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Effects of feeding a single or sequence of beta-adrenergic agonists on cull cow meat quality

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ABSTRACT

Sixty cull cows were implanted and assigned to four treatments: C = concentrate ration only; RH = supplemented with ractopmaine-HCl (8.33 mg/kg of feed) for 25 d; ZH = supplemented with zilpaterol-HCl (ZH) (200 mg head $^{-1}$d^{-1}) for the last 20 d; and RH + ZH = supplemented with RH for 25 d followed by ZH for 20 d. All cows were fed a concentrate ration for 74 d. *Infraspinatus* steaks from cows supplemented with RH and/or ZH had lower ($P<0.05$) shear force than steaks from C cows. *Longissimus* (LM) steaks from the 6–8th rib section of ZH and RH + ZH cows had decreased ($P<0.0001$) desmin degradation at 10 and 21 d postmortem compared to steaks from C and RH cows. Collagen solubility of the LM was increased ($P<0.05$) by ZH and RH + ZH compared to C. There were no treatment differences in 12th rib LM tenderness when enhanced with calcium lactate. Color and sensory traits of meat from RH + ZH cows were not different from C but flavor intensity was greater and off-flavor less than for C cows.

1. Introduction

Cows culled from cow-calf, seedstock, or dairy operations account for approximately 80,000 metric tons of boneless beef each year (Woerner, 2010). A majority of meat from cull cows is utilized for ground beef; however, the National Market Cow and Bull Audit (NCBA, 2007) indicated that an increased number of plants were fabricating merchandisable cuts from cow carcasses. Although notable improvements in management of cull cows have been made, numerous negative attributes are associated with meat from cull cows, such as lower carcass weights, smaller LM areas, less fat thickness (FT), inferior muscling, yellower external fat color, and darker lean color than A-maturity, USDA Select grade steer carcasses (Stelzleni, Patten, Johnson, Calkins, & Gwartney, 2007). Meat from cows also has been characterized as tougher, less juicy, and possessing more undesirable off-flavors (Woerner, 2010) than meat from young cattle.

Realimentation of cows by feeding a high-energy ration prior to harvest can improve carcass weights, muscling, and quality characteristics (Boleman, Miller, Butck, Cross, & Savell, 1996; Miller, Cross, Crouse, & Jenkins, 1987; Patten et al., 2008; Sawyer, Mathis, & Davis, 2004; Schnell, Belk, Tatum, Miller, & Smith, 1997; Wooten, Roubieck, Marchello, Dryden, & Swingle, 1979). The commercially available β-adrenergic agonists (β-AA), ractopamine-HCl (RH) and zilpaterol-HCl (ZH) have been evaluated in cull cow feeding programs. In young cattle, β-AA have profound effects on growth performance and carcass yields, but several studies have shown that the effectiveness of β-AA in mature cows is less pronounced (Carter, Johnson, Thrift, & Foster, 2006; Dijkhuis, Johnson, & Carter, 2008; Harborth, 2006; Holmer, Homm, Berger, McKeith, & Killefer, 2009; Neill et al., 2009). In contrast, Strydom and Smith (2010) and Lawrence, Gasch, Hutcheson, and Hodgen (2011) reported increased performance, carcass yield, and conformation scores when cows were supplemented with ZH at 8.33 mg head^{-1} for 30 d.

Reduced density of β-adrenergic receptors (β-AR) and decreased sensitivity of receptors to agonists have been reported in older humans and animals (Elfellah, Dalling, Kantola, & Reid, 1989), which might reduce the effectiveness of β-AA in cow feeding programs. A trend for RH supplementation to increase β_2-AR mRNA levels has been reported in heifers (Sissom et al., 2007), steers (Winterholler et al., 2007), and cows (Gonzalez, Dijkhuis, Johnson, Carter, & Johnson, 2008). We hypothesized that feeding RH prior to ZH supplementation would up-regulate β_2-AR and increase the effectiveness of ZH.

Although β-AA can improve lean meat yields (Mersmann, 1998), meat sensory characteristics can be negatively affected. High calpastatin activity is widely accepted to be responsible for

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interference of normal postmortem tenderization in β-AA-supplemented cattle (Wheeler & Koohmaraie, 1992). The use of calcium salts has been evaluated to overcome reduced postmortem muscle proteolysis. Lawrence, Dikeman, Hunt, Kastner, and Johnson (2003) reported that calcium salts, such as calcium chloride, calcium lactate, and calcium ascorbate, increase tenderness by activating calcium-dependent enzymes.

The objectives of our study were to explore the effects of feeding a single or sequence of β-AA to cull cows on ground beef color, Warner Bratzler shear force, and steak sensory characteristics as well as the effects of calcium lactate enhancement on sensory profiles of meat from β-AA-supplemented cows. Our interest in feeding cows for 74 d was to add value to by transitioning cows from a "cull" cow to what industry refers to as a "white" cow market in which cows have white fat resulting from grain feeding and in which a significant proportion of the carcass is used for steak and roast production.

2. Materials and methods

Procedures involving cows were approved by the Kansas State University Institutional Animal Care and Use Committee. Procedures involving human subjects were approved by the Kansas State University Institutional Review Board.

2.1. Animals

Sixty crossbred, mature cows meeting established criteria (primarily of British breeding, not pregnant, aged from 2 to 8 years, weighing from 454 to 590 kg, and with a body condition score from 2 to 5) were procured from sale barns in western Kansas, or were cull cows from the Agriculture Research Center in Hays, KS. Eighty-four cows were purchased and the total was winnowed to 60 cows based on the criteria described. One cow was removed after the study began because of sickness and another was removed because she had negative body weight gain.

