THE CONTRIBUTION OF MUSCLE pH DIFFERENCES TO THE RELATIVE TENDERNESS OF MEAT FROM BULLS AND STEERS

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SUMMARY

Relationships between shear force values of cooked beef longissimus muscle and ultimate meat pH values were investigated under conditions where cold-shortening was prevented by temperature control. The curvilinear relationships shown, with maximum shear values at a pH of approximately 6.0, were consistent with some previous studies, but not with others where cold-shortening may have influenced the outcome. Because the relationship between shear force and pH was not significantly different for beef from bulls and steers, it is possible that significant differences in the tenderness of beef from these two sources may arise if their mean pH values are different. An increase in pH over the range from about 5.5 to 6.2 was associated with a significant decrease in sarcomere length which may in part have accounted for the associated increase in shear force values.

INTRODUCTION

Although the differences are frequently not statistically significant, beef from bulls is very often somewhat tougher than that from comparable steers (Field 1971; Seideman et al. 1982). Small differences in the amount and structure of collagen (see for example Cross et al. 1984) may account for these differences to a limited extent, but Dransfield et al. (1984) concluded that the main cause must reside in the myofibrillar components of muscle. The fact that bull beef can be tougher in the absence of cold-shortening conditions (Dransfield et al. 1984) suggests that the thicker layer of insulating fat on steer carcasses is not entirely responsible, although it may play an important role in some situations.

A number of studies have reported that the likelihood of high ultimate pH values is greater for meat from bulls than steers (Martin et al. 1971; Wythes and Shorthose 1984; Jones et al. 1986), but the possibility that this may account for some of the reported differences in tenderness does not appear to have been widely discussed. The increase in toughness that sometimes accompanies an increase in pH from about 5.5 to 6.2 (Bouton et al. 1973; Dransfield 1981) may be particularly important in this respect, and the suggestion that such increases are more marked in the absence of cold-shortening conditions (Purchas et al. 1988) requires further investigation.

The objectives of the studies reported here were to investigate further the nature of the pH/tenderness relationship over the pH range from 5.5 to 6.2 when cold-shortening conditions were avoided, and to test for differences in this relationship between beef from bulls and steers.

EXPERIMENTAL METHODS

Two experiments involving 16 to 20mo male Friesian cattle raised on pasture are described, the first comprising 80 bulls, and the second comprising 40 bulls and 40 steers. A sample of the longissimus muscle from the 10 to 13 rib region (ca 800 g) was obtained from the carcass of each animal within 90min post mortem. After being placed in plastic bags the muscle samples were held at ambient temperature (15-20°C) for 24h and then at 0-3°C for 6d, at which time each was processed and the following measurements were made:

1. Warner-Bratzler shear values on samples cooked to 70°C.
2. Meat colour in terms of percent reflectance at 630 nm.
3. Ultimate pH of a muscle homogenate in 5 mM iodoacetate.
4. Expressible water using a filter paper press method.
5. Sarcomere length by a laser diffraction technique.
6. Intramuscular fat by extraction with petroleum ether.

RESULTS

Mean carcass weights were 240kg for the bulls of Experiment 1 and 216 and 214kg, respectively, for the bulls and steers of Experiment 2. Shear values for Experiment 1 showed a curvilinear relationship with pH,

Table 1. Mean values for characteristics of meat from the 80 bulls of Experiment 1, and the significance of linear and quadratic components within regression relationships with ultimate pH.

Item	Mean	SD	Regression Linear	Regression Quadratic	R^2 (%)
Ultimate pH	6.31	0.38	-	-	-
WB shear (kg)	7.10	2.76	***	***	54
Sarcomere L. (μm)	1.53	0.16	**	**	17
R630	16.1	3.7	***	ns	64
Expressible juice	36.6	4.1	***	ns	28
Cooking loss (%)	20.9	4.2	***	ns	74

Table 2. Mean values for characteristics of meat from bulls and steers of Experiment 2.

Item	Group Bulls	Group Steers	Group effect
Number	40	40	-
Ultimate pH	6.16	5.64	***
WB shear (kg)	8.21	7.87	ns
Sarcomere length (μm)	1.53	1.65	***
R630	18.4	23.8	***
Expressible juice	36.6	41.4	***
Cooking loss (%)	24.0	26.0	ns
Intramuscular fat (%)	0.55	1.69	***

