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

Relationship between intermediate pH toughness in the striploin and other muscles of the beef carcass

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ABSTRACT

Striploin (*m. longissimus dorsi et lumborum*) with ultimate pH values of 5.8 – 6.2 can be tough, and this toughness may persist despite prolonged ageing (> 45 days) although little is known about the effect of intermediate pH on other muscles. The aim of this work was to examine the relationship of intermediate-pH toughness in the striploin with other muscles. The shear force values were measured in seven muscles, collected from 20 heifers and aged at –1°C for 2, 7, 14, 30 or 60 days. The shear force of intermediate pH striploins after 2 days correlated with all other muscles except the chuck tender (*m. supraspinatus*) (P<0.001). However, the significance of these correlations was reduced with ageing and, by 14 days, only the shear force of the cuberoll (*m. longissimus thoracis*) correlated with the striploin (P<0.001). These results suggest that all muscles apart from the striploins and cuberolls from intermediate-pH carcasses will tenderise to acceptable levels after 14 days of chilled storage.

Keywords: pH; tenderness; beef.

INTRODUCTION

A relationship has been shown to exist between ultimate pH and tenderness in the *m. longissimus dorsi et lumborum* (LD) of both beef (Purchas and Aungsupakorn, 1993) and lamb (Watanabe *et al.*, 1995), such that the toughness increases as the pH rises to between 5.8 and 6.0 then declines again as the pH rises above 6.0.

In lamb, intermediate-pH toughness will reduce during ageing (Watanabe *et al.*, 1995), but beef can show persistent toughness even after prolonged ageing (Simmons and Cairney, 1997). For this reason, specifications for quality meats, including the Meat Board Quality Mark for the New Zealand domestic market, exclude beef carcasses with an ultimate pH > 5.8, as measured in the LD. Downgrading a whole carcass represents significant loss to both wholesalers and retailers, and raises the question of whether the effects of intermediate-pH in the LD is representative of other muscles in the carcass. Therefore, this paper evaluates the relationship between intermediate-pH toughness in the striploin and other muscles of the carcass.

MATERIALS AND METHODS

Twenty intermediate-pH carcasses were selected from a prime heifer kill, at 24 hours post-mortem, on the basis of a pH probe measurement from the striploin. The carcasses were boned out on a commercial boning line and seven standard cuts were collected from each carcass: striploin (*m. longissimus dorsi et lumborum*), cuberoll (*m. longissimus dorsi et thoracus*), 'D' cut rump (*m. gluteus medius* and *m. gracillus*), inside (*m. semi membranosus*), flat (*m. biceps femoris*), eye of the round (*m. semi tendinosus*) and the chuck tender (*m. supraspinatus*). These cuts were selected on the basis of both the value and their proportion of the total carcass. The pH was measured in each muscle, the cuts were divided into five equal portions and aged at –1°C for 2, 7, 14, 30 or 60 days. After ageing, samples were cooked in a boiling waterbath to a 75°C-endpoint temperature. After chilling, ten 1 cm x 1 cm slices were prepared with the muscle fibres running longitudinally along the slice. The shear force (kgf) of each sample was measured using a MIRINZ tenderometer.

The statistical relationship between the data was analysed using a Pearson Product Moment correlation coefficient (r). Differences in shear force between muscles were analysed using an analysis of variance (ANOVA).

RESULTS

The average pH of the striploins was 5.88 and was significantly correlated with the pH in the cuberoll (5.85, r = 0.65, P<0.001), Fflat (5.87, r = 0.46, P<0.05), eye of the round (5.91, r = 0.58, P<0.01) and chuck tender (5.84, r = 0.51, P<0.05). The pH of the rumps and the insides were lower than that of the striploins (5.70 and 5.73) and did not correlate with that of the striploins.

In all muscles, the shear forces declined during storage (P<0.001) (Table 1). The shear forces of the striploins and cuberolls were significantly tougher initially and aged more slowly that the other muscles. At 2 and 7 days, the shear forces of the striploins and cuberolls were significantly higher than the other muscles, while by 14 days, the shear forces of the striploins were still significantly higher that chuck tender and eye of the round (P<0.01). At later time points, the shear forces of all the muscles were equivalent.

Within each carcass, the shear force of the striploin after 2 days of chilled storage correlated with all other muscles except that of the chuck tender. The correlations became weaker with increasing ageing time so that, by 14 days of storage, a significant correlation was found only between the striploin and the cuberoll (Table 2). A correlation appeared between the striploin and both the inside and the chuck tender at 30 days of storage, but this only just reached significance (P<0.05) and the commercial implications are likely to be marginal.

The percentage of intermediate-pH samples that had a shear force >8 kgf at each timepoint is shown in Table 3. The striploins and, to a lesser extend, the cuberolls had the greater number of unacceptable samples through to 30 days of storage, but reached levels comparable to other muscles by 60 days of storage.

TABLE 1: Changes in shear force (kgf) during storage from seven commercial cuts from prime heifer carcasses with intermediate pH.

