Project Summary

Managing Interactions among Pre-harvest Factors and Postmortem Tenderization during Aging to Enhance Beef Tenderness

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Background

Meeting consumer demands for product quality and consistency are fundamental to the beef industry's efforts to increase consumer demand for beef. Past research has demonstrated that for the majority of consumers, tenderness is the sensory attribute that has the greatest influence on eating satisfaction. Experimental market research has demonstrated that improving beef tenderness not only increases the likelihood that consumers will purchase beef, but also increases how much they are willing to pay. Pre-harvest management systems that facilitate production of consistently tender beef would assist in attaining industry goals to build consumer demand and add value to cattle.

The objectives of this study were:

1) Characterize interactions among three primary pre-harvest factors known to affect tenderness (genotype, gender, and implant program) and determine their combined effects on early postmortem tenderness and rate and extent of tenderization during subsequent postmortem aging for two beef muscles (*longissimus* and *gluteus medius*), and;
2) Utilize results from the first objective to design a systematic approach for managing and end-product tenderness.

Methodology

Steers (n = 185) and heifers (n = 158) born between Jan. 9 and May 25, 2006 were identified for use in this study. Crossbred calves (289 calves sired by Charolais bulls and 54 calves sired by Angus bulls) were weaned at conventional ages, pre-conditioned and placed in a feedlot for finishing for 137 to 166 days.

The calves were sorted by sex, stratified by weaning weight and assigned randomly to one of two implant regimes—conventional or delayed.

Hair samples for genotyping were obtained from each animal at the time final weights were recorded. The samples were used to test for tenderness gene markers through a commercially available test (GeneSTAR Tenderness), which consists of a panel of three gene markers (T1, T2 and T3) for two different genes, calpastatin (CAST) and calpain (CAPN1).

Additional factors that have been found to affect early postmortem tenderization were monitored throughout the growing/finishing period, including behavior and temperament. Cattle were scored using a previously developed system and evaluated on their behavior in the chute, exit speed, pen score and post-transport score.

Morbidity was quantified by the number of diagnosed cases (i.e. hospital visits during the growing/finishing in the feedlot) and using a post-harvest lung scoring system that identified either the presence or absence of any lesions (dark depressed purple areas primarily in the right, anterior ventral lobe).

After finishing, the cattle were harvested at a commercial beef processing plant when they were between 12 to 16 months of age. Following slaughter, pre-rigor carcasses were electrically stimulated, and then were chilled for 48 hours. After the carcasses were chilled, a USDA grader assigned marbling and lean maturity scores. In addition, two experienced evaluators evaluated each carcass for fat thickness, adjusted fat thickness, kidney, pelvic and heart fat (KPH), as well as skeletal maturity. Ribeye areas were obtained for each carcass using a video image analysis system. Objective color measurements of the ribeye face were also recorded.

At 48 hours postmortem, striploins (IMPS/NAMP 180) and top sirloin butts (IMPS/NAMP 184) were removed from the right sides of each carcass. The top sirloin was further fabricated with the removal of the *gluteus medius*, and samples were obtained from the *longissimus* and the *gluteus medius* muscles for pH determination.

Each *gluteus medius* and striploin sample was fabricated into five sections that were randomly assigned to each of five postmortem aging periods (three, seven, 14, 21 and 28 days). After being aged, the muscle sections were fabricated into 2.54 centimeter thick steaks.

As part of the second objective of the project, the researchers investigated the effects of quality grade, genotype, and objective color measurements on Warner Bratzler shear force measurements for tenderness using a statistical model.

Findings

Cattle in the experimental sample exhibited considerable variation in temperament, however fewer than 10 percent of the cattle were characterized as "nervous" or "flighty" (based on pen, chute, and post-transport behavior scores) and less than 20 percent of the cattle exhibited "moderate" or "high" chute exit speeds.

The number of animals treated for illness one or more times during the experiment was approximately one in five. The incidence of cattle with one or more detectable lung lesions at slaughter was about one in 20.

Cattle genotypes determined using the GeneSTAR Tenderness panel are summarized in the following table. This commercial test classifies animals according to the total number of favorable alleles ("stars") that they possess. Based on the three-marker tenderness panel, which identifies polymorphisms (T1, T2, and T3) in two specific genes (calpastatin and μ-calpain), an animal could possess from zero to six favorable tenderness alleles (zero, one or two favorable alleles for each marker).

