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Overview of a TQM Approach for Improving Beef Tenderness

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INTRODUCTION

Steers and heifers comprising the U.S. "fed" beef supply are highly variable in biological type, age, and management background (most are grain-finished, but they are started on feed at different ages, given different growth promoting implants, fed for differing periods of time, and slaughtered at different ages). The beef industry's current system for ensuring acceptable product tenderness involves "mass inspection" (USDA Quality Grading) of completed products (carcasses) at the end of the production process. Although this system results in general categorization according to tenderness differences, product value is lost due to inaccuracy of sorting methodology (Quality Grades account for approximately 5 to 30% of the variation in beef tenderness) and because "inferior" products have been produced and must be sold at discounted prices. Additionally, the effectiveness of the present grade-based "quality assurance" system is reduced even further by the fact that most (over 80%, according to the 1995 National Beef Quality Audit) of the beef carcasses produced by "fed" steers and heifers fall within a very narrow range in USDA Quality Grades (Select and Choice) Cattle producers have been very successful in producing cattle that are very uniform with respect to Quality Grade, yet it has been estimated that, still, 1 in 4 beef steaks "doesn't eat right".

An alternative approach for ensuring product tenderness, which would involve the use of Total Quality Management principles in a "Palatability Assurance Critical Control Points" (PACCP) system, was proposed at the 1994 National Beef Tenderness Conference. Application of such a system requires identification of causes of non-conformance (in this case, toughness) and, then, focuses on prevention of non-conformance through control of inputs and processes. This report summarizes results of a project commissioned by the National Cattlemen's Beef Association to develop a Total Quality Management System, using a combination of "critical control points" and "corrective actions", which could be used to reduce the incidence of retail beef tenderness problems in loin (top sirloin and top loin) steaks.

DEVELOPMENT OF A TQM MODEL

Establishing a Baseline and Defining Non-Conformance

To measure the effectiveness of the TQM model, it was necessary to establish a baseline against which effects of any modification of the system could be compared. A retail steak audit conducted in 8 different U.S. cities determined that beef cuts were available to consumers in as few as 3 days post-harvest and that the average length of time between harvest and retail display was approximately 21 days. Also, few U.S. beef processors presently use high-voltage electrical stimulation. Correspondingly, we chose to use shear force values of cuts from

unstimulated, control carcass sides that had been aged for 3 days ("worst-case" scenario) and 21 days ("normal" scenario) to serve as baselines for comparison.

It also was necessary to define conformance vs. non-conformance with respect to tenderness. For the purposes of testing the TQM model in this study, non-conformance, for both top sirloin and top loin steaks was defined as a shear force value equal to or greater than 4.54 kg based on the consensus established at the 1994 National Beef Tenderness Conference. To evaluate the effectiveness of various intervention steps, shear force was assumed to be normally distributed and a probability density function was computed (using the mean, standard deviation, and threshold shear force value) for each baseline and after application of each intervention. This approach provided the probability (expected occurrence) of non-conformance. The goal of TQM is to reduce the occurrence of non-conformance.

Inputs and Production Process Control

Cattle-Type and Management Practices. Cattle included in this project (n = 192) were sired by 31 bulls (4 to 7 steer calves per sire). Eight different sire breeds were represented: Angus, Belgian Blue, Braford (5/8 Hereford X 3/8 Brahman), Braunvieh, Charolais, Limousin, Red Brangus (5/8 Red Angus X 3/8 Brahman), and Simmental. Implants were administered twice (Synovex-S, followed by Revalor-S) during finishing. The cattle were started on feed as calves and fed high-concentrate, grain diets in commercial feedlots until they attained approximately .45 inch external fat thickness over the rib eye at the 12th rib. All of the carcasses produced by the steers were classified as A-maturity, and 92% of the carcasses had marbling scores of Slight and Small. The distribution of Quality Grades was 1% Prime, 6% Upper 2/3 of Choice, 41% Low Choice, 51% Select, and 1% Standard.

Genetic Interventions. Two different intervention steps, associated with genetic inputs into the system, were evaluated:

- Genetic Intervention A - The worst 25% of sires were eliminated, based on progeny group means for 14-d longissimus shear force. Progeny of eight sires (four *Bos taurus* and four *Bos indicus* composite) were eliminated.
- Genetic Intervention B - The best 25% of sires were selected, based on progeny group means for 14-d longissimus shear force. Progeny of eight sires (five *Bos taurus* and three *Bos indicus* composite) were included in the selected group.

