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Genetic and management factors affecting beef quality in grazing Hereford steers

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ABSTRACT

Attributes contributing to differences in beef quality of 206 Hereford steers finished on pasture were assessed. Beef quality traits evaluated were: Warner–Bratzler meat tenderness and muscle and fat color at one and seven days after slaughter and trained sensory panel traits (tenderness, juiciness, flavor, and marbling) at seven days. Molecular markers were CAPN1 316 and an SNP in exon 2 on the leptin gene (E2FB). Average daily live weight gain, ultrasound monthly backfat thickness gain and rib-eye area gain were estimated. Molecular markers effects on meat quality traits were analyzed by mixed models. Association of meat quality with post weaning growth traits was analyzed by canonical correlations. Muscle color and marbling were affected by CAPN1 316 and E2FB and Warner–Bratzler meat tenderness by the former. The results confirm that marker assisted selection for tenderness is advisable only when beef aging is a common practice. The most important sources of variation in tenderness and color of meat remained unaccounted for.

1. Introduction

One of the objectives of beef producers is to offer a product that fulfills the requirement of high quality by consumers. There are several factors affecting the final quality of beef. Genetic variation in quality attributes, among and within breeds, has been well documented (Marshall, 1999). Aside from the genetic background of the animals other non genetic factors, especially feeding regime, highly influence meat quality. Pre-slaughter handling and slaughter and processing procedures (Belk, Scanga, Smith, & Grandin, 2002) also play a very important role in defining the final quality of carcasses. Most reported experiments evaluating the effect of these factors on meat quality apply to feedlot cattle (Eilers, Tatum, Morgan, & Smith, 1996; Jiang et al., 2010; Monsón, Sañudo, & Sierra, 2005; Wheeler, Savell, Cross, Lunt, & Smith, 1990). However, there could be a differential response of beef quality traits to those same factors in more extensive systems. A good example are grazing systems, which are recognized for producing beef with less fat and with beneficial properties for human health, when compared to more intensive production systems (Wood et al., 2003).

Beef color and marbling mostly define the preferences of beef buyers. Meat color, including fat color, is usually associated with freshness and quality, but it has also been associated with tenderness (Wulf, O'Connor, Tatum, & Smith, 1997). Furthermore, color could be the main single factor used by consumers to determine whether they will purchase a meat cut (Kropf, 1980). On the other hand, tenderness, juiciness, connective tissue content and flavor of meat are quality attributes evaluated at the time of consumption which is between 1 and 5 days after slaughter in Argentina. Even though being subjective sensations, sensory panels and objective measurements provide objective information to establish the influence of the different factors. According to Caine, Aalhus, Best, Dugan, and Jeremiah (2003), the mean correlations of WBSF with sensory assessment of beef tenderness are in the range of −0.75 to −0.77, but the variability across experiments is high.

The discovery of molecular markers, accounting for a significant proportion of additive genetic variance in economic traits, provided an additional tool to animal breeders. Traits like tenderness and meat color, which are difficult to measure under commercial conditions or previous to slaughter, have become of special interest for researchers due to the possibility of identifying molecular markers that would be used as an aid to selection (Van der Werf & Kinghorn, 1999). In live animals, calpains participate in the protein breakdown, and after slaughter are responsible for the maturation process. Single

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nucleotide polymorphisms (SNPs) on the μ-calpain gene (CAPN1) have been associated with meat tenderness (Page et al., 2004), but also with different growth traits (Miquel et al., 2009). Leptin is involved in the regulation of energy balance. Plasma concentration and molecular markers on the gene have also been associated with several growth and carcass traits that could have an influence on beef quality (Altmann & Von Borell, 2007; Schenkel et al., 2005). However, Johnston and Graser (2010) observed that markers should be evaluated in the populations that they are intended to be used. The objective of this research was to identify attributes of the animal that contribute to differences in beef quality for Hereford cattle finished on pastures.

2. Materials and methods

2.1. Animals and phenotypic information

Animal handling and experimental procedures were in accordance with the Handbook of Procedures for Animal Welfare of the National Service of Animal Health (*Servicio Nacional de Sanidad Animal*, SENASA) of Argentina. The study was conducted on 206 Hereford steers that were fattened on perennial, fertilized pastures. The experiment started in April, 2006 when the steers were 8 to 10 months old, and it ended in October, 2008. All the steers were kept and fed in the same field throughout the whole period of the trial. Pasture was a mix of different types of legumes and grasses, including alfalfa, white clover, perennial ray grass, fescue and orchard grass. The steers were weighed monthly, and scanned by utrasound for backfat thickness and rib-eye area over the 12th–13th rib interval, every 3 months. The experiment was planned in order to slaughter the steers by the end of fall (June) 2008, with at least 6 mm of backfat thickness. Several unexpected complications, including a severe drought, made it impossible to reach that target end point. Therefore, from May 2008 on the frequency of ultrasound measurements was increased (monthly) in order to slaughter steers as soon as they reached the specified backfat thickness. By October 2008 it was decided to finish the experiment, sending to slaughter only those steers with known sire that carried the least frequent marker genotypes and were closest to the target backfat thickness. In this way, slaughter took place on five different occasions between March and October 2008. In total, 162 steers of known age, with complete carcass evaluation and sired by 15 bulls were slaughtered (Table 1).

