EFFECT OF ELECTRICAL STIMULATION AND TEMPERATURE ON HOTBONED BEEF

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Background

Much of the variability in the eating quality of beef stems from the manner in which muscles (carcass and individual cuts) are treated up to the onset of rigor. Until this time carcasses are generally treated as a whole unit. However within the carcass, muscles will experience quiet different kinetic profiles in terms of pH and temperature profiles which results in variation in contraction, proteolysis, calcium release and denaturation of proteins. The resulting meat will have different degrees of toughness and tenderness. The approach in this project is to examine the beef carcass as a set of individual muscles and commercial cuts and to establish the optimum treatment at the early postmortem period. Interest in boning of unchilled carcasses (hot-boning or hot processing) has arisen as result of economic advantages stemming from savings in space, energy, labour, materials and supplies as well as a result of demonstrated improvements in the functional properties and quality of the product (Kastner, 1983). During hot-boning muscles are removed form the carcass which allows them to contract stonger than muscle conventionally chilled in the stretched state attached to the skeleton. To limit unfavourable properties of contracted hot-boned beef electrical stimulation is used to accelerate the deline of pH to a level critical for development of cold shortening (below 6.2) and thus avoid the toughening effects of cold shortening.

Objectives

The objective of this research is to reduce the variability in meat eating quality by developing techniques and regimes which control many of the biochemical and physical events which cause inconsistency. Variability will be reduced by application of electrical techniques in combination with hot-boning of the carcass.

Methods

Heifers (n=16) of similar age, size and grade were slaughtered by stunning using a captive-bolt pistol and exanguination. Carcasses (n=8) were hot-boned within 90 mins *pm*. Once excised the left hand side *longissimus dorsi* (LD) and *semimembranosus* (SM)) muscles were subjected to low voltage electrical stimulation (LVES) at 90V, 3x 60 secs and 14Hz while the right hand side muscles were not electrically stimulated (NES). The LVES and NES muscles were halved and stored at two different chilling temperatures (1) 2° C until 48 h (2) 10° C for 10 h followed by 2° C until 48 h. A second group of carcasses (n=5) were conventionally dressed and split into two sides. The left hand side of each carcass was chilled at 2° C for 48h while the right hand side of the carcass was chilled at 10° C for 10 h followed by storage at 2° C until 48h postmortem at which time the LD and SM muscles were excised. The rate of temperature and pH fall was monitored up to 2 days. Freshly cut samples (2.5 cm thick) were taken at 2, 7 and 14 days postmortem, vacuum packed and stored at -20°C for Warner-Bratzler shear force and sensory analysis. Samples were taken for sarcomere length determination at 2 days post mortem. Samples were taken at day 2,7 and 14 for proteolytic analysis.

Results and Discussion

LVES accelerated the pH decline of hot-boned muscles. LVES muscles had significantly ($P<0.001$) lower pH values than NES at both chilling temperatures compared to the NES muscles (Fig. 1a and 1b). This is in agreement with results presented in the literature (Carse 1973; Bendall *et al* 1976). Hot-boning alone resulted in tougher beef regardless of chilling rate WBSF values were significantly ($P<0.001$) higher when compared to cold boned muscles. This may be due to loss of physical constraint, which would be provided if attached to the skeleton. LVES significantly ($P<0.001$) lowered WBSF values in hot boned LD and SM muscles subjected to slow and fast chilling. However a combination of LVES and slow chilling was most effective at producing tender beef. (Fig. 2a and 2b). Sensory results for tenderness reflected WBSF results. Hot-boned muscles which were not subjected to LVES had significantly ($P<0.001$) shorter sarcomeres than cold boned muscles at both chilling temperatures. LVES resulted in significantly ($P<0.001$) longer sarcomeres in hot-boned SM muscle subjected to fast and slow chilling. SM muscle which was subjected to a combination of LVES and fast chilling had a mean sarcomere length of 1.5um whereas fast chilling with out stimulation had a mean sarcomere length of <1.2um (Fig. 3b). Therefore it appears that the prevention of shortening has a role to play in increased tenderness with regard to the stimulated SM muscle. However LVES did not have an effect on sarcomere length the LD. This suggests that prevention of cold shortening is not the sole contributor to tenderness induced by electrical stimulation. SDS-PAGE was carried out in order to qualitatively determine the rate of proteolysis. The presence of the 30 kDa component is a result of troponin-T breakdown, hence is used an indicator for proteolysis. It was observed that cold shortened muscle aged over a 14 day period. LVES appeared to alter the degradation of proteins as less proteolysis was evident at day 7 post mortem in stimulated samples then those which were not. A possible hypothesis could be that LVES creates an environment of low pH in early post-mortem muscle that is unsuited to the cystine proteases (calpains). LVES did not have a positive effect on proteolysis. Therefore increased proteolysis cannot be accounted for the increased tenderness in the LVES samples. This increased tenderness may be due to physical disruption in the LD muscle and a combination of prevention of cold shortening and physical production in the SM muscle.

