
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Pre- and post-rigor treatment of intermediate-pH beef to reduce toughness

B.C. THOMSON, M.M. AULD, AND N.J. SIMMONS

Meat Science, Food Systems and Technology Platform, AgResearch, Ruakura, Private Bag 3123, Hamilton, New Zealand.

ABSTRACT

As injections of acid and calcium chloride solution reduce toughness in beef of normal pH (5.4 - 5.7) beef, these solutions may also tenderise intermediate pH (5.7 - 6.2) beef. Portions of intermediate-pH striploins from four bulls were allocated to the following treatments :– control, lactic acid (0.55 M, 10 % w/w, injected within two hours of slaughter) or calcium chloride (0.3 M, 10 % w/w, injected 20 hours after slaughter). The samples were stored at 15 °C for 24 hours, then at – 1 °C for a further nine days. 24 hours after slaughter the shear force of the lactic- acid-treated samples was non-significantly less than the control (12.7 vs 15.4 kgF). Nine days after slaughter, the lactic acid and control samples remained unacceptably tough, while the calcium chloride samples (7.5 kgF) were acceptable. Therefore, it may be possible to use calcium chloride to reduce intermediate pH toughness.

Keywords: pH; tenderness; lactic acid; calcium chloride; meat.

INTRODUCTION

Carcasses with intermediate ultimate-pH values (5.7 - 6.2) are downgraded due to potential toughness problems (Clarke, 1988). Past work has shown 30-40% of meat within the intermediate-pH category does not age to an acceptable tenderness level (Purchas and Yan, 1997). A number of treatments including lactic acid or calcium infusions, have been successfully used to reduce toughness in normal pH meat (Berge *et al*., 1998; Koohmaraie *et al*., 1989). The aim of this work was to determine whether lactic acid or calcium chloride could reduce toughness in intermediate-pH striploins.

MATERIALS AND METHODS

Four prime bulls were slaughtered using commercial procedures without post-stun electrical stimulation. Intermediate-pH (5.7 - 6.2) carcasses were selected. Within 30 minutes of slaughter, the *longissimus dorsi* muscles (striploin) were removed from both sides of each carcass. The striploins were transversely divided into three portions and allocated to a treatment in accordance with a Latin square design. The treatments were control, lactic acid (0.55 M, 10 % w/w, injected within two hours of slaughter), and calcium chloride (0.3 M, 10 % w/w, injected 20 hours post-slaughter). Injection amounts of 8.3 and 8.8 % (weight injected/weight of meat) were retained for the lactic acid and calcium chloride treatments, respectively.

The samples were injected using a syringe and an 18-gauge needle at three depths and with 1 cm between each injection point. The change in pH over time was determined in the control and acid-treated samples using a spear electrode at three different points. Samples were stored for the first 24 hours after slaughter at 15 °C and then at – 1 °C for nine days. After each storage period, the sub-samples (approx. 200 g) were cooked in a boiling water bath (100 °C) to an internal temperature of 75 °C. After cooling on ice overnight, the tenderness was determined using a MIRINZ tenderometer on ten 1 x 1 cm slices with the fibre running longitudinally along the slice (Frazerhurst and MacFarlane, 1983).

Statistical analysis was conducted using the GLM procedures in SAS for Windows (Version 6.12, SAS Institute Ltd, Cary, NC, USA).

RESULTS

The first pH value of the samples injected with lactic acid indicated that the pH had dropped from 6.4 to 5.05. It then increased to 5.5 over the next 3 hours. The ultimate pH was lower in the acid-treated samples than in the control (Figure 1). The ultimate pH of the control and calcium-treated samples were above the 5.7 required for intermediate-pH meat (Table 1).

TABLE 1. The effect of lactic acid and calcium chloride injection on pH and shear force (kgF) 24 hours and 9 days post-slaughter in striploins from bulls (n=4 per treatment).

