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Effects of hot boning and moisture enhancement on the eating quality of cull cow beef

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ABSTRACT

The effects of chilling method and moisture enhancement were examined for improving eating quality of *semimembranosus* (SM) and *longissimus lumborum* (LL) from 62 cull beef cows. Chilling method included hot boning muscles after 45 to 60 min postmortem or conventional chilling for 24 h. Moisture enhancement included 1) a non-injected control (CONT) or injection processing (10% of product weight) using 2) Sodium Tripolyphosphate/salt (Na/STP), 3) Sodium Citrate (NaCIT), 4) Calcium Ascorbate (CaASC), or 5) Citrus Juices (CITRUS). Chilling method by moisture enhancement treatment interactions ($P < 0.09$) were due to decreased hue, chroma and sarcomere length values in hot boned vs. conventionally chilled product (SM and LL) for CaASC vs. other moisture enhancement treatments. Chilling method by moisture enhancement treatment interactions ($P < 0.05$) were due to decreased shear force and increased tenderness in conventionally chilled vs. hot boned LL using CaASC vs. Na/STP. Moisture enhancement can improve tenderness of cull cow beef depending on combinations of chilling method and moisture enhancement treatments used.

1. Introduction

Cull cows are mature females over 30 mo of age that have been eliminated from cattle herds for various reasons including low productivity, poor health or condition, poor temperament, age, failure to reproduce, and (or) management decisions by producers. In Canada, beef from cow carcasses is generally used for further processing (Mandell, Campbell, Quinton, & Wilton, 2006) due to poor eating quality (tenderness, juiciness, flavor) and lack of consistency in tenderness (Mandell et al., 2006; Stelzleni, Patten, Johnson, Calkins, & Gwartney, 2007). The quality and consistency of cull cow beef need to be improved for expanding markets beyond processing and ground beef production for greater utilization in food service and retail meat industries. Cull cow beef tenderness can be improved by placing cows on high grain diets for an extended period prior to slaughter (Schnell, Belk, Tatum, Miller, & Smith, 1997) but this is not economically feasible with current high grain prices. Grading systems can sort cull cow carcasses according to palatability or processing characteristics (Hilton et al., 1998; Hodgson, Belk, Savell, Cross, & Williams, 1992), but these systems do not assess lower-quality cuts such as muscles from the round. While postmortem aging can improve tenderness for *longissimus* muscle from cull cows, other methods of postmortem processing are needed to alleviate problems with quality and consistency of cull cow beef and add value, especially for muscles from the round.

Hot boning (removal of muscles from the carcass prior to chilling and development of rigor) was initially developed to reduce energy usage and operating costs in beef processing (Cuthbertson, 1980). This process reduces shrink during chilling and drip loss during vacuum pack storage, along with providing more uniform and stable product color (Cross & Tennent, 1980; Sammel et al., 2002). Moisture enhancement (injection of meat with food grade chemicals) has been used to improve beef quality since the 1980s (Smith, Simmons, McKeith, Bechtel, & Brady, 1984) with moisture enhanced product from youthful animals marketed at North American grocery chains. The benefits of this commercial process include improvements in beef tenderness and water holding capacity (WHC) (McGee, Henry, Brooks, Ray, & Morgan, 2003; Vote et al., 2000).

There is potential for combining hot boning with various moisture enhancement solutions for processing cull cow beef especially with less tender cuts found in the round based on previous work conducted processing youthful beef. Phosphates have been used to increase tenderness and WHC by minimizing the decrease in muscle pH that occurs in the conversion of muscle to meat (Boles & Swan, 1997; Lee, Steveson-Barry, Kauffman, & Kim, 2000). While tenderness enhancement of cull cow beef using calcium chloride ($CaCl_2$) has been inconsistent along with development of undesirable off-flavors (DeYonge-Freeman, Pringle, Reynolds, & Williams, 2000; Morgan, Miller, Mendez, Hale, & Savell, 1991), Lawrence, Dikeman, Hunt, Kastner, and Johnson

Abbreviations: CM, Chilling method; ME, Moisture enhancement; HB, Hot boned; CC, Conventionally chilled; SM, *Semimembranosus*; LL, *Longissimus lumborum*; MET, Moisture enhancement treatments; CONT, control; CITRUS, Citrus Juices; NaCIT, Sodium Citrate; CaASC, Calcium Ascorbate; Na/STP, Sodium Tripolyphosphate/salt.

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(2003) successfully used Calcium Ascorbate to enhance the quality of beef from cattle under 30 mo of age. Sodium Citrate has been used as a glycolytic inhibitor for pre-rigor youthful beef, decreasing lactic acid production and improving tenderness and WHC (Jerez, Calkins, & Velazco, 2003). Citrus juice marination decreased muscle pH and total collagen, while increasing soluble collagen and sensory panel assessment of tenderness and juiciness in muscles from the round (Burke & Monahan, 2003). This additive may be effective for cull cow beef and its high connective tissue content, improving tenderness and value adding the product while using "natural" juices rather than a food grade chemical.

The objective of this study was to examine the effects of hot boning and (or) moisture enhancement of cull cow beef on product appearance, quality, and shelf life. Four different food additives were used to examine concurrently different modes of action for enhancing quality of beef that is high in connective tissue content and highly variable in eating quality. The ultimate goal is to develop processing procedures for cull cow beef to ensure a quality eating experience and increase consumer demand by developing value added products to increase returns for the beef industry.

