



## Slaughter weight, sex and age effects on beef shear force and tenderness



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### ABSTRACT

In Argentina, beef cattle prices decrease as slaughter weight increases regardless of animal age or carcass maturity, and this decrease is significantly greater in heifers (15%) than in steers (5%). The objectives of the present study were to (1) determine whether shear force and tenderness differ between heifers of different slaughter weight, and between heifers, steers and cull cows of similar slaughter weight; (2) evaluate whether such differences, if any, could be overcome by extending beef aging period; and (3) understand the main causes of such differences in beef shear force and tenderness. Meat from heavy heifers (H-HEIFER, 381–420 kg BW) was compared to meat from light heifers (L-HEIFER, 300–340 kg BW), steers (STEER, 391–450 kg BW) or cull cows of similar weight (COW). At slaughter, carcass characteristics were determined and *Longissimus thoracis* (LM) and *Gluteus medius* (GM) muscle samples collected for shear force determination. Total and insoluble collagen, sarcomere length and intact troponin-T content, and sensory panel scores, were evaluated for LM. Aging effect was evaluated for shear force and sensory panel scores. Irrespective of muscle or aging period, increasing heifer slaughter weight did not impact negatively on beef shear force or tenderness levels; heifers and steers of similar slaughter weight had similar beef shear force and tenderness levels; whereas heifer beef was more tender ( $P < 0.05$ ) than that from cow of similar slaughter weight. Tenderness differences were not overcome by extending the aging period. Based on a principal component analysis, shear force and tenderness differences appear to be associated to the variation in chilling rate and sarcomere length.

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### 1. Introduction

Despite a need to increase beef production, Argentine domestic market favors low slaughter weights regardless of animal age or carcass maturity. As heifers' and steers' slaughter weight increases from 300 to 400 kg, price (\$/BW kg) is reduced in both cattle groups, but to a greater

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extent in heifers (15% and 5%, respectively) (Mercado de Liniers, 2012). As a result of these negative relationships, steers commercialized through Mercado de Liniers<sup>2</sup> are evenly distributed through the different slaughter weight categories, whereas 58% of the heifers are commercialized at light weights (317 kg BW on average).

Tenderness is one of the main attributes used by consumers to define beef quality (Grunert et al., 2004) and, in general, consumers are willing to pay more for more tender beef (Boleman et al., 1997; Destefanis et al., 2008; Killinger et al., 2004a, 2004b; Lusk et al., 2001; Miller et al., 2001; Platter et al., 2005). Although tenderness is negatively correlated to animal age when evaluated using a wide range of ages (Shorthose and Harris, 1990; Schönfeldt and Strydom, 2011), a less clear association is observed when comparing smaller age ranges. Some studies (Shackelford et al., 1995; Wulf et al., 1996) showed negative effects of animal age on tenderness, whereas no such effects were observed by other authors (Field et al., 1996; Lawrence et al., 2001). Furthermore, increasing slaughter weight within a given ossification or maturity score has shown to have no effect or to improve the Meat Quality score (MQ) from the Meat Standard Australia prediction model (Watson et al., 2008). Increasing slaughter weight by 100 kg in Argentinean pasture fattening systems would increase animal age at slaughter by no more than five months.

When comparing beef tenderness from samples aged for 14 d, neither Zinn et al. (1970) nor Choat et al. (2006) observed differences between heifers and steers, but when aged for only 7 d, lower tenderness in heifers were observed by Choat et al. (2006). This suggests that initial differences in tenderness could be overcome if most of the post-rigor tenderization phase effect is allowed to proceed (Koochmaria and Geesink, 2006). It is worth noting that in all the above studies where animal age effect on tenderness was evaluated (Field et al., 1996; Lawrence et al., 2001; Shackelford et al., 1995; Wulf et al., 1996) samples were aged for 14 d; thus, initial differences in tenderness could have been minimized. Given that, in Argentina, beef is consumed within seven days after slaughter, tenderness differences could be observed when comparing beef from cattle of slaughter groups differing in weight, age or sex.

The objectives of the present study were to (1) determine whether beef shear force and tenderness differ between heifers of different slaughter weight, and between heifers, steers and cull cows of similar slaughter weight; (2) evaluate whether such differences, if any, could be overcome by extending beef aging period; and (3) understand the main causes of such differences in beef shear force and tenderness between slaughter groups.

## 2. Material and methods

### 2.1. Animals and treatments

A total of forty Aberdeen Angus cattle from the same cow-calf herd were used. At weaning (April–May) 20

female calves were selected and randomly assigned to one of two treatments defined by the slaughter weight: light heifers (**L-HEIFER**; 300–340 kg BW) and heavy heifers (**H-HEIFER**, 381–420 kg BW). At the same time, 10 male calves were selected to be slaughtered when they reached the weight to be classified as heavy steers (**STEER**, 391–430 kg BW). In the next production cycle (March of the following year), after rectal palpation of the cows from the original herd, ten non-pregnant cows that had at least two lactations were selected (**COW**). Animals ( $n=10$  per slaughter group) corresponding to a given treatment (slaughter group) were slaughtered on the same date. Heifers and steers from each treatment were slaughtered when the group's average and median BW were within its slaughter weight range; in turn, cows were slaughtered after two months of fattening.

### 2.2. Animal management

Animals were assigned to a 10 ha consociate temperate pasture, comprised by *Medicago sativa*, *Lolium perenne*, *Bromus unioloides*, and *Festuca arundinacea* as the main forage species. Animals grazed under a rotational system with the objective to optimize body weight gain and forage utilization. Animal initial and final weight were determined as the average of its individual weight determined in two consecutive days at the beginning and end of their fattening period. During the fattening period, animals were weighed every 21 d. When the average BW of the animals assigned to a given slaughter group reached the defined slaughter weight, or after two months of fattening for COW, animals were shipped to a commercial slaughter house. Following regular practices in Argentina, animals were rounded up at 03:00 pm and, after an overnight feed withdrawal, they were shipped at 01:00 pm, and arrived in the slaughter house 1.5 h later. At 7:00 am of the following day, animals were slaughtered. They were stunned with a captive bolt without being electrically immobilized or stimulated. Carcasses were moved into the chiller within one hour after being stunned.

### 2.3. Measurements and sampling at harvest

At harvest, hot carcass and kidney fat weight (kg) were registered within 45 min postmortem. At 3 h postmortem, *Longissimus thoracis* muscle pH (pH@3 h) and temperature (Temp@3 h) were measured between the 12th and 13th ribs using a portable pH-meter (Sper Scientific model 850081) with a temperature penetration probe and a pH penetration probe type 13 (Testo). At 24 h, postmortem pH determination was repeated (ultimate pH).

Twenty-four hour postmortem, the rib section was removed from the left side of each carcass by cutting between the 6th and 7th thoracic vertebrae and 13th thoracic and 1st lumbar vertebrae. At the same time, the top sirloin was removed from the left carcass side. Both primals were then transported to the meat laboratory at the Instituto Nacional de Tecnología Agropecuaria-Estación Experimental Agropecuaria Balcarce (INTA-EEA Balcarce; Balcarce, Buenos Aires, Argentina) and stored at 2 °C till the following day for fabrication.

<sup>2</sup> Buenos Aires live cattle market that commercializes approximately 6000 heads per day (2006–2011). Daily prices for the different categories are used as reference prices for other cattle transactions in Argentina.

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