IMPROVING BEEF TENDERNESS BY PREVENTING MUSCLE SHORTENING IN THE CARCASS

A 10

R. L. Hostetler, B. A. Link, W. A. Landmann and H. A. Fitzhugh, Jr.

INTRODUCTION

The adverse effect on tenderness of allowing excised muscles to shorten was demonstrated as early as 1948 by Lowe and later by others. Excised muscle that was restrained from shortening, or stretched, was more tender than muscle allowed to shorten as demonstrated by Herring *et al.* (1965a).

Locker in 1960 suggested that the extent of shortening that takes place in a muscle within the intact carcass may depend on the way the carcass is suspended. Herring *et al.* (1965b) supported Locker's hypothesis when he found that some muscles from sides laid on a table, thus simulating a standing position, were more tender than the same muscles from the opposite side suspended in the conventional manner. Many of the larger commercially important muscles from the carcasses suspended in the conventional manner were less tender indicating that the conventional method may have a detrimental effect on the tenderness of these muscles. With this in mind, Hostetler *et al.* (1970) selected the obturator foramen as the point of suspension of the carcass to utilize the force of gravity in maintaining the muscles of the round and loin in a stretched state. A significant improvement in the tenderness of muscles studied indicated that the experimental method was preferable to the standard method.

The present study compares the conventional method of suspension, the method of Herring *et al.* (1965b) (laying the carcass on a table), the method of Hostetler *et al.* (1970) (suspending from the aitch bone) and two additional methods of suspending the carcass to determine which method or methods improve the tenderness of various beef muscles.

MATERIALS AND METHODS

Forty Santa Gertrudis steers ranging in age from approximately 13 to 19 months and in weight from 425 to 535 kg were randomly slaughtered over a two week period. Bleeding, evisceration, splitting and washing were completed while the carcass was suspended by the Achilles tendon. After washing, sides of the carcass were each given one of the preselected treatments and placed in the cooler at 2 C. The time required from stunning to treatment and placement in the cooler was kept to one hour.

The five treatments (table 1) were applied to ten sides per replicate (2 sides per carcass, 5 carcasses) according to the standard balanced incomplete block design (Cochran and Cox, 1957). A minimum of four replications is required for the standard design; eight replications were used for this experiment. The method of analysis corrected for the effects common to sides from the same carcass. *A posteriori* tests of differences among treatments were made on a within-muscle basis using the Student-Newman-Keuls procedure with a significance level of 0.05 (Sokal and Rohlf, 1969).

After holding the carcasses in the cooler for seven days, nine muscles were excised from each side of the animal. The nine muscles were the *triceps brachii* (TB) from the thoracic limb; the *longissimus* (LG) and the *psoas major* (PM) from the lumbar region; the *adductor* (AD), *gluteus medius* (GM), *rectus femoris* (RF), *semimembranosus* (SM), *semitendinosus* (ST), and *biceps femoris* (BF) from the pelvic limb.

Excised muscles were frozen and two adjacent steaks, 2.54 cm thick, were cut from the thickest portions of the muscles, wrapped in freezer paper and stored at -20°C. Random numbers were assigned to one of each pair of steaks which were then cooked in numerical order. A 100 g sample cut from each steak was cooked for 46 minutes to approximately 70 C in a 175 C oven. The methods of sample preparation for Warner-Bratzler shear determinations and for a six-member taste panel, as well as the methods of shearing and scoring were described by Cover *et al.* (1962).

Fibers for sarcomere length determinations were obtained from adjacent uncooked steaks by placing a small piece of muscle in a Waring blender and running the blender for 13 to 30 seconds to separate fibers. Sarcomere lengths in 10 fibers from each steak were measured using a 40x objective and a filar micrometer.

RESULTS AND DISCUSSION

The analysis of variance revealed that sarcomere length variation between animals, muscles and treatments were all significant. Also, there was a significant treatment by muscle interaction. At least one or more of the treatments changed the sarcomere length of fibers from all muscles studied.

Ease of fragmentation scores and shear value variations between animals, muscles and treatments were significantly different as were the respective treatment by muscle interactions. One or more of the treatments significantly changed the ease of fragmentation scores for all muscles except the ST and BF muscles. Also the shear values of all muscles except the PM were significantly changed by treatment.

