

EFFECTS OF ELECTRICAL STIMULATION AND AGEING ON TENDERNESS IN BEEF CARCASSES

B. L. McINTYRE

W.A. Dept of Agriculture, Baron-Hay Court, South Perth, W.A. 615 1.

SUMMARY

Thirteen Brahman x Shorthorn steers approximately 18 months of age with a mean carcass weight of 190 (\pm 7.1) kg and a mean fat thickness of 5.8 (\pm 1.9) mm at the rump P8 site were subjected to 4 post-slaughter treatments. These were: no electrical stimulation or ageing (NIL); electrical stimulation, no ageing (ES); no electrical stimulation, ageing (AGED); electrical stimulation and ageing (ESAGED). The tenderness of the longissimus thoracis et lumborum muscle was measured using shear force and taste panel tenderness scores. Both ES and AGED treatments had significantly ($P < 0.05$) lower shear force measurements and taste panel scores than the NIL treatment. While shear force was significantly ($P < 0.05$) higher for the AGED than for the ES treatment, there was no difference between treatments in taste panel score. The meat from the ESAGED treatment was significantly ($P < 0.05$) more tender by both measurements than that from either ES or AGED treatments.

Keywords: beef, tenderness, electrical stimulation, ageing.

INTRODUCTION

Meat tenderness is important to beef consumers. Two of the most important factors which effect tenderness are cold toughening and ageing.

Electrical stimulation has been introduced into many abattoirs in Australia in recent years in order to prevent cold toughening. Cold toughening results when muscle tissue is chilled too rapidly after slaughter and is associated with a shortening of the muscle fibres. While many studies have demonstrated significant improvements in tenderness as a result of electrical stimulation, (Davey *et al.* 1976; Bouton *et al.* 1978) others have shown little or no response (Davey *et al.* 1976; McIntyre and Ryan 1984). The extent of the response is related to the rate at which carcasses chill after slaughter. The rate of chilling can vary with chiller conditions such as temperature and air flow patterns and with carcass characteristics such as size and fat thickness.

Ageing can also have an important influence on the tenderness of beef. Meat stored above freezing point increases in tenderness with time, a process thought to be associated the activity of proteolytic enzymes which degrade the structure of the filaments making up the muscle fibre. Ageing of beef is widely practised through the use of vacuum packaging. The benefits of ageing have been widely demonstrated. In carcasses that had been cold toughened, ageing the meat for periods of 3–4 weeks at 0–1°C was shown to improve the tenderness to the extent that shear force was comparable to that of meat prevented from cold toughening using Tenderstretch (Bouton *et al.* 1973) or electrical stimulation (Taylor and Cornell 1985; Powell 1991). However, Davey *et al.* (1967, 1976) and Herring *et al.* (1967) found that muscles which had been subjected to severe cold toughening did not respond fully to ageing. Because of the variety of chilling conditions and size and fatness of carcasses being processed, there is undoubtedly a wide range in the degree of cold toughening taking place in Australian abattoirs.

The aim of this project was to determine the effects of electrical stimulation and ageing on tenderness in relatively light and lean carcasses subjected to chiller conditions favouring cold toughening.

MATERIALS AND METHODS

Animals

Thirteen Brahman x Shorthorn steers, approximately 18 months old at slaughter, were used in this investigation. They had been born in early summer in the Kimberley region of Western Australia and transported, after weaning at 6 months of age, to the south-west of W.A. They spent the next 8 months during winter, spring and early summer grazing improved clover/grass pastures. They were then fed *ad libitum* on a high concentrate diet (approximately 55% hay : 45% grain) for the last 3 months before slaughter.

Post-slaughter treatments

Animals were yarded, weighed and trucked (about a 2 h journey) to the abattoir, where they remained in the lairage overnight without access to feed or water. Following slaughter, the carcasses were placed in a chiller with controlled temperature of 1°C. The carcasses occupied the total holding capacity for beef in the chiller which, under similar conditions in previous experiments, invariably

induced a large degree of cold toughening in the meat. Within 35 min of slaughter, one side of each carcass was electrically stimulated (800 volts RMS; 14.3 pulses per second) for 2 min while the other side remained unstimulated. Fat thickness was measured on the hot carcass over the rump at the P8 site. The next day the carcasses were quartered between the 10th and 11 th ribs and weighed and the longissimus thoracis et lumborum muscle was removed from the loin joint from both sides of each carcass. These samples were cut into 2 sections and vacuum packaged. One of the sections was randomly allocated to an ageing treatment and was stored at 1°C for a further 22 days before being frozen at -18°C to await tenderness testing. The other section was frozen on the day of sampling and stored at -18°C.