Table 1. Genotypic and allelic frequencies for GeneSTAR Tenderness gene markers

		Genotype[1], %			Frequency	
GeneSTAR marker	Gene	0	1	2	Unfavorable allele	Favorable allele
CAST-T1	Calpastatin	0	24	76	0.12	0.88
CAPN1 316-T2	μ-Calpain	57	37	6	0.75	0.25
CAPN1 4751-T3	μ-Calpain	18	44	38	0.40	0.60

Frequency of the favorable T1 allele was very high (0.88) among the experimental group. The researchers also thought it was noteworthy that all cattle in the current study had at least one favorable allele. Only 6 percent of the cattle had two favorable T2 alleles.

More than 98 percent of the carcasses had USDA quality grades of Choice or Select, and 86 percent had calculated USDA yield grades of 2 or 3. There was considerable variation in *longissimus* color values, but only one carcass was categorized as a dark cutter.

Tenderness values as measured through Warner Bratzler shear force of the longissimus and the *gluteus medius* after three, seven, 14, 21 and 28 days of postmortem aging were different between the two muscles across all aging periods. The *gluteus medius* showed less improvement in tenderness as postmortem aging time increased from three to 28 days. The results indicated that postmortem aging periods of 14 days to 28 days were very effective for enhancing *longissimus* tenderness, but were considerably less effective for improving tenderness of the *gluteus medius*.

The second objective of this study was to design a systematic approach for managing end-product tenderness through the control and management of pre-harvest and post-harvest factors. The most effective approach identified for enhancing striploin and top sirloin tenderness involved:

1. Use of minimum postmortem aging specifications for striploins and top sirloins (postharvest);
2. Use of tenderness gene markers (pre-harvest);
3. Quality grading of carcasses using current USDA standards (postharvest);
4. Sorting Select and Low Choice carcasses based on objective color measurements (postharvest).

Application of these strategies sorted carcasses into three tiers:

Tier 1—Most Tender

- Tier 1 represented 26 percent of the experimental sample and consisted of the following:
    - All Premium Choice carcasses
    - Low Choice carcasses that were a) were produced by cattle with four or more stars for tenderness and b) had high *longissimus* L* values
- Tier 1 carcasses produced *longissimus* and *gluteus medius* steaks with the following characteristics:
    - Mean longissimus Warner Bratzler shear force (WBSF) = 3.27 kilograms; probability of consumer acceptance = 0.77
    - Mean gluteus medius WBSF = 3.99 kilograms; probability of consumer acceptance = 0.61

Tier 2—Acceptable tenderness

- Tier 2 represented 57 percent of the experimental sample and consisted of the following:
    - Low Choice carcasses that were a) produced by cattle with four or more stars for tenderness and b) had low *longissimus* L* values, together with all Low Choice carcasses produced by cattle with three or fewer starts for tenderness.
    - Select carcasses produced by cattle with four or more stars for tenderness, together with Select carcasses that were a) produced by cattle with three or fewer stars for tenderness and b) had high *longissimus* L* values.
- Tier 2 carcasses produced *longissimus* and *gluteus medius* steaks with the following characteristics:

- Mean *longissimus* WBSF = 3.54 kilograms; probability of consumer acceptance = 0.72
- Mean *gluteus medius* WBSF = 4.13 kilograms; probability of consumer acceptance = 0.58

Tier 3—Least Tender

- Tier 3 represented 17 percent of the experimental sample and consisted of the following:
  - Select carcasses that were a) produced by cattle with three or fewer stars for tenderness and b) had low *longissimus* L* values.
- Tier 3 carcasses produced *longissimus* and *gluteus medius* steaks with the following characteristics:
  - Mean *longissimus* WBSF = 3.96 kilograms; probability of consumer acceptance = 0.62
  - Mean *gluteus medius* WBSF = 4.37 kilogram; probability of consumer acceptance = 0.51

Implications

The application of tenderness management strategies as developed by the researchers compiling this report sorted beef carcasses into three categories with respect to *longissimus* and *gluteus medius* tenderness. Categorizing Premium Choice, Low Choice and Select carcasses in this manner was effective in improving tenderness and predicted consumer acceptability of Low Choice and Select *longissimus* and *gluteus medius* steaks.

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