Conclusions

Electrical stimulation prevented the toughening effect which results from hot-boning. A combination of slow chilling and electrical stimulation was most effective at promoting tenderisation.

Pertinent literature

Bendall, J.R. (1978). Variability in rates of pH fall and of lactate production in the muscles on cooling beef carcasses. Meat Sci. 2, 91

Kastner, C.L. (1983). Food Technol., 37, 96.

Acknowledgements

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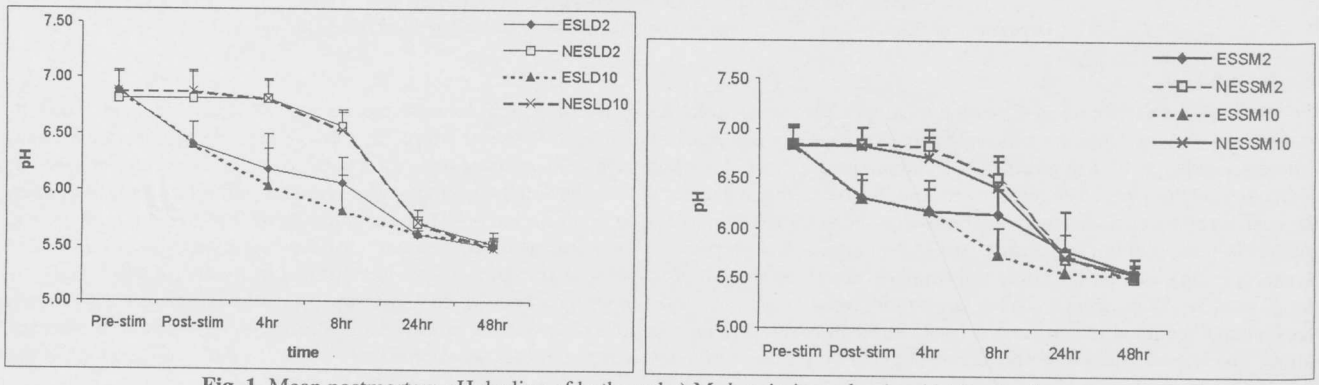

Fig. 1. Mean postmortem pH decline of hotboned a) M. *longissimus dorsi* and b) *Semimebranosus* stored at 2°C and 10° over 14 days postmortem

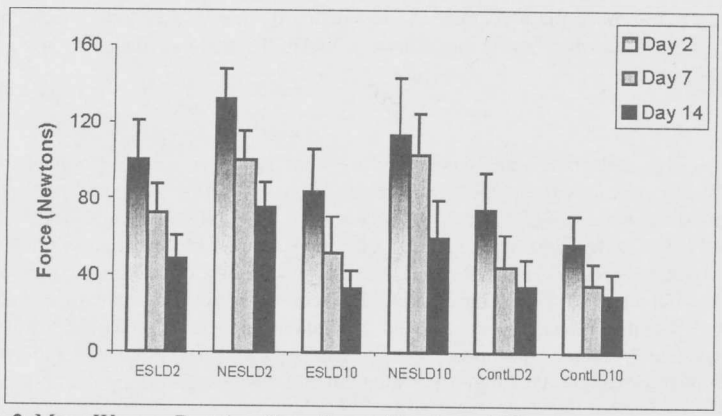

Fig. 2. Mean Warner -Bratzler Shear force of hot-boned LD muscle and cold-boned LD stored at 2°C and 10°C. similar trends were found for SM muscle.

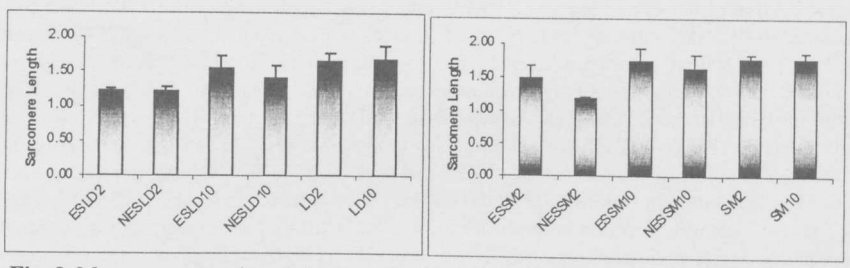

Fig. 3. Mean sarcomere length (um) results for (a) LD and (b) SM muscles for hotboned stimulated and non-stimulated samples and conventional at both storage temperatures.