2.2. Treatments

Cows were implanted in the right ear with Revalor-200 (200 mg of trenbolone acetate and 20 mg estradiol; Intervet/Schering Plough Animal Health, Millsboro, DE) on d 0 and stratified by body weight, body condition score, and ultrasound fat thickness into four treatments (n = 15 cows/treatment) consisting of: 1) concentrate fed for 74 d (C); 2) concentrate fed for 49 d then supplemented with RH (Optaflexx; Elanco, Greenfield, IN) for 25 d (RH); 3) concentrate fed for 51 d then supplemented with ZH (Zilmax; Intervet/Schering Plough Animal Health, Millsboro, DE) for 20 d prior to a 3-d withdrawal before harvest (ZH); 4) concentrate fed for 26 d then supplemented with RH for 25 d followed by ZH for 20 d prior to a 3-d withdrawal before harvest (RH + ZH). In the RH and RH + ZH treatments, RH was supplemented at a level of 200 mg $head^{-1}$ d^{-1}. In the ZH and RH + ZH treatments, ZH was supplemented at 8.33 mg/kg of feed (100% DM basis). We chose to implant the C cows with Revalor® because previous research (Neill et al., 2009) demonstrated that supplementing cull cows with β-AA is more effective in combination with Revalor® implants. The diet consisted of 77% ground sorghum grain, 20% sorghum silage, 1.6% soybean meal, and 1.4% supplement (urea, calcium, and salt).

2.3. Subprimal fabrication/processing

Cows were harvested and fabricated at a commercial slaughter facility. At 4 d postmortem, carcasses were fabricated according to guidelines of the North American Meat Processors (NAMP) Association (NAMP, 2006). The primal rib (NAMP # 103), shoulder clod (NAMP # 114), and tenderloin (NAMP # 189) from the left side of carcasses were retrieved and transported to Kansas State University in Manhattan, KS. Aging times were assigned based on limitations of project timing and by considering the aging curves reported in the National Cattlemen's Beef Association Industry Guide for Beef Aging (NCBA, 2006). Three 1.91-cm steaks were cut from the *longissimus* muscle (LM), starting from the anterior end, and vacuum-packaged for collagen and desmin degradation analyses. One steak for desmin analysis was frozen at −40 °C after 10 d of postmortem aging, and the second desmin and collagen samples were frozen at −40 °C after 21 d postmortem aging. Two 2.54-cm steaks were cut from the posterior portion of the 6–7–8th rib LM and aged for 21 d at 2 °C before non-enhanced Warner Bratzler shear force (WBSF) measurements were obtained. *Psoas major* muscles (PM) were subjected to 21 d of postmortem aging before two 2.54-cm steaks were cut for WBSF and two 2.54-cm steaks were cut from the posterior end for sensory evaluation. Steaks for WBSF were not frozen, but sensory steaks were frozen at −40 °C until sensory panels could be conducted. The *infraspinatus* muscle (IF) was removed from shoulder clods and two 2.54-cm flat iron steaks were cut and subjected to 14 d of postmortem aging prior to WBSF evaluation.

The remainder of the shoulder clod was closely trimmed of fat, and 85% lean ground beef was produced by grinding product through a 0.953-cm plate, mixing thoroughly, and fine-grinding through a 0.138-cm plate. Ground beef (~0.98 kg) was packaged in polyvinyl chloride (PVC) on 20.32 cm × 14.61 cm × 1.74 cm foam trays (2S, Cryovac Sealed Air, Duncan, SC) and overwrapped with oxygen-permeable film (MAPAC M film, 23,250 cm^3/m2/24 h, 72 gauge, Resinite Packaging Films, Borden, Inc., North Andover, MA) for retail color display.

2.4. Enhancement

At 7 d postmortem, LM roasts from the 12th-rib portion of the rib primal were used for enhancement. Roasts were injected (Model Imax 420; Wolftec, Inc., Werther, Germany) with a 0.1-M calcium lactate (PURAC America, Inc., Lincolnshire, IL) brine to a target 11% pump. After enhancement, roasts were allowed to sit for 1 h before 2.54-cm steaks were cut and aged for an additional 7 d prior to WBSF and sensory evaluation. Steaks used for WBSF measurements were not frozen, but sensory steaks were frozen at −40 °C until sensory panels could be conducted. The 9–10–11th rib section was used for carcass composition prediction (Weber et al., 2012).

2.5. Cooking of steaks

Steaks for WBSF and sensory analysis were cooked in a forced-air convection oven (Blodgett, model DFG-102 CH3, G.S. Blodgett Co., Burlington, VT) set at 163 °C. Steaks were turned at an internal temperature of 40 °C and cooked to an endpoint internal temperature of 70 °C, as monitored by copper-constantan thermocouples in the approximate geometric center of each steak.

2.6. Warner Bratzler shear force (WBSF)

At 14 d postmortem, IF and enhanced LM steaks were cooked for WBSF determination. For the IF, the connective tissue strip was avoided when coring samples for WBSF measurement. At 21 d postmortem, non-enhanced tenderness of LM and PM steaks were cooked for WBSF determination. All steaks were cooked according to the procedures described above, cooled to room temperature, and stored at 2 °C ± 2 °C overnight. Eight 1.27-cm cores were removed parallel to the muscle fibers using a 1.27-cm corer (G-R Manufacturing Co., Manhattan, KS) attached to an electric drill (Craftsman 3/8″ Electric Drill, Sears, Hoffman Estates, IL). Cores were sheared perpendicular to the muscle fibers using a WBS Testing Machine (G-R Elec. Mfg. Co., Manhattan, KS). The machine was