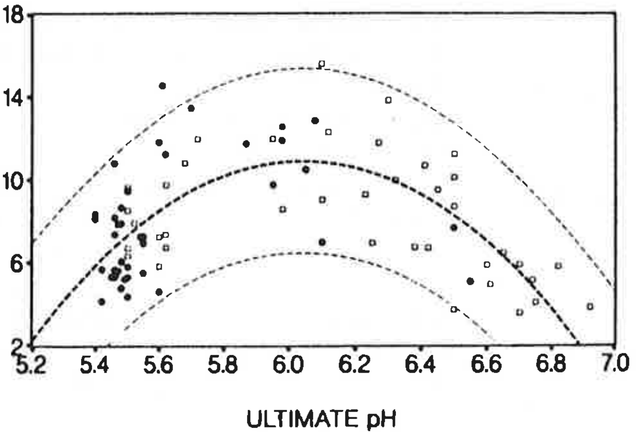

Figure 1. Changes in WB shear force values with increasing ultimate pH values for samples from bulls (open squares) and steers (solid circles) of Experiment 2 showing the overall quadratic regression line with 95% confidence limits.

with a peak at a pH of 5.95 and decreasing shear force values at lower and higher pH values. Sarcomere length decreased with increasing pH but at a decreasing rate to give a curvilinear relationship. The other relationships shown in Table 1 were all linear with increases in pH being associated with a darker colour (lower percentage reflectance values at 630nm), a decreased expressible juice area (cm^2/g), and a decreased level of cooking loss.

Most of the differences between beef from bulls and steers shown in Table 2 (Experiment 2) can be attributed to the significantly higher average pH values for the bull beef. Thus, meat from steers had longer sarcomeres, a lighter colour, and higher values for expressible juice. Beef from steers also had about three times as much intramuscular fat but the mean level was still low. Relationships with pH (Table 3) were similar to those shown for Experiment 1 except that colour (R630) and cooking loss had significant quadratic components. Details of the curvilinear relationship between WB shear and pH are shown in Figure 1.

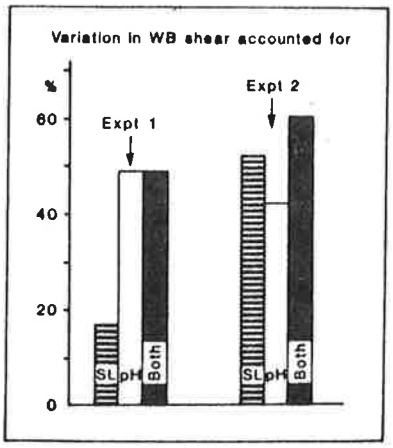

Figure 2. The percentage of variation in WB shear force values accounted for by sarcomere length (SL), or pH separately, or by both of these variables together for samples with pH values up to 6.2 for Experiment 1 (n = 23) and Experiment 2 (n = 56).

After adjusting for differences in pH, significant group effects on sarcomere length, colour, and expressible juice disappeared. In contrast, cooking loss differences became highly significant apparently because of a markedly reduced error mean square.

The increase in pH over the range up to 6.2 was associated with decreases in sarcomere length (r = -0.72 and -0.52 for Experiments 1 and 2 respectively), and as shown in Figure 2 the percentage of variation in WB shear force accounted for in the same set of samples was similar for either sarcomere length or pH alone, or these two variables combined. This implies that the pH effect on shear force values for those samples with pH values up to 6.2 was largely through an effect on sarcomere length.

DISCUSSION

As ultimate meat pH values increase above about 6.2 meat tenderness almost invariably improves, but the situation is less clear at pH values up to this point with the nature of the relationship varying with muscle and cooking temperature (Dransfield 1981). The suggestion that increases in toughness with increasing pH up to 6.2 will be more clear when cold-shortening is avoided (Purchas et al.1988) is supported by the results herein, and evidence is also provided that this relationship is similar for beef from bulls and steers. For the set of data presented, mean shear values for bulls and steers did not differ significantly because most bull pH values were above the peak and most steer values were below it. However, based on the regression relationship in Figure 1 shear values for beef from bulls would exceed those for steers if the mean pH for the former was higher than for the steers, but was not high enough to be beyond the peak of the shear-force/pH curve.

If the effect of pH in the range up to 6.2 on shear force values is mediated through an effect on the degree of pre-rigor shortening, then it might be expected that such an effect would be less clear if some cold-shortening had taken place, as the effect of shortening induced by any factors other than pH (such as low temperatures) would mask the pH effect. The evidence for a negative relationship between between pH and sarcomere length presented here is not particularly strong, but it is supported by other reports for beef (Bouton et al.1973; Purchas et al.1988). For the data of Bouton et al (1973) the decreased sarcomere length was not associated with an increased shear force, probably because all the sarcomere lengths were high due to the stretching treatments.

CONCLUSIONS

In the absence of cold-shortening conditions meat tendernesses differences between beef from bulls and steers may arise from differences in pH.

Shorter sarcomeres appear to be at least partially responsible for decreased meat tenderness as pH values increase from about 5.5 to 6.0.

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