

Project Summary

**Defining the Value of Genome-Enabled Improvement and Precision
Management of Beef Tenderness**

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Animal Genetics**

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Background

Pre-harvest management practices that enhance tenderness or reduce variation are viewed as important contributors to the beef industry's strategy to produce the high-quality products demanded by consumers. Pre-harvest factors that affect tenderness include a number of traits under genetic control or traits inherent to the individual animal including genotype, sex, age, temperament and health status (Tatum, 2006). Other pre-harvest factors outlined by Tatum (2006) affecting tenderness are related to beef cattle production practices. In addition to pre-harvest management of tenderness, a number of methodologies maybe implemented to improve tenderness post-harvest.

The objective of this study was to investigate the utilization of genomically-enabled selection strategies for the improvement of Warner-Bratzler shear force (WBSF) tenderness and to explore the changes in the value of beef products as they accrue to different sectors of the beef value chain.

Methodology

To achieve these objectives, a marker-assisted genetic selection simulation model was constructed to evaluate a variety of selection strategies where selection intensity is modified to evaluate the expected change in genetic merit of progeny, replacement females and cow herds for WBSF by year. Then, the predicted changes in WBSF over time resulting from the simulation were combined with a model of the U.S. beef industry to identify how consumer demand shifts, resulting from improved meat tenderness, result in changes in beef and cattle prices, quantities and economic profitability at four points in the beef marketing chain. In addition to this more "macro" approach, researchers quantified the economic value of the improvements in WBSF to a hypothetical branded product utilizing a tenderness-based grid, and identified the value of the genetic selection program at improving brand non-conformance.

Findings

- Increased selection pressure on WBSF via utilization of genotyping and molecular breeding values (MBV) results in increasing levels of favorable genetic merit for WBSF. More intense selection of sire candidates yields increased response.
- Selection of replacement females on the basis of their MBV estimated from genotype results accelerates genetic improvement in progeny and cow herds.
- Selection of sires using WBSF MBV (an estimate of net merit for WBSF) results in increases in favorable allele frequencies among progeny, replacements and cows. Loci with large allele substitution effects experience the largest changes in favorable allele frequency while loci with small allele substitution effects experience little change in favorable allele frequency.
- Expected phenotypic WBSF values for progeny entering the commercial beef trade decrease by 0.11 and 0.27 kg for selection systems that randomly select replacement females and utilize sires from the upper 50% and 5% of the eligible candidates, respectively. Implementation of a marker-assisted replacement female selection system results in decreases in progeny mean WBSF of 0.21 and 0.37 kg for selection systems that utilize sires from the upper 50% and 5% of the eligible candidates, respectively.
- The present value of a 20-year strategy to select bulls in the upper 50% of genetic potential to improve WBSF is predicted to produce economic benefits of \$3.5 billion.

Complimenting this strategy by using marker-based information to select replacement heifers would increase the total economic benefits to \$5.9 billion.

- The upper 50% bull selection strategy with (without) marker assisted replacement heifer selection would result in increased profitability (not counting genetic testing costs) of \$8.06/head (\$4.34/head) for feeder cattle and \$2.86/head (\$1.54/head) for fed cattle in 20 years.
- The present value of a very aggressive 20-year strategy to select bulls in the upper 5% of genetic potential to improve WBSF is predicted to produce economic benefits of \$8.6 billion. Complimenting this strategy by using marker-based information to select replacement heifers would increase the total economic benefits to \$10.9 billion.
- Regardless of selection strategy, the total economic benefits from a genetic selection program are predicted to be distributed as follows: 38% to consumers, 18% to the retail sector, 3% to the packing sector, 11% to the feedlot sector, and the remaining 30% to all firms involved in supplying feeder cattle.
- The discounted cost of a 20-year strategy to select bulls in the upper 50% of genetic potential to improve WBSF is predicted to be \$301.32 million; including marker-based replacement heifer selection raises total projected costs to \$8.21 billion.
- An upper 50% bull selection program with (without) marker-based replacement heifer selection would reduce brand non-conformance, defined as the percentage of carcasses classified as “very tough” (WBSF > 5.4kg), from 30% down to 24% (27.4%) by year 20. The value of the upper 50% selection program with (without) marker-based replacement heifer selection to a brand in year 1 for risk neutral producers estimated to be \$2.68/head (\$2.58) and by year 20 is estimated to be \$9.56/head (\$5.16/head).
- An aggressive upper 5% bull selection program with (without) marker-based replacement heifer selection would reduce brand non-conformance, defined as the percentage of carcasses classified as “very tough” (WBSF > 5.4kg), from 30% down to 22.1% (25.3%) by year 20. The value of the upper 5% selection program with (without) heifer replacement to a brand in year 1 for risk-neutral producers estimated to be \$6.35/head (\$6.39) and by year 20 is estimated to be \$16.44/head (\$12.28/head).
- Depending on the selection strategy, the value to a brand from reducing non-conformance is anywhere from \$0.02 to \$2.00/head higher for producers that are risk averse relative to those that are risk neutral as the selection strategies serve to reduce not only the mean WBSF but the variability in WBSF, and thus economic returns, as well.

Implications

Value of improved WBSF to precision management

WBSF MBV could be used to classify progeny directly into non-conformance risk groups enabling the targeted application of pre- and post-harvest management interventions to reduce WBSF below a brand's specific WBSF threshold. Progeny of sires of specific genotypes, either desirable or undesirable, could also be targeted for precision management through the value chain by directing progeny (or their products) into brands or marketing channels with defined specifications. It is anticipated that this precision management would further improve the value of beef products to consumers through reduction in overall mean and variance in WBSF.

Reference

Tatum, J. D. (2006). "Executive Summary: Pre-harvest cattle management practices for enhancing beef tenderness." Available online at:

<http://www.beefresearch.org/CMDocs/BeefResearch/Pre-Harvest%20Cattle%20Management%20Practices%20for%20Enhancing%20Beef%20Tenderness.pdf>

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