For ease of discussion in relating the changes in sarcomere length to changes in tenderness, the nine muscles studied were placed into three groups according to their changes in sarcomere length by treatment. Muscles in Group One had significantly longer sarcomeres in all four of the experimental treatments than the vertical control (figure 1). In muscles of Group Two, the sarcomere lengths of the hip-tied and hip-free treatments were significantly different from each other. Group Three consists of two muscles whose sarcomere lengths were either unchanged or shortened by all experimental treatments as compared to the vertical control.

Increases in sarcomere lengths of muscles in Group One (figure 1) resulted in increased ease of fragmentation scores and decreased shear force values, both indications of improved tenderness. The LG muscle was significantly more tender in all of the experimental treatments than the vertical control. The tenderness results of the SM and ST muscles are not as consistent. The mean shear values of the SM muscle from the horizontal and hip-free treatments were significantly lower than for the vertical control but were not significantly different from the other two treatments. Ease of fragmentation score means of the SM muscle from the hip-free and hip-tied treatments were significantly higher than the vertical control or horizontal treatments. For the ST muscle, the ease of fragmentation scores were not significantly different among the five treatment means. The mean shear value of the ST muscle for the hip-tied treatment was significantly lower than the vertical control but not significantly different from the other treatment means.

Muscles in Group Two either increased in tenderness or remained unchanged when sarcomere lengths were increased by treatment. The changes that took place in sarcomere lengths of muscles in this group (figure 1) would lead one to expect marked increases in the tenderness of muscles of the hip-free and hip-tied treatments, especially in the AD and BF muscles. It was, however, the GM and RF muscles which responded most favorably to these two treatments. The GM and RF muscles were significantly more tender in the hip-free and hip-tied treatments than the vertical control or the other two treatments.

The horizontal and hip-free treatments significantly increased the tenderness of the AD muscle over the vertical control as indicated by ease of fragmentation scores and shear values. The mean ease of fragmentation score for the hip-free treatment of the BF muscle was significantly higher than the other treatments, but shear value means were not significantly different among any of the five treatments. An earlier study (Cover *et al.*, 1962) had shown the BF muscle to have characteristics that cause the measurement of shear values not to relate to other measures of tenderness if the muscle was not cooked sufficiently to soften the connective tissue. This finding may partially explain the results of the present study.

Muscles in Group Three decreased in sarcomere length in some of the treatments (figure 1). Mean sarcomere lengths of the PM muscle from the hip-tied, hip-free and horizontal treatments were significantly shorter than the vertical control or the neck-tied treatments. Ease of fragmentation means for the hip-free and hip-tied treatments were significantly lower than the vertical control. However, shear force means for the PM muscle were not significantly different among the five treatments. Even though the tenderness of the PM muscle was decreased by some of the treatments, it was still among the most tender muscles in the beef carcass.

Sarcomere lengths of the TB muscle of the vertical control and the hip-free treatments were significantly longer than the other treatments. Ease of fragmentation scores were significantly higher and shear values were significantly lower for the vertical control and hip-free treatments than the hip-tied or neck-tied treatments.

The correlated effect of treatments on sarcomere length and tenderness was examined after adjustment for animal-muscle differences. The correlations between sarcomere length and the two measures of tenderness, shear value and ease of fragmentation score, were -.64 and 0.89, respectively. In general, therefore, if a treatment produced an increase in sarcomere length in a muscle, the muscle increased in tenderness. Relatively small increases in sarcomere lengths beyond two microns produced marked improvement in the tenderness of most muscles studied. Further increases in sarcomere length to about three microns or longer did not increase the tenderness in the same proportion.

SUMMARY

Improved muscle tenderness of the major muscles of the loin and round was achieved by preventing their shortening during the onset of rigor mortis. Shortening which may take place in some muscles of the beef carcass suspended conventionally by the Achilles tendon was minimized by changing the point of suspension so as to maintain muscle lengths near that of the standing animal. All four of the experimental methods tested increased the sarcomere lengths of major muscles and improved their tenderness as measured by a taste panel and the Warner-Bratzler shear. Of the methods tested, suspension by the obturator foramen appears to be the most practical method.