The 4 treatments were: no electrical stimulation or ageing (NIL); electrical stimulation, no ageing (ES); no electrical stimulation, ageing (AGED); electrical stimulation and ageing (ESAGED).

Meat quality evaluations

While still frozen each section of meat was further divided into 2 using a band saw. One part remained intact for determination of shear force while the other was cut into steaks 17 mm thick for taste panel evaluation and measurement of muscle pH.

Meat for shear force measurement was removed from the freezer and left overnight to thaw at room temperature. External fat and connective tissue were removed and the sample trimmed to weigh between 350 and 400 g. This sample was placed in a plastic bag and cooked in a water bath at 80°C for 90 min and cooled in running tap water. Shear force was measured on an Instron Universal Food Testing Machine according to the methods described by Bouton *et al.* (1973).

Steaks for taste panel evaluation were thawed at room temperature and cooked between the heated plates of a Sunbeam combination grill for 4 min at the maximum temperature setting (medium-well done). The steaks were trimmed of external fat and cut into samples of approximately 2.0 by 2.0 cm and offered, while still warm, to a 12 member taste panel with previous experience at tenderness evaluations. Panelists scored tenderness on a 6-point scale from 1, very tough to 6, very tender. Two taste panels were conducted each day and each 1 consisted of the 4 treatments from the 1 animal.

Muscle pH was measured on 1 of the steaks, after thawing to room temperature, using a portable meter equipped with a meat probe.

Statistical analyses

The data were subjected to analysis of variance to compare the effects of electrical stimulation by ageing. A term removing the between animal variation was also included and the effects were tested against the within animal variation. Because of unequal variation for the various treatments, the analysis was performed on logarithmic transformations of the shear force and taste panel data. For the purpose of presentation, the antilog of these means are also presented in the results. Least squares means were tested for significant differences.

RESULTS

The live animal and carcass characteristics of the animals are shown in Table 1. On the day prior to slaughter, the animals had a mean liveweight of 352 kg, a carcass weight between 180 and 200 kg and a fat thickness between 4 and 10 mm with an average of 5.8. The muscle pH of all animals lay within the range of 5.4 to 5.6 and there was no evidence of any dark-cutting carcasses. Of the 13 animals in the experiment, 4 had 2 permanent incisor teeth and the remainder still had only their milk teeth.

Table 1. Liveweight, carcass weight and meat characteristics of the experimental animals

Meat colour scored using a range from 1, very light pink to 6, very dark

	Mean	Range	s.d.
Full liveweight (kg)	352	327-369	14.7
Carcass weight (kg)	190	180-203	7.1
P8 fat thickness (mm)	5.8	4-10	1.9
Muscle pH	5.50	5.45-5.58	0.03
Meat colour score	3.15	3-4	0.38

The effects of treatments on shear force and taste panel tenderness are shown in Table 2. Both electrical stimulation and ageing significantly ($P < 0.05$) improved shear force and taste panel tenderness assessments. In both cases there was also a significant ($P < 0.05$) stimulation x aging interaction.

Table 2. Mean shear force and taste panel tenderness scores of the longissimus thoracis et lumborum muscle from NIL, AGED, ES and ESAGED treatments

Taste panel scores range from 1, very tough to 6, very tender

Means with different letters differ significantly ($P < 0.05$)

	NIL	Post slaughter treatment		ESAGED
		AGED	ES	
Log shear force (kg)	1.02a	0.80b	0.68c	0.63d
Shear force (kg)	10.5	6.3	4.8	4.3
Log taste panel score	0.29a	0.60b	0.60b	0.70c
Taste panel score	1.9	4.0	4.0	5.1

For shear force measurements, all treatments differed significantly ($P < 0.05$) from one another. The NIL treatment had the highest shear force value and the ESAGED the lowest. In both stimulated and unstimulated meat, ageing resulted in a significant ($P < 0.05$) reduction in shear force, but the improvement was much greater in the unstimulated meat. The AGED treatment had a significantly ($P < 0.05$) higher shear force than the ES treatment.

The results of taste panel assessments also showed that the NIL treatment had the toughest meat and the ESAGED treatment the most tender. In both stimulated and unstimulated meat the taste panel scores were significantly ($P < 0.05$) improved by ageing with the greatest improvement being for the unstimulated meat. In this assessment there was no significant ($P > 0.05$) difference between the AGED and the ES treatments.

