The effect of SmartStretch™ on hot-boned mutton loins

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***Abstract*— Research has shown that stretching meat before *rigor* can increase the tenderness of meat. The aim of this study was to evaluate the effect of SmartStretch™ technology and ageing on the tenderness of hot-boned m. *longissimus lumborum* in sheep. Hot-boned mutton loins were removed from both sides of 27 similar carcasses and randomly allocated to either a stretch or control treatment. Each loin was portioned into two sub-samples which were randomly allocated to ageing treatments of 0 or 5 days. Shear force, sarcomere length, cooking loss, purge loss and colour stability were measured. Stretching only significantly ($P < 0.05$) reduced shearforce in conjunction with ageing. Sarcomere length was significantly ($P < 0.05$) increased by stretching. Important presentation traits were affected by stretching in different ways: cooking loss %, was significantly ($P < 0.05$) reduced by stretching and ageing, but purge loss significantly ($P < 0.05$) increased due to stretching. Stretching significantly ($P < 0.05$) increased lightness (L*) for all three days of measurement, but had no impact on the other colour parameters. Stretching hot boned m. *longissimus lumborum* did not improve initial tenderness, regardless of the increased sarcomere length, but did in combination with ageing. Stretching had little impact on colour, but may affect the retail presentation of meat by increasing purge loss.**

***Keywords*— SmartStretch™, hot-boning, stretching**

I. INTRODUCTION

Hot-boning of sheep meat has many financial advantages to the sheep processing industry. Savings can be made primarily by reduction in storage, refrigeration and transport costs as compared to cold-boned mutton [1]. There is a negative perception of hot-boning on the consumer acceptance of the product [2]. Stretching pre-*rigor* of hot-boned beef striploins [3], sheep meat topsides [4] and sheep meat legs [5], using the same technology as this study in all cases, resulted in a significant reduction in shear force, suggesting that stretching of hot-boned primals results in improved tenderness. In this study the ability of the SmartStretch™ technology to improve the tenderness of sheep loins was examined and the reconfiguration of the technology required to process this small cut was assessed.

II. MATERIALS AND METHODS

A. Treatments and sampling

Hot-boned loins, both left and right, were removed from 27 similar mutton carcasses, which were sourced from the lots slaughtered at a commercial hot-boning abattoir on one day. Each loin was trimmed from the cranial end to 30 – 35 cm in length and was randomly allocated to either a stretch treatment or control treatment. The loins allocated to the SmartStretch™[6] treatment were ejected from the SmartStretch™ machine. Each loin was portioned into two sub-samples, which were randomly allocated to ageing treatments of 0 or 5 days. Unlike previous experiments [3, 4, 5, 7, 8, 9, 10], this study used a specially designed sheep rubber with a resting diameter of 25mm. The rubber used in all previous experiments had a resting diameter of ≈ 65mm. The rubber had the external ribs roughly trimmed off to improve flexibility and had been inserted into a sleeve of PVC piping to prevent it from warping in the expand phase of the SmartStretch™ process [6]. A packaging unit ≈ 40mm diameter, was also developed for this experiment and packaging 60mm laying flat was used. The 0 day aged samples were frozen within four hours post-mortem and stored at -22°C until sampling. The 5 day aged samples were held at 3-4°C and then purge was measured on the whole cut. Test samples were cut from fresh and frozen at -22ºC.

B. Analytical methods

Loin length and circumference: The length and circumference, at three points, were measured on all samples and following treatment for stretched samples.

Initial pH and temperature: The pH and temperature were measured using a calibrated glass combination pH probe (potassium chloride) Ionode intermediate junction pH electrode, (TPS Pty Ltd., Brisbane, Queensland) attached to a data recording pH meter (TPS WP-80) in all loins just prior to the application of the stretch treatment. Muscle temperature was measured using a stainless steel cylindrical probe attached to the same meter.

Sarcomere length: Sarcomere length was measured using laser diffraction as previously described [11] on samples aged for 0 days.

Shear force: Warner Bratzler shear force was measured on samples aged for 0 and 5 days, using a method previously described [4].

Cooking loss: Samples used for Warner Bratzler shear force determination were weighed pre and post cooking to measure the amount of cooking loss.

Final pH: This was determined using an iodoacetate method adapted from that described by [12] and as described by [13].

Purge loss: The purge loss was the percentage weight difference between the packaged sample before and after 5 days ageing.

