Postmortem changes in pH and shear force in three commercial bull beef cuts

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ABSTRACT

This experiment investigated the differences between fillet, strip loin and rump cuts obtained from carcasses of pasture-fed bulls. Four samples of each cut were collected on two different occasions and aged at 15°C for 2, 24, 48 ,72 and 120 hours. The pH of the fillet and rump cuts did not change post-slaughter. The pH of the strip loin was higher at slaughter but declined over time and by 48 hrs post-slaughter there were no differences in the pH value of the three cuts. Shear force was determined using a MIRINZ tenderometer. The fillet had the lowest shear force and the rump cut had the highest. There were no differences in the activities of the components of the calpain system at 2 hours post-slaughter. These results suggest that the differences in meat quality and particularly ultimate tenderness, between the three cuts were not due to differences in the activities of the components of the calpain system or pH

Keywords: pH; tenderness; fillet; strip loin; rump; bovine.

INTRODUCTION

In a number of New Zealand abattoirs, carcasses from young pasture fed bulls are hot boned . A number of table cuts are kept but the rest of the carcass is converted into manufacturing meat. The different table cuts vary with respect to meat quality particularly colour and tenderness. Tenderness is a very important attribute of meat quality (Lawrie, 1991). Jeremiah *et al.* (1992) reported that when cuts from the same animal were prepared in the same way consumer panels consistently listed tenderness as the most important attribute contributing to their enjoyment of the meat.

The calcium dependent protease (calpain, E.C. 3.4.22.17) system, particularly the activity of calpastatin has been implicated in the post slaughter tenderisation process (Koohmaraie, 1992). Koohmaraie *et al.* (1988) found higher activities of calpastatin and µ-calpain in *longissimus dorsi* than in the *psoas major*. Therefore differences in the activities of the components of the calpain system may contribute to differences in tenderness between the various cuts. In bull beef high pH values can affect the degree of tenderisation that occurs during the aging process and therefore any differences in pH between the cuts may also affect the quality of the final meat product.

This experiment aimed to compare the post slaughter changes occurring in three commercially available table cuts of varying quality from pasture-fed young Friesian bulls to determine whether pH and/or the activity of the components of the calpain system may be responsible for the differences in meat tenderness as determined using shear force.

MATERIALS AND METHODS

On two different occasions four fillets (*psoas major*), four strip loins (*longissimus dorsi*) and four rumps (*glutaeus medius*) were obtained from young pasture fed Friesian from a commercial abattoir. Samples (approx 200 g) of each cut were aged in a waterbath at 15°C for 2, 24, 48, 72 and 120 hours post slaughter. The activities of the components of the calpain system were determined 2 hours post slaughter, while shear force was determined 24, 48, 72 and 120 hours post slaughter. pH was determined after each aging period by inserting a $Ag/AgCl_2$ (Toledo, Mettler) electrode into the center of each piece of meat.

Calpastatin, µ-calpain and m-calpain activities were separated on a DEAE Sephacel column using a NaCl stepwise gradient using the method of Sainz *et al.* (1992) as modified by Dobbie *et al.*, (1995). After separation the activities of the different components were determined using an assay with casein as the substrate as described by Wheeler and Koohmaraie (1991). Shear force was determined by cooking approximately 150 g of muscle in a 100°C waterbath until the internal temperature of the sample reached 75°C. The cooked samples were cooled on ice until their internal temperature reached 4°C (Graafhuis *et al.*, 1991). The force required to shear across the grain of a strip having a 10 mm by 10 mm cross-sectional area was determined using a MIRINZ pneumatic tenderometer (Frazerhurst and MacFarlane, 1983).

The data was analysed using a generalised linear model in Minitab (Minitab for Windows, Version 10.1, Pennsylvania).

RESULTS

As expected shear forces at slaughter differed between muscles. The shear force was higher in the rump than the fillet throughout the aging period ($P < 0.05$). The shear force of the strip loins was intermediate between the rump and the fillet 24 hours post slaughter, but the difference between the strip loin and the fillet disappeared within 48 hours of slaughter (Table 1). Two hours post slaughter pH values in the strip loins were higher than those in the rump and fillet cuts ($P < 0.003$) and the pH of the strip loins

was still slightly higher 24 hours post slaughter ($P < 0.10$, Table 1). There were no differences in the activities of calpastatin, μ-calpain or m-calpain two hours post slaughter ($P > 0.05$, Table 1).

TABLE 1: Postmortem changes in pH, shear force (kg) and the activity of the components of the calpain system (U/g fresh muscle) in strip loins, fillets and rump cuts from pasture-fed Freisian bulls (mean, SE; n=8 samples per cut).