2.2. Molecular analyses

One SNP on the CAPN1 gene (CAPN1 316) and another on the Leptin gene (E2FB) were analyzed. These two SNPs were the first commercial markers for beef quality traits (tenderness and body fatness, respectively). The CAPN1 316 is a G/C SNP in exon 9 of CAPN1 gene (Page et al., 2002) and E2FB is a C/T transition in exon 2 of the Leptin gene (Buchanan et al., 2002). DNA was extracted from 300 μl of blood using Illustra GFX™ Genomic Blood DNA Purification Kit (GE Healthcare, Buckinghamshire, UK). Marker CAPN1 316 was analyzed by PCR-RFLP method using the following primers: 5′-ccagggccagatgg tgaa-3′ (forward) and 5′-cgtcgggtgtcaggttgc-3′(reverse) and BtgI restriction enzyme. Marker E2FB was genotyped with tetra-primer ARMS-PCR method (Ye, Dhillon, Ke, Collins, & Day, 2001) using two sets of primer pairs (outer and inner primers). The outer primer pair was: 5′-gacgatgtgccacgtgtggtttcttctgt-3′ (forward) and 5′-cggttctacct cgtctcccagtccctcc-3′ (reverse). The inner primer pair was: 5′-tgtcttac gtggaggctgtgcccagct-3′ (forward) and 5′-agggttttggtgtcatcctggacctttc g-3′ (reverse).

Among the 15 bulls identified as sires of steers, there were 1 CC, 2 CG and 12 GG, according to their CAPN1 316 genotypes; and 2 CC, 7 CT and 6 TT sires according to the E2FB marker.

Genotypic frequencies of the initial sample of steers (n = 206) for CAPN1 316 were 1, 13 and 86% for CC, CG and GG, respectively. Genotypic frequencies for E2FB were 7, 40 and 53% for CC, CT and TT, respectively.

For the sample of slaughtered steers (n = 162) genotypic frequencies were 1 CC, 16 CG and 83 GG (CAPN1 316 marker) and 9 CC, 42 CT and 49 TT (E2FB marker).

2.3. Meat sampling and physical determinations

Steers were slaughtered at a private abattoir after resting for 24 h in paddocks with available water, according to SENASA regulations. At slaughter, left carcass sides were electro stimulated applying 21 V and 0.25 A during 5 s and placed in a chiller at 1–5 °C for 24 h. Carcass pH and temperature were measured at 1, 3, 6, 9 and 24 h post-mortem in the *longissimus* muscle, at a point located over the interval between ribs 12th and 13th. A block of steaks corresponding to the 8th to 13th ribs was removed from each left half carcass. The block was divided into two pieces that were vacuum-packed. The fraction between 8th and 10th ribs was frozen at -18 ± 1 °C (1 day aging treatment) and the rest was aged for 7 days at 3 ± 1 °C (7 day aging treatment), and then frozen at -18 ± 1 °C. Prior to being thawed, each block was subsampled using an electric saw in steaks of 2.5 cm width, vacuum packaged and kept at −18 °C.

The following analytical determinations in meat samples were performed at the *Instituto de Tecnología de Alimentos*, *Instituto Nacional de Tecnología Agropecuaria* (INTA) in Castelar, Buenos Aires.

2.4. Warner–Bratzler shear force (WBSF)

WBSF was measured in steaks corresponding to the 10th and 13th ribs. Once thawed, under refrigerated conditions (4–7 °C), they were boned, weighed and placed in a pre-heated shell style electric grill for 10 min, until internal temperature reached 71 °C (AMSA, 1995). Cooked steaks were weighed and cooled to <10 °C. Eight 1.3 cm-diameter cores were extracted from each steak parallel to the muscle fiber orientation

Table 1
Means and standard errors for final weight (FW), average daily gain (ADG), final backfat thickness (BFT), average monthly backfat thickness gain (AMBFTG), final rib-eye area (REA), average monthly rib-eye area gain (AMREAG) and age at slaughter (AGE) for each slaughter group (SG).

Trait	Slaughter group (date of slaughter) (n)									
	SG1 (04/17) (37)		SG2 (07/03) (34)		SG3 (07/10)(34)		SG4 (09/11)(33)		SG5 (10/30)(24)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
FW (kg)	447	27.4	514	37.99	520	42.91	513	42.54	560	51.84
ADG (g/day)	697	51	717	52	727	59	648	51	645	62
BFT (mm)	6.74	0.87	6.58	0.69	6.92	0.89	5.78	1.08	5.95	1.50
AMBFTG (mm/30 days)	0.321	0.081	0.270	0.051	0.289	0.055	0.205	0.048	0.171	0.043
REA (cm^2)	56.66	6.93	56.46	6.39	57.73	6.73	58.65	7.17	58.84	6.64
AMREAG (cm^2/30 days)	1.78	0.48	1.70	0.34	1.86	0.32	1.53	0.34	1.47	0.32
AGE (day)	596	13.9	669	14.7	679	14.6	740	14.1	784	17.4