Retail colour: Retail colour display was examined on 5 day aged samples. A frozen slice of m. *longissimus lumborum* (3 cm thick) was taken from each sample and thawed overnight at 3-4°C. The following day a fresh surface was cut on each sample and they were over wrapped with PVC food film wrap (15 µm thickness). After a blooming period of 30-40 min, each sample was measured with a Hunter Lab meter (Model 45/0-L) with an aperture size of 25 mm, which was calibrated with black and white tiles using Illuminant D-65, with 10 degree standard observer. Samples were displayed in the chiller under lighting (~1000 lux) and measured once a day for 4 days. Each sample was measured twice at each measurement time and the values averaged.

C. Statistical analyses

Linear mixed models using restricted maximum likelihood (REML) within ASReml [14] were used to analyse the data. The models contained fixed effects for stretch treatment (stretch or no stretch) and ageing time (0 or 5 days) and the interactions between these as appropriate. Carcase was fitted to the model as a random term for initial pH, initial temperature and purge loss. The random terms fitted for shear force and cooking loss were carcase, the interaction between carcase and side and cook batch. The fixed effects for colour traits also included time on display and its interaction with stretch and ageing treatments. The random terms fitted included carcase, the interactions between carcase and ageing, time on display and stretch treatment and the combined interaction of these.

III. RESULTS AND DISCUSSION

As expected there was no significant difference between the initial pH and initial temperature for each treatment. The average temperature (25.3°C) and pH (6.6) for the muscles shows that they were still pre-*rigor* when stretched. No significant increase in loin length was shown for the stretched samples (7%). Sarcomere length (Table 1) was significantly ($P < 0.05$) increased by stretching, but this was not matched by significant tenderness improvements at 0 days (Table 2), suggesting the lack of a relationship between sarcomere length and tenderness in stretched samples.

Table 1: Predicted sarcomere means and standard errors. Means having a following letter different are significantly different ($P < 0.05$).

Treatment	Sarcomere (µm)		
	0 day		
Control	1.50	*0.04*	a
Stretch	1.61	*0.04*	b

Ageing significantly ($P < 0.05$) improved the tenderness of the samples for both the control and stretch treatments (Table 2). Stretching also significantly ($P < 0.05$) improved tenderness, but

only for the aged samples. This is at odds with the results of a previous experiment involving mutton where initial tenderness gains resulting from stretching had disappeared with ageing in full legs [5]. Substantial physical damage was done to the samples during the stretching process in the current study, with some samples being torn into pieces. It is contended that the rubbers which were supplied for this work had weak sections in the wall and thus bulging developed under vacuum which caused uneven expansion and compression, resulting in damage to the integrity of the loin structure. It is unknown why the shear force of the aged stretched loins was much lower than the control.

Table 2: Predicted shear force means (N) and standard errors (s.e.) for stretch. Means having a following letter different are significantly different ($P < 0.05$).

Treatment	Shear force (N)					
	0 day			5 day		
Control	65.8	*3.86*	c	48.6	*3.86*	b
Stretch	60.8	*3.86*	c	29.2	*3.86*	a

Table 3: Predicted cooking loss % and thaw loss % and standards errors (s.e.) for stretch and ageing treatments. Means having a following letter different within a test are significantly different ($P < 0.05$).

Treatment	Cooking loss %					
	0 day			5 day		
Control	23.5	*0.98*	c	21.1	*0.98*	b
Stretch	22.1	*0.98*	b	19.7	*0.98*	a
	Purge loss %					
Control				0.5	*0.09*	a
Stretch				2.3	*0.27*	b

Cooking loss %, was significantly ($P < 0.05$) reduced by stretching and ageing (Table 3). The suggested relationship between purge loss and cooking loss as a result of stretching [4] was not significant ($P > 0.05$) in this study. There was increased purge loss ($P < 0.05$) due to stretching consistent with previous results [5]. Purge loss is important because it negatively affects the retail presentation of the product by making the product unsightly and reducing saleable weight [15], while cooking loss represents a loss of product content, juiciness and tenderness to the consumer [16]. Stretching and ageing in combination in this study had a positive impact on cooking loss. Total fluid loss was similar between treatments.

Lightness (L*), redness (a*), yellowness (b*) and brownness (ratio 630/580nm) were measured with the Hunter Lab meter over 72 hours of retail display. Stretching significantly ($P < 0.05$) increased lightness for all three days of measurement, but had no impact on the other colour parameters.

