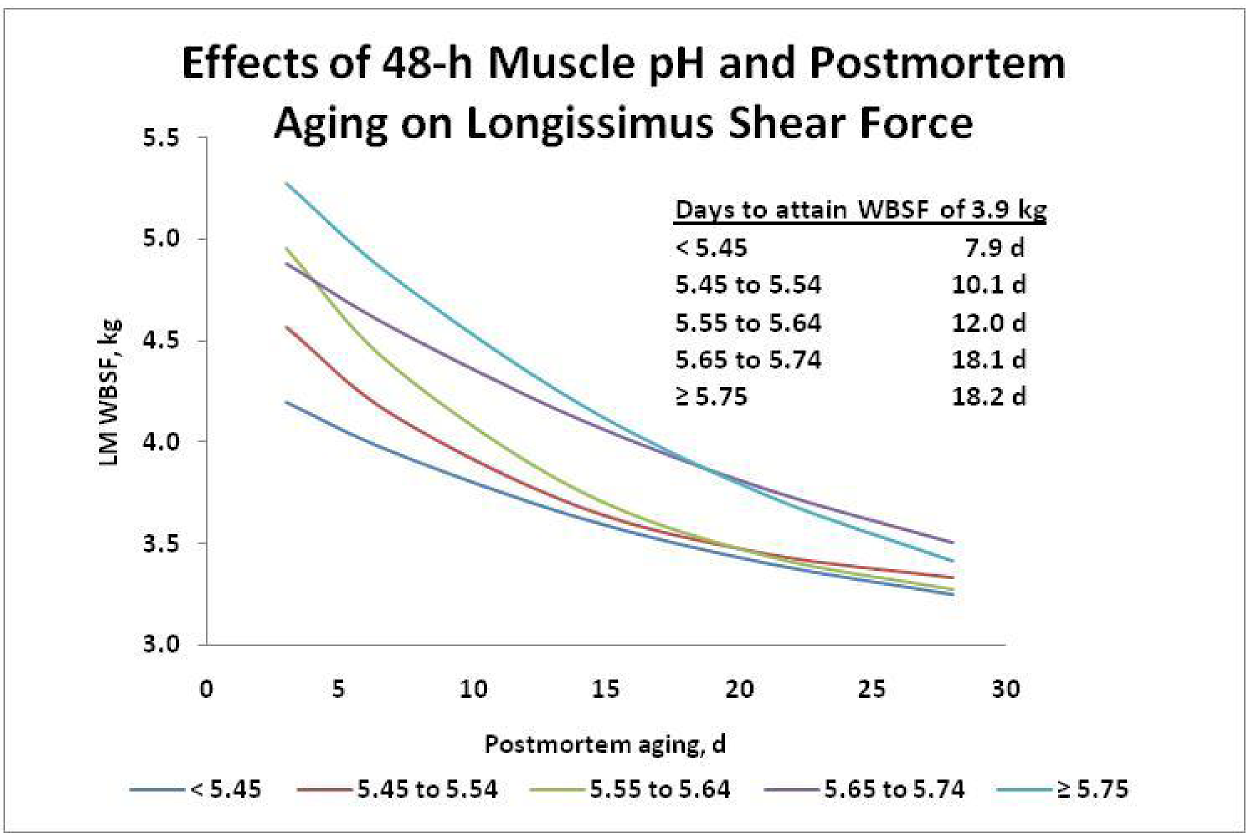
Crossbred heifer (n = 72) and steer (n = 72) calves (herd contemporaries) were weaned at five to seven months of age, placed in a research feedlot and finished on conventional, corn-based finishing diets. When the cattle were 12 to 14 months old, animals representing each sex class were sorted into sire groups, blocked by weight (light, medium, heavy), and assigned randomly to four treatment groups: A) Control, 0% added dietary Mg, B) 0.25% added dietary Mg, C) 0.50% added dietary Mg, and D) 0.75% added dietary Mg. Supplemental Mg was provided in the form of magnesium oxide (MgO) for the final 14 days of the finishing period. The basal diet contained 0.2% Mg. Cattle comprising the three blocks were humanely harvested using conventional, commercial procedures on three different dates within a two-week period. On the day before each harvest date, animals comprising each block (steers and heifers from all four treatment groups) were commingled in a large pen to induce a stress response associated with agonistic behavior. Data recorded for each animal included: 1) behavior scores (pen behavior, chute behavior, chute exit speed), 2) physiological stress indicators (heart rate, respiration rate, rectal temperature, plasma epinephrine and norepinephrine concentrations, blood lactate concentration, muscle glucose concentration, muscle lactate concentration, glycolytic potential, 48-hour *longissimus* pH), 3) carcass quality indicators (carcass maturity, marbling score, *longissimus* *L**, *a**, *b** color measurements, and dark cutter incidence), and 4) *longissimus* muscle (LM) Warner-Bratzler shear force (WBSF) measured at three, seven, 14, 21 and 28 days postmortem.

Findings

Heifers and steers exhibited distinctly different stress responses. Heifers were more excitable than steers during pre-harvest handling and exhibited a short-term (acute) stress response that resulted in increased meat toughness without a concomitant increase in muscle pH. Steers, on the other hand, exhibited greater physical activity (sustained stress) during the mixing period and, therefore, produced carcasses with lower muscle glycogen concentrations and higher 48-hour muscle pH values compared with heifers. Steers also produced tougher strip steaks than did heifers. Within the range of muscle pH values observed in this study (5.3 to 6.1), increased 48-h muscle pH was associated with increased beef toughness in both steers and heifers. Effects of pH on LM shear force, which were most pronounced at three and seven days postmortem, diminished during postmortem aging and were no longer significant once LM steaks had been aged for 21days (see Figure). Results suggested that stress-induced toughness of strip steaks from beef carcasses with final LM pH values greater than 5.65 could be problematic unless strip loins are aged for about 18 days or longer. Supplementation of cattle with Mg increased serum Mg concentration, but had no effect on any of the physiological stress indicators or meat quality characteristics measured in this study. There was no evidence to support the premise that Mg supplementation of cattle lessens the effects of pre-harvest stress on beef quality characteristics.

Implications

Identification of cattle management systems to facilitate production of beef that consistently delivers a quality eating experience would assist in attaining industry goals of building consumer demand and adding value to cattle. This study identified distinctly different stress responses for heifers vs. steers, both of which reduced tenderness. Additionally, stress-induced increases in muscle pH significantly reduced early postmortem tenderization, thereby influencing aging requirements for beef strip loins. These results emphasize the importance of stress avoidance during pre-harvest handling and shipment of cattle.



For more information contact:
National Cattlemen's Beef Association
9110 East Nichols Avenue
Centennial, Colorado 80112-3450
(303) 694-0305