ACKNOWLEDGEMENTS

This investigation was supported in part by the King Ranch Chair of Basic Animal Science and Biochemistry, Texas A&M University.

TABLE 1. DESCRIPTION OF TREATMENTS GIVEN TO SIDES OF BEEF

Descriptive term	Description of method
Vertical	The conventional or control method with the side suspended from the Achilles tendon.
Horizontal	Side laid on table, bone side down, with limbs perpendicular to vertebrae.
Neck-tied	Side suspended from the cervical vertebrae with the hind limb held perpendicular to the vertebrae by tying it to the fore limb.
Hip-free	Side suspended from the obturator foramen with fore and hind limbs free.
Hip-tied	Side suspended from the obturator foramen with the fore limb held perpendicular to the vertebrae by tying it to the hind limb.

LITERATURE CITED

Cochran, W. G. and G. M. Cox. 1957. Experimental Designs. John Wiley and Sons, Inc., New York.

Cover, S., S. J. Ritchey and R. L. Hostetler. 1962. Tenderness of beef. I. The connective tissue component of tenderness. J. Food Sci. 27: 469.

Herring, H. K., R. G. Cassens and E. J. Briskey. 1965a. Sarcomere length of free and restrained bovine muscles at low temperature as related to tenderness. J. Sci. Fd. Agric. 16:379.

Herring, H. K., R. G. Cassens and E. J. Briskey. 1965b. Further studies on bovine muscle tenderness as influenced by carcass position, sarcomere length and fiber diameter. J. Food Sci. 30:1049.

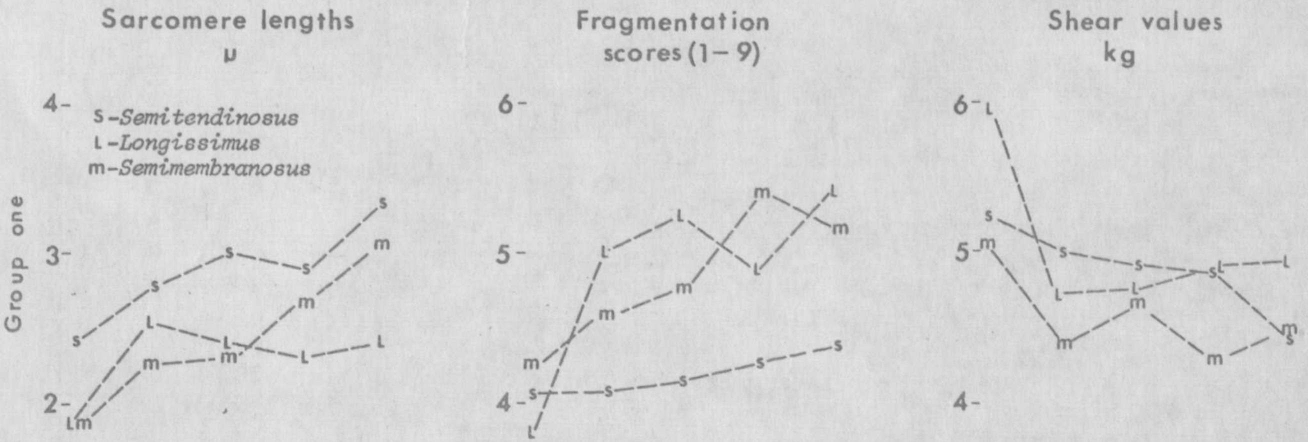
Hostetler, R. L., W. A. Landmann, B. A. Link and H. A. Fitzhugh, Jr. Influence of carcass position during rigor mortis on tenderness of beef muscles. I. Comparison of two treatments. J. Anim. Sci. (In press).

Locker, R. H. 1960. Degree of muscular contraction as a factor in tenderness of beef. J. Food Sci. 25:304.

Lowe, B. 1948. Factors affecting the palatability of poultry with emphasis on histological post-mortem changes. In E. M. Mrak and G. F. Stewart (Eds.) Advances in Food Research, Academic Press, New York.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Company San Francisco.