	Treatment				
	Control	Lactic acid	Calcium	SEM	P
pH 24 hours	6.05[a]	5.35[a]	5.89[ab]	0.29	0.02
Shearforce 24 hours	15.4	12.7	14.7	4.10	0.64
Shearforce 9 days	12.8[a]	10.4[ab]	7.5[b]	2.12	0.02

[ab] values without a common subscript letter with different letters are significantly different at the 5% level

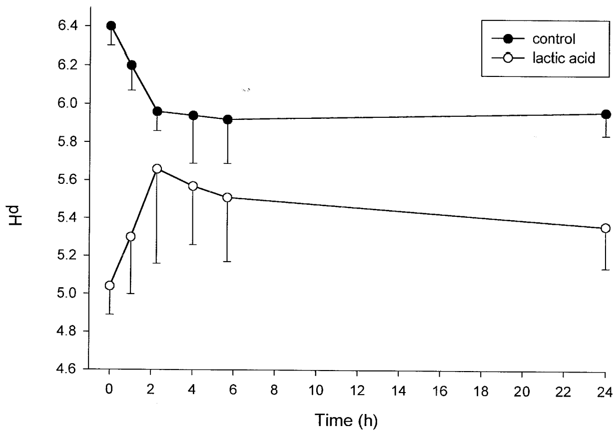
The shear force values of the control samples demonstrated the characteristic intermediate-pH toughness and remained unacceptably tough (kgF > 11) after 9 days of aging. The shear force of the lactic-acid-treated samples tended to be less than the control samples 24 hours post-slaughter (12.7 vs 15.4 kgF) although the difference was not significant. Nine days post-slaughter, the lactic acid samples did not differ significantly from the control samples.

In contrast, after nine days of aging, following calcium chloride injection, shear force values were significantly less than those of the control samples (Table 1).

DISCUSSION

Lactate accumulates in muscle during the *post-mortem* period from the degradation of glucose by glycolysis, this is accompanied by a pH decline, typically to around 5.5 if

FIGURE 1. The effect of lactic acid treatment on meat pH over the 24 hours post-treatment (mean ± SEM, n= 4 samples per treatment) with the treatment being applied 2 hours post-slaughter.



sufficient glycogen is present in the muscle at slaughter. Lactic acid and acetic acid marinades and infusions has been used to decrease background (connective tissue) toughness and microbial contamination in normal pH beef (Eilers *et al.*, 1994, Ertbjerg *et al.*, 1995). In the present experiment, the elevated pH of intermediate-pH meat was corrected using lactic acid infusion. This treatment initially reduced the pH to 5.05 but the ultimate pH of the samples rose to 5.35, presumably as the infused lactic acid diffused into, and was buffered, in the intracellular space. This ultimate pH is only slightly lower than that observed in normal-pH beef.

The reduction in ultimate pH by lactic-acid treatment did not significantly affect tenderness compared with the control, intermediate-pH samples. One possible explanation for toughness is the effect of pH on the activity of the two proteolytic systems potentially involved in tenderisation, the calpains and the cathepsins, since both of these proteolytic systems are pH-dependent. A lower pH should result in earlier activation of the cathepsin system, resulting in an increased initial tenderisation rate. This was not found in the present experiment. However, Berge *et al.* (1998) found a decrease in the toughness (m-force) 2 days post-slaughter in the *pectoralis profundus* muscle when an ultimate pH of 5 was achieved. But they also found that by 14 days post-slaughter, the lactic-acid-treated samples had not tenderised any further, while the controls had, thereby eliminating treatment differences. Berge *et al.* (1998) found an increase in the cathepsin B+L activity in the soluble fraction and a decrease in the activity in the membrane fraction when meat with a pH between 5.4 and 5.7 was used. The reason for the lack of effect in the current experiment needs to be investigated further. In intermediate-pH bull beef, Thomson *et al.* (1999) found a decrease in the activity of m-calpain in intermediate-pH bull beef compared to bull beef with an ultimate pH below 5.7. It is possible that in intermediate-pH beef reducing the pH with lactic acid would reduce the activity of m-calpain further and this could have counteracted any increased cathepsin activity due to the reduced pH.