DISCUSSION

The results of the taste panel assessments showed no difference in the tenderness of meat between the ES and AGED treatments (Table 2). The animals included were chosen at the middle of the carcass weight range and at the lower end of the fat thickness range (Table 1) acceptable to the domestic market in Western Australia, and would have been relatively susceptible to the effects of cold toughening; also, from previous experience, the chiller conditions were known to produce a high degree of cold toughening. Despite these combined effects, the ageing treatment produced meat with taste panel tenderness score comparable to that of the electrical stimulation treatment. By contrast, shear force tests indicated that the ES treatment was more tender than the AGED treatment (Table 2). From the shear force values I would have expected the meat from the AGED treatment to be rated as relatively tough by the taste panelists. However sensory evaluations must provide the ultimate test of tenderness.

The results were in general agreement with those of Taylor and Cornell (1985) and Powell (1991). These workers both used similar stimulation and ageing treatments to those in this experiment. Taylor and Cornell (1985) found that while ageing provided a small advantage over stimulation in taste panel assessments, there was no difference in the shear force values. Powell (1991) found no significant differences in either taste panel or shear force between stimulated and aged treatments. In all 3 of these studies the meat had been subjected to a long period of ageing (between 21 and 28 days at 1°C). This raises the question as to whether acceptable tenderness can be produced with a shorter ageing period. Both Save11 *et al.* (1981) and Wheeler *et al.* (1990) showed that as ageing time increased the advantage of electrical stimulation over ageing was progressively reduced. However, the point at which acceptable tenderness is reached is probably not clearly definable, as it will depend on the initial degree of cold toughening. In these circumstances and in the absence of electrical stimulation, a period of no less than 3 weeks at 1°C may be necessary to provide a guarantee of tenderness.

In this experiment there was a large and **significant response** to electrical stimulation (NIL v. ES treatments, Table 2). Meat from the NIL treatment had very high shear force values and was rated as tough to very tough by the taste panel. Similar differences were reported between corresponding treatments by both Taylor and Cornell (1985) and Powell (1991).

There was an added benefit in to be gained from combining both electrical stimulation and ageing treatments. Meat from the ESAGED treatment was significantly more tender by both shear force and taste panel assessments than either ES or AGED treatments (Table 2). In studies by both Taylor and Cornell (1985) and Powell (1991) the same effect was shown although differences were not always significant.

It is likely that the incidence of cold toughening will be greater in future with increasingly stringent hygiene requirements and other benefits of faster chilling rates, such as extended shelf life, thus increasing the importance of measures to maintain acceptable tenderness standards. The results of this study indicate that where cold toughening is likely, tenderness is maximised by a combination of both electrical stimulation and ageing. Where ageing is limited, electrical stimulation is necessary to provide an acceptable product. If neither electrical stimulation nor a reasonable ageing period is given the meat may well be tough.

REFERENCES

- BOUTON, P. E., FISHER, ANNE L., HARRIS, P. V. and BAXTER, R. I. (1973). *J. Food Technol.* 8: 39-49.
- BOUTON, P. E., FORD, A. L., HARRIS, P. V. and SHAW, F. D. (1978). *J. Food Sci.* 43: 1392-6.
- DAVEY, C. L., GILBERT, K. V. and CARSE, W. A. (1976). *NZ J. Agric. Res.* 19: 13-8.
- DAVEY, C. L., KUTTEL, H. and GILBERT, K. V. (1967). *J. Food Technol.* 2: 53-6.
- HERRING, H. K., CASSENS, R. G., SUESS, G. G., BRUNGARDT, V. H. and BRISKEY, E. J. (1967). *J. Food Sci.* 32: 317-23.
- McINTYRE, B. L. and RYAN, W. J. (1984). *Proc. Aust. Soc. Anim. Prod.* 15: 468-71.
- POWELL, V. H. (1991). *Meat Sci.* 30: 195-205.
- SAVELL, J. W., MCKEITH, F. K. and SMITH, G. C. (1981). *J. Food Sci.* 46: 1777-8 1.
- TAYLOR, D. G. and CORNELL, J. G. (1985). *Meat Sci.* 12: 243-5 1.
- WHEELER, T. L., SABELL, J. W., CROSS, H. R., LUNT, D. K. and SMITH, S. B. (1990). *J. Anim. Sci.* 69: 3677-86.