NT = neck-tied, HF = hip-free and HT = hip-tied.



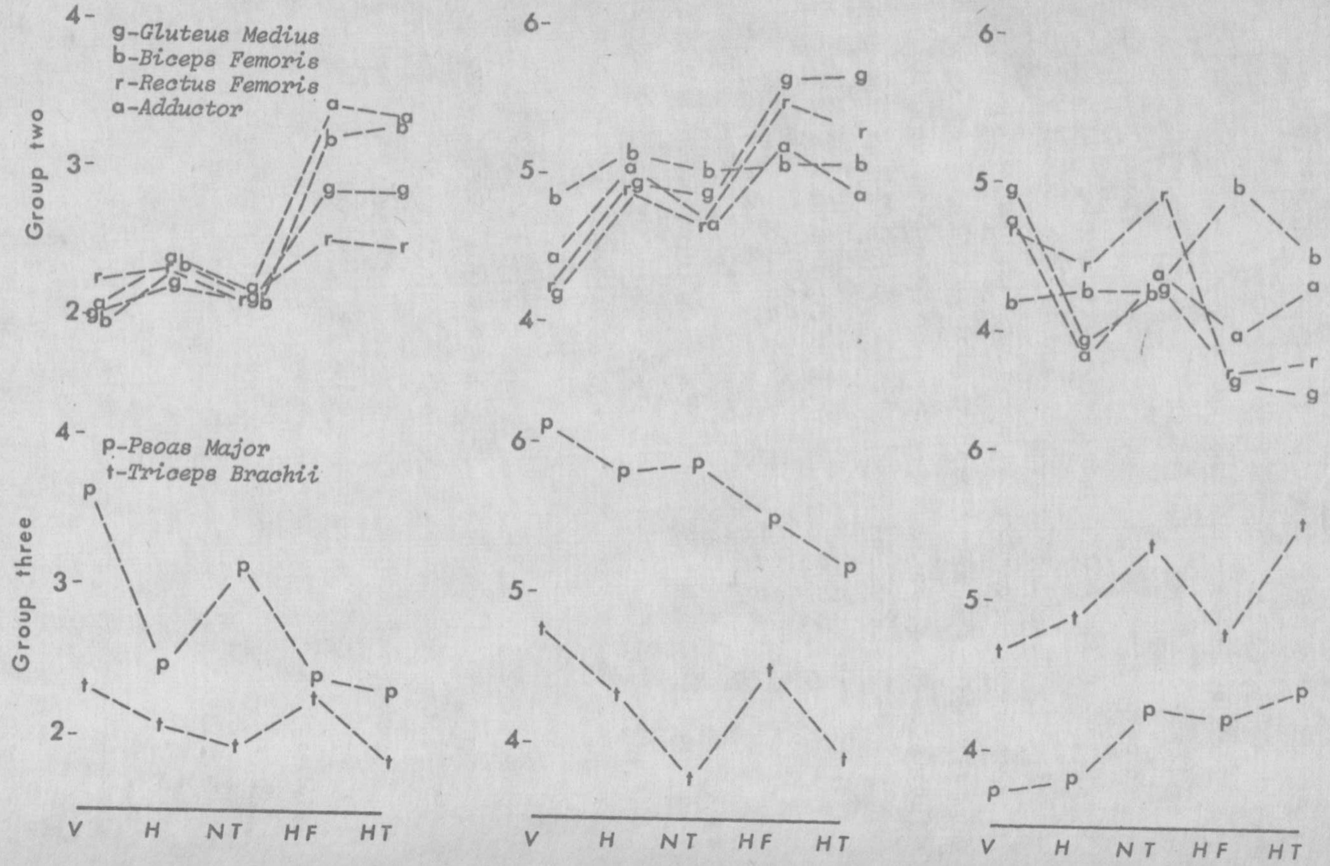


Figure 1. Summary of treatment effects on muscle tenderness. Fragmentation scores: 1 = very tough, 9 = very tender. Treatments: V = vertical control, H = horizontal, NT = neck-tied, HF = hip-free and HT = hip-tied.