(Note: Either A or B was used; the two genetic interventions were not used together)

Postmortem Interventions and Corrective Actions. Two postmortem intervention steps involving combined use of aging, high-voltage electrical stimulation (ES), and calcium- activated tenderization (CAT) were identified and evaluated:

- Postmortem Intervention Step 1 - Application of high-voltage ES to all carcasses; age cuts for 14 to 21 days.
- Postmortem Intervention Step 2 - Sort carcasses into two tenderness categories ("tender" vs. "tough") based on top loin shear force at 1 day postmortem: (A) Cuts with day-1 shear values below 5 kg ("tender") were aged 7 to 14 days; (B) Cuts with day-1 shear values of 5 kg or higher ("tough") received CAT and were aged 7 days.

EFFECTIVENESS OF TQM MODEL FOR IMPROVING TENDERNESS

Data showing the effectiveness of the TQM model are summarized in Figures 1 and 2. Baseline data indicate that the test sample of cattle produced relatively tough beef. Probabilities indicated that the expected rate of non-conformance after 3 days of aging ("worst-case" baseline) was 1 in 2 for top sirloin steaks and nearly 2 in 3 for top loin steaks. After 21 days of aging ("normal" baseline) the expected failure rate was still nearly 1 in 3.

Use of high-voltage ES (Postmortem Intervention Step 1) without genetic intervention decreased the probability of non-conformance to .19 for top sirloin steaks and .22 for top loin steaks. Use of day-1 shear force sorting and CAT (Postmortem Intervention Step 2) improved tenderness slightly, when used without genetic intervention.

Even after applying both postmortem intervention steps, nearly 1 out of 5 steaks failed to conform to the desired shear force specification, suggesting that application of postmortem technology cannot be expected to completely eliminate tenderness problems and that some attention must be given to improving the quality of "raw" materials. The following quote stresses the importance of the quality of raw materials to the quality of a finished product.

Once the grapes hit the dock, it's too late for us to correct the fruit. You can make good or bad wine from good grapes, but you can't make good wine from bad grapes. So we try to help farmers grow premium grapes for our wines."
(Bob Reed, Llano Estacado Winery)

These same principles apply to the production of "quality" beef. It is difficult to produce tender beef using cattle that are inherently "tough".

Elimination of the "worst" 25% of sires decreased the probability of non-conformance to .18 for top sirloin steaks and to .16 for top loin steaks. On the other hand, selection of the "best" 25% of sires reduced the probability of non-conformance to .11 for top sirloin steaks and to .06 for top loin steaks. Use of either genetic intervention currently would require progeny testing of sires to identify "tough" vs. "tender" genotypes. However, if an automated system for measuring tenderness could be developed and implemented, progeny tenderness data would become more readily available to cattle producers and could be used for selection and management to improve beef tenderness.

Use of high-voltage ES, along with 14 to 21 days of aging (Postmortem Intervention Step 1) further reduced the expected rates of non-conformance beyond that achieved using genetic

intervention. Use of day-1 shear force sorting and CAT (Postmortem Intervention Step 2) improved tenderness slightly, when used in combination with Genetic Intervention A; however, when Genetic Intervention B was used, only a few top sirloins and no top loins received calcium injection treatment, so Postmortem Intervention Step 2 had little effect.

CONCLUSIONS AND RECOMMENDATIONS

The effectiveness of applying TQM principles to enhance beef tenderness was tested. The test population of cattle was genetically diverse, but was constrained to include youthful steers with no more than 3/8 *Bos indicus* inheritance. Feeding and pre-slaughter management of the cattle were consistent with procedures recommended for production of grain-finished beef of an acceptable quality level. Moreover, the slaughter endpoint (.45 inch external fat thickness) was chosen to result in production of mostly Select and Choice grade carcasses (98% of the resulting beef carcasses qualified for these two grades).

Two interventions were very effective and are recommended for use in a TQM model for improving beef tenderness:

1. Selection of the top (most tender) 25% of sires, based on progeny group means for 14-day top loin shear force.
2. High-voltage ES of all carcasses, followed by a 14 to 21-day postmortem aging period.

Use of these two interventions reduced the expected rate of non-conformance to approximately 6% (1 in 17) for top sirloin steaks and 1% (1 in 100) for top loin steaks. Achieving this level of conformance required the use of genetic and postmortem interventions.

FIGURE 2. TQM MODEL EFFECTIVENESS FOR THE TOP LOIN