2. Materials and methods

2.1. Processing of cull cows

Sixty-two cull beef cows (predominantly British or Continental breeding) from University of Guelph beef research stations were used in the study. Animals were cared for according to the protocol approved by the University of Guelph Animal Care Committee, based on guidelines and principles of the Canadian Council on Animal Care (Olfert, Cross, & McWilliam, 1993). Cull beef cows (aged 2.6–16.9 yr) were harvested at the University of Guelph Meat Laboratory on 15 slaughter dates (4 to 6 cows per slaughter date) according to industry procedures that included stunning with captive bolt prior to exsanguination. Electrical stimulation was not used in the harvesting process. For individual carcasses, each side was allocated to be either chilled intact at <4 °C for 24 h prior to processing or to be hot boned at approximately 45 to 60 min postmortem with removal of *longissimus lumborum* (LL) and *semimembranosus* (SM) muscles. Approximately equal numbers of left and right sides were used for respective conventional chilling or hot boning treatments to evaluate chilling method.

Carcasses were assessed by an experienced carcass evaluator on the conventionally chilled side of the carcass based on Livestock and Poultry Carcass Grading Regulations (Canadian Food Inspection Agency, 1992) to determine carcass grade and yield characteristics. The 12th/13th rib interface was used to assess grade fat (mm; minimum fat depth in the last quadrant over the *longissimus*), and *longissimus* muscle area (LMA) (cm^2), and subjective marbling score using methods described by Streiter, Campbell, and Mandell (2012).

Following hot boning, SM and LL muscles were trimmed of all external fat and connective tissue, cut into two separate roasts identified by location (cranial and caudal portions of the SM (Kolle, McKenna, & Savell, 2004) and LL), weighed, and randomly allocated to moisture enhancement treatments. Muscles were balanced for location due to potential location effects on palatability attributes, primarily tenderness (Kolle et al., 2004). Moisture enhancement treatments included 0.3 M Calcium Ascorbate (CaASC), 0.2 M Sodium Citrate (NaCIT), combination of 2% Sodium Chloride and 0.4% Sodium Tripolyphosphate (Na/STP), Citrus Juice marinade (CITRUS; 30% concentrated lemon juice, 30% fresh, refrigerated orange juice (not from concentrate), 40% water), or a non-injected control (CONT). A water injected control was not used as previous findings found no effects on tenderness measurements by injecting water (Wheeler, Koohmaraie, Lansdell, Siragusa, & Miller, 1993).

Roasts were moisture enhanced immediately after hot boning and trimming using a Pokomat single-row needle injector to 10% of product weight (target value for % solution injected); roasts were then allowed to sit for a few minutes prior to reweighing. Following moisture enhancement, roasts were tumbled continuously for 1 h under vacuum (LYCO, Columbus, Wisconsin, USA) to more evenly distribute enhancement solutions into the meat. Non-injected control roasts were also tumbled following the same procedure. Muscles were weighed both pre- and post-injection to determine percent solution injected. In addition, roasts were weighed post-tumbling to determine percent solution retained. After 24 h chilling, SM and LL muscles were removed from conventionally chilled carcass sides and processed at 24 h postmortem as previously described for hot boned muscles.

2.2. pH and color measurements

After initial processing, roasts were vacuum packaged and aged 14 d postmortem at <4 °C prior to further processing. At 14 d postmortem, 2.5 cm thick steaks were removed from each roast and tagged for identification. These steaks were evaluated on a fresh basis for color, pH, and shelf life, using methods described by Streiter et al. (2012), or frozen at −24 °C prior to shear force and sensory panel evaluations. In addition, a sample of lean was obtained from each muscle, placed in Whirl-Pak® bags, and frozen at −20 °C until assessed for sarcomere length using the microscope method described by Streiter et al. (2012).

2.3. Warner–Bratzler shear force determination

Steaks were processed for shear force and cooking loss determinations using the methods described by Streiter et al. (2012). Approximately eight, 1.5 cm (diameter) by approximately 2.5 cm (length) cores were removed from each steak parallel to the muscle fibers (AMSA, 1995) using a drill press mounted corer (Mastercraft 10 inch Drill press). Cores were sheared perpendicular to muscle fibers using a TA-XT Plus Texture Analyzer (Texture Technologies Corp., Scarsdale, NY) fitted with a Warner–Bratzler blade (crosshead speed of 3.3 mm s^1).

2.4. Sensory panel evaluation

Thirty University of Guelph students were recruited by email to participate in a trained sensory panel. These individuals were screened over the course of 2 days with 8 students selected for the sensory panel. The 8 panelists were trained over the course of 2 weeks based on procedures outlined by AMSA (1995) and with the aid of a sensory analysis specialist.

Animals of Piedmontese breeding and cows younger than 4 yr or older than 10 yr were excluded from the sensory panel to select a cull cow population more representative of the beef industry. Ten steaks were randomly chosen from each of the respective 10 chilling method by moisture enhancement treatments and then allocated to sensory panel evaluation days. In addition, ten 14 d aged steaks of Red Branded Beef (Canada AA quality grade; USDA Select equivalence) (CBGA, 2010) sourced from a commercial beef packing plant were randomly chosen and added as an additional control to evaluate how the eating quality of cull cow beef compared to beef typically found in North American retail grocery stores. Sensory panel evaluations were conducted approximately 4 d per wk over a 5 wk period.

Steaks were prepared for sensory panel evaluation using the protocol described by Streiter et al. (2012). Steak samples were evaluated using a 10 cm line for the following palatability traits:

1. Softness — the force required to compress the sample between the molar teeth (0 being very firm, and 10 being very soft),
2. Tenderness — the force required to chew measured after three chews excluding the first bite as a chew (0 being very tough and 10 being very tender);