There was no effect of the calcium chloride infusion on tenderness when it was applied shortly before cooking but 9 days post-infusion the calcium chloride-treated samples were more tender than the controls. This suggests that the effect of the calcium chloride injection required time for the effect to be observed. This result is in agreement with the results from normal pH beef samples (Diles *et al.*, 1994; Koohmaraie *et al.*, 1989; 1990; Wheeler *et al.*, 1991). Increasing the calcium concentration is believed to increase the activity of the calpain enzymes, which are calcium-dependent, and thereby increase the rate of tenderisation.

CONCLUSION

It appears that the treatment of intermediate-pH meat samples with calcium chloride may reduce the toughness of beef following a period of aging. A method using calcium chloride has been developed for commercial use in normal pH meat in the USA and from these results it would appear to be worth further investigation for use in NZ for intermediate-pH meat. Reducing the ultimate pH to < 5.5 with lactic acid, did not have a significant effect on toughness suggesting that it was not pH alone which caused the unacceptably high degree of toughness in these intermediate-pH samples.

ACKNOWLEDGMENTS

The funding for this work was supplied by Meat NZ .

REFERENCES

Berge, P.; Ertbjerg, P.; Melchior-Larsen, L.; Astruc, T.; Miller, A.J. 1998. Tenderisation of beef by lactic acid treatment applied at different times postmortem. *44th International Congress of Meat Science and Technology, Barcelona:* 710-711.

Clarke, R. 1988. Meat board promotion aims to boost meat sales. *New Zealand Farmer* **120**: 7.

Diles, J.J.B.; Miller, M.F.; Owen, B.L. 1994. Calcium chloride concentration, injection time and aging period effects on tenderness, sensory and retail colour attributes of loin steaks from mature cows. *Journal of Animal Science* **72**: 2017-2021.

Eilers, J.D.; Morgan, J.B.; Martin, A.M.; Miller, R.K.; Hale, D.S.; Acuff, G.R.; Savell, J.W. 1994. Evaluation of calcium chloride and lactic acid injection on chemical, microbiological and descriptive attributes of mature cow beef. *Meat Science* **38**: 443-451.

Ertbjerg, P.; Larsen, L.M.,; oller, A.J. 1995. Lactic acid treatment for upgrading low quality beef. *41st International Congress of Meat Science and Technology, San Antonio*: 670-671.

Frazerhurst, L.F.; MacFarlane, P. 1983. NZ Patent No. 19094.

Koohmaraie, M.; Crouse, J.D.; Mersmann, H.J. 1989. Acceleration of postmortem tenderisation in ovine carcasses through transfusion of calcium chloride: Effect of concentration and ionic strength. *Journal of Animal Science* 67*:* 934-942.

Koohmaraie, M.; Whipple, G and Crouse, J.D. 1990. Acceleration of postmortem tenderisation in lamb and Brahman-cross beef carcasses through infusion of calcium chloride. *Journal of Animal Science* **68**: 1278-1283.

Purchas, R.W.; Yan, X. 1997. Investigations into why intermediate pH meat is often less tender. *43rd International Congress of Meat Science and Technology*, Auckland, New Zealand: 596-597.

Thomson, B.C.; Dobbie, P.M.; Cox, N.R.; Simmons, N.J. 1999. Differences in the post-mortem kinetics of the calpain system in meat from bulls and steers. *New Zealand Journal of Agricultural Research* **42***:* 47-54.

Wheeler, T.L.; Koohmaraie, M. and Crouse, J.D. 1991. Effects of calcium chloride injection and hot boning on the tenderness of round muscle. *Journal of Animal Science* **69**: 4871-4875.