Time (hours)	Fillet	Strip loin	Rump	SE	P
pH					
2	5.54	6.01	5.76	0.075	0.003
24	5.56	5.81	5.59	0.050	0.09
48	5.56	5.71	5.6	0.052	0.40
72	5.67	5.77	5.81	0.042	0.40
120	5.65	5.81	5.68	0.049	0.38
Shear force					
24	8.6	11.5	15.1	0.97	0.03
48	8.1	7.9	13.3	0.84	0.01
72	5.7	7.9	11.6	0.89	0.01
120	6.8	7.7	9.5	0.47	0.09
Calpastatin	2.3	2.02	2.30	0.068	NS
μ-calpain	0.37	0.43	0.51	0.048	NS
m-calpain	0.39	0.55	0.50	0.115	NS

DISCUSSION

Tenderness makes an extremely important contribution to the overall enjoyment of meat by consumers (Lawrie, 1991) and varies between the different cuts (Olson *et al.*, 1976). In this experiment the fillet required less force to cut it and was therefore more tender than the rump cut both before and after aging. The fillet has a reputation for being dependably tender. This is why it is generally used for grilling or braising and this is reflected in its price. The rump cuts tend to be tougher requiring longer cooking and therefore rump cuts are cheaper than the fillet. The shear force of the aged rump cut was high enough to be marginal for consumer acceptance. Twenty four hours post slaughter the strip loin had a shear force intermediate between the fillet and the rump cut, however it aged more than these two cuts so that by 48 hours the shear force of the strip loin was in the acceptable range and the same as the fillet. The low shear force in the fillet at 24 hours meant that even though it aged slowly the shear force of the fillets were always in the tender range (below 10). Therefore, the ultimate level of tenderness is similar between the strip loin and fillet cuts although the rates of tenderisation differed. Olson *et al.* (1976) and Koohmaraie *et al.* (1988) found that the level of tenderness in the *longissimus dorsi* improved over the aging period but the *psoas major* did not. However, the final levels of tenderness were similar between both muscles. In this experiment, both the rump and fillet cuts aged slowly, but the rump cut was still tough at the end of the aging period. This technique of determining shear force can only be used post rigour and it is possible that the fillet ages rapidly immediately post slaughter and this would not be detected using this technique.

Two hours post slaughter the strip loins had significantly higher pH values than the rump and fillet cuts. However, the pH value in the strip loin declined with time post slaughter while the pH in the fillet and rump cuts remained stable. In the strip loin it took 24 hours to reach the ultimate pH. Similar results were observed by Koohmaraie *et al.* (1988) when they compared *psoas major* and *longissimus dorsi* samples. In Koohmaraie *et al.* (1988)'s study the ultimate pH value was reached within 3 hours in the *psoas major* as compared to around 12 hours post slaughter in the *longissimus dorsi*. They did not determine changes in pH in the *glutaeus medius*. However, all samples achieved an acceptable ultimate pH value of less than 5.7 24 hours post slaughter and were not significantly different from each other. Therefore, neither the pH value 2 hours post slaughter or the ultimate pH value could account for the differences between cuts in shear force at the end of the aging period. However, the higher pH 2 hours post slaughter followed by the decline in pH over the first 24 hours post slaughter in the strip loin as compared to the rump and fillet cuts may have had a carryover effect on the change in tenderisation from 24 to 120 hours post slaughter.

The activity of the components of the calpain system particularly the activity of calpastatin, have been implicated previously in myofibrillar protein degradation (Goll *et al.*, 1992) and tenderness (Koohmaraie, 1992). Koohmaraie *et al.* (1988) found that in the *longissimus dorsi* the activity of the calpain system was higher than in the *psoas major* with approximately half the level of m-calpain activity in the *psoas major*. In contrast, in this experiment there were no differences in the *in vitro* activities of the components of the calpain system between the three cuts post slaughter two hours post slaughter. Therefore, in this experiment the activities of the components of the calpain system measured two hours post slaughter did not reflect the differences between the cuts in shear force measured 24 or 120 hours post slaughter. The calpain enzyme activitities were lower in this study than in a previous study in our laboratory (Thomson *et al.*, 1996). This could have been related to age or seasonal effects. The ultimate pHs and shear forces in this present study were also higher than the previous study supporting the lower calpain activity. *In vitro* when the activities of the components of the calpain system are measured under optimal conditions at pH 7.5, in the presence of excess substrate and calcium; reducing the pH reduces the activity of the calpains. The optimal pH for calpain activity *in vitro* appears to be around 7.5. The lower pH in the fillet and rump 2 hours post slaughter may reduce the activity of μ-calpain and the ability of calpastatin to inhibit μ-calpain activity in the meat. This reduction in the activity of the components of the calpain system could reduce the amount of proteolysis occurring post slaughter and therefore reduce the amount of tenderisation occurring by this pathway.

The differences in shear force determined in this experiment between the three cuts were typical of those observed in previous studies (Olson *et al.* 1976 and Koohmaraie *et al.* 1988). In contrast to the work of Koohamaraie *et al.* (1988) the activities of the components of the calpain system did not vary between the three muscles. The pH values and the activities of the components of the calpain system did not explain the differences in shear force between the three cuts

after aging for 120 hours. However, the change in pH over the first 24 hours post slaughter may influence the rate of tenderisation occurring through its effects on the actual activities of the components of the calpain system within the muscle tissue.

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