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COW BEEF TENDERNESS ENHANCEMENT THROUGH SUPERSONIC SHOCK WAVE TREATMENT

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Background.

Consumer reaction to tenderness of products consumed will determine if the purchase is repeated in the future (Morgan *et al.*, 1991). Technology for tenderness enhancement is economically important to the consumer, processor, and producer. Increased consumer satisfaction stimulates additional sales and profits.

Physical techniques of tenderness enhancement have been developed to alter the normal sarcomere of bovine muscle. A well-studied method includes electrical stimulation, which accelerates the natural contraction and relaxation course of muscles and increases the rate of glycolysis. Physical alteration to the carcass includes suspension by the obturator foramen to increase sarcomere length. Claus and Marriott (1991) developed a prerigor carcass muscle stretching treatment, the "Tendercut" process, to improve tenderness of the rib, loin, and round muscles.

Other physical techniques have included hydrostatic and more recently hydrodynamic pressure. Kennick *et al.* (1980) determined that hydrostatic pressure accelerates aging and improves tenderness. Zuckerman and Solomon (1998) reported that hydrodynamic pressure from shock waves instantaneously ruptures sarcomeres and contributes to meat tenderness enhancement. Shock waves were created by meat samples being treated with an explosive charge suspended in a container of water. Solomon *et al.* (1997) reported that this technique reduced the shear force of fresh or cold shortened beef steaks by 49-72%.

At the present, no single technique has been accepted industry-wide for improving beef tenderness due to implementation costs, inefficiency, inconvenience, or the adverse effects on sensory attributes. Although technologies exist to enhance tenderness, problems such as unacceptable and high variability of tenderness still remain.

Objective.

The objective of this study was to explore the efficacy of shock wave treatment as a technique for the tenderness enhancement of cow beef that is expected to be less tender than the muscle from younger animals.

Methods.

Six cull cows that all graded U.S. Commercial C and D maturity as beef carcasses were slaughtered in a commercial meat plant. At 24 hr postmortem, 18 cm of *m. longissimus lumborum* (LD) muscles were removed from both sides caudal to the 12th/13th thoracic vertebrae and subsequently trimmed to 6.25 mm external fat. Two LD muscles of each carcass were randomly assigned to control (C) and supersonic shock wave treatment (SSW). The samples were vacuum packaged, and stored at 2-3°C. On the second day, the samples were transferred to a commercial pilot plant facility (Tenderwave Inc., Buena Vista, Va.), where the vacuum packaged muscles were encapsulated with evacuated rubber bags. At ca 48 hr postmortem, shock wave tests were conducted using 350 g of explosive in each shot. The explosive was composed of trinitrotoluene (TNT) explosive and pentaaerythritol tetranitrate (PETN). The bags were placed in the bottom of the tank 19 cm between the explosive and bags. The treated muscles were stored at 2-3°C. At 5 days postmortem, the muscles (both C and SSW treatments) were cut into 2.5 cm steaks. After exposure to air for 40 min, CIE L* a* b* values of steaks were measured using a Minolta Chromameter (Model CR-200, Minolta Camera Co., Ltd., Osaka, Japan) which was calibrated using a white plate (CIE L = 57.91, a* = 0.71, b* = +2.44). At this time, Standard Plate Count (SPC) was determined for both treated & control samples using the surface swab method. The steaks were vacuum packaged and stored at -29°C.

Shear Force Measurement

Two frozen LD steaks from each muscle were thawed at 4°C for 20 hr and then roasted to an internal temperature of 71°C in a 165°C Blodgett oven (GCS Service, Inc., Richmond, Va.) according to AMSA guidelines (1995). Cooked samples were chilled to approximately 25°C and 8-10 cores (12.7 mm diameter) were removed parallel to the muscle fiber. Warner-Bratzler shear force for all samples was determined with a computer interfaced Instron (Model 1011, Instron Corp., Canton, Mass.). Fifty-kg transducers were used, with a crosshead speed of 200 mm/min and 10% load range. Eight to 10 cores from each steak were sheared and the averages of total energy and maximum peak force were calculated for each steak.

Sensory Evaluation

LD samples from two steaks of each treatment cut 2.5 cm thick were prepared with the same procedure as for shear force measurement. The samples were cut into 1 x 1 x 1 cm cubes and evaluated by a trained sensory panel. The tenderness (myofibrillar and overall), juiciness, and connective tissue amount of two steaks from each muscle were evaluated in taste panel booths under red light by eight trained panelists. An 8-point scale (1=extremely tough and 8=extremely tender for myofibrillar and overall tenderness; 1=extremely dry and 8=extremely juicy for juiciness; and 1=abundant and 8=none for amount of connective tissue) was used. These panelists were trained following the general guidelines for AMSA (1995).

Thaw Loss and Cook Loss

The percentage of thaw loss and cook loss for LD steaks was determined on samples cooked for shear force determination. Thaw loss is the percentage of purge in the package after the steaks thawed and was calculated based on the whole package, bag material, and the beef steak weight. The cooking loss values were calculated based on the weight loss of the samples before and after cooking.

Statistical Analyses

Data were analyzed using the General Linear Model (GLM) procedures of the Statistical Analysis Systems Institute Package

(1996). Completely randomized block design (six replications and two treatments) was used. When significance ($P<0.05$) was determined for treatment, means were separated using the Least Significant Difference test (SAS, 1996).

Results and Discussion.

Most of the sensory scores of shock wave treated beef LD steaks were more tender as reflected by higher ($P<0.05$) values than those which were untreated. The myofibrillar tenderness score of shock wave treated samples was improved by 11.6%. These results agree with those reported by Berry *et al.* (1997) and Solomon (1998).

The scores for connective tissue amount closely paralleled those of myofibrillar tenderness. However, less improvement (9.0%) of connective tissue amount suggests that connective tissue protein may be resistant to destruction by supersonic shock wave treatment. The close relationship of this score to other measurements indicate that trained sensory panelists tend to rate connective tissue amount similar to other tenderness evaluations. The lack of effectiveness on connective tissue is relatively consistent with other tenderness improvement techniques, which tend to affect the myofibrillar components more than the stromal proteins.

The overall tenderness improvement of shock wave treated samples was 11.5% ($P<0.05$). This result should be expected since overall tenderness score is a composite of other tenderness evaluations. Juiciness scores were not affected by shock wave treatment, which agrees with results reported by Berry *et al.* (1997), and Solomon (1998).

However, the objective tenderness measurements revealed that the data from all treatments did not differ ($P>0.05$) in Warner-Bratzler total energy and peak force required for shearing the cored samples. The small differences in objective measurements, which were less than that reported by Berry *et al.* (1997), Solomon *et al.* (1997) and Solomon (1998), may be attributable to the samples being acceptable in tenderness without the shock wave treatment.

The magnitude of the response to the shock wave treatment varied from animal to animal. There is no obvious explanation for the pattern observed. Two plausible explanations are that differences in sample size and in the acoustical match of these samples with water may have provided the variation of treatment response.

Thaw loss, cooking loss, SPC count and CIE L^* a^* b^* were not affected ($P>0.05$) by the shock wave treatment (data not shown). This observation seems reasonable since this treatment method should have a minimal effect on these traits.

Additional research may be needed to verify the effectiveness of this technique under commercial conditions. The high damaged rate and the potential improvement of packaging material and technique is critical to the implementation of this technique in the meat industry.

Conclusions.

Hydrodynamic shock wave treatment improved the sensory traits of cow beef, but the effect on shear force measurements was reduced since these samples exhibited acceptable shear force values. Further research should be conducted to evaluate the effectiveness of this technique under a commercial processing environment.

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