Cut	Storage time (days post-mortem) 2	7	14	30	60
Striploin	14.3[a]	11.2[a]	9.4[a]	8.0	5.7
Cuberoll	11.1[b]	8.6[c]	8.1[b]	7.7	4.6
Rump	9.8[bc]	8.6[c]	8.2[b]	7.9	6.6
Inside	9.4[bc]	8.1[c]	7.3[b]	6.9	5.6
Flat	8.5[c]	7.5[c]	7.4[b]	7.1	5.6
Eye of round	8.1[c]	7.5[c]	7.0[b]	7.0	5.8
Chuck tender	8.6[c]	7.2[bc]	6.6[b]	6.6	5.2
SEM	0.3	0.2	0.2	0.2	0.2
Significance	***	***	***	ns	ns

Figures within columns containing different superscripts are significantly different
(*** P>0.001)

TABLE 2: Correlation coefficients between shearforces of the striploin and other cuts at different storage periods from prime heifer carcasses.

Cut	Storage time (days post-mortem) 2	7	14	30	60
Cuberoll	0.49*	0.56*	0.76***	0.41	0.26
Rump	0.66**	0.45*	0.39	0.14	0.26
Inside	0.65**	0.64**	0.29	0.51*	0.29
Flat	0.57*	0.57*	0.36	0.44	0.03
Eye of round	0.47*	0.57**	0.39	0.24	-0.23
Chuck tender	0.29	0.66**	0.15	0.51*	-0.13

* P<0.05, ** P<0.01, *** P<0.001

TABLE 3: Percent of cuts with shear force values > 8 kgf from prime heifers after different storage periods

Cut	Storage time (days post-mortem) 2	7	14	30	60
Striploin	89	50	60	37	2
Cuberoll	65	47	40	47	5
Rump	50	30	35	20	15
Inside	50	20	5	5	5
Flat	45	25	15	20	0
Eye of round	30	30	15	10	5
Chuck tender	37	15	10	11	0

DISCUSSION

These results demonstrate that, before ageing, a significant correlation exists between toughness in the LD and toughness in the other muscles examined in this experiment. However, with storage, the shear force of the LD becomes a poor predictor of shear for other muscles from the carcass.

Past work, together with the results of this study, have illustrated the complex nature of the intermediate-pH problem. Intermediate-pH meat can age normally and reach acceptable levels of tenderness suffers from no toughness problem (Silva *et al.*, 1999), or it can be tough initially with improving tenderness with storage, although the ageing rate of the intermediate-pH samples is slower than that of normal-pH beef (Purchas *et al.*, 1999). Furthermore, intermediate pH meat can be tough initially and remain in this state,unchanged despite prolonged chilled storage (Simmons and Cairney, 1997). While each of these three conditions were found within the intermediate pH sample population used in this study, most striploins reached an acceptable level of tenderness, but only after 30 days of ageing. This demonstrates that, generally, the rate of ageing is significantly slower in intermediate-pH striploins from beef, an effect also noted in intermediate-pH lamb (Watanabe *et al.*,1995). While the persistent toughness problem tends to predominate in the striploins and cuberolls, the greater proportion of insides and flats with high kgf values after 2, 7 and 14 days of ageing, demonstrates that intermediate pH toughens (or reduces the ability to age) in other muscles also, though not as severely.

The toughness of intermediate-pH meat has been attributed to the activity of the proteolytic enzymes under different pH conditions (Yu & Lee, 1986). However, it is not clear why the pH dependency of the proteolytic enzymes should produce such differing tenderness outcomes when the samples are all of similar, albeit at intermediate, pH. Alternatively, the contraction of muscle during the pre-rigor period appears to increase in proportion to the ultimate pH (Purchas and Aungsupakorn, 1993; Wahlgren *et al.*, 1997), and muscle shortening can induce toughness. Up to 20% shortening causes initial toughening but allows normal tenderness development after ageing, while severely shortened muscle (>40% shortening) remains irreversibly tough (Davey *et al.*, 1967). Perhaps slight differences in the extent of muscle shortening define the difference between meat that is permanently tough and meat that is initially tough but eventually tenderises during storage. It was noted that the ten 1 cm x 1cm shear force sub-samples from each sample were unusually variable, particularly from the striploin and cuberoll. This variability was evident in the sarcomere lengths measured from fibres of these muscles (data not shown).

As a further contributing factor, the conditions of stress that created the glycogen depletion in the first instance may have an influence on the tenderising process in ways not yet clear.

CONCLUSIONS

In this study, intermediate-pH striploins did reach an acceptable level of tenderness but only after 30 days of ageing. However, the shear forces remained variable and this persisted even after extreme periods of ageing, making any assurance of a consistent product difficult. Other muscles from intermediate-pH carcasses (identified by the presence of intermediate-pH in the striploin) are also tougher but become acceptable with adequate ageing periods. Therefore, the recommendation should be that other muscles from intermediate pH carcasses can be sold under a Q-Mark specification but they should undergo 14 days of chilled storage before retail.

ACKNOWLEDGEMENTS

This work was funded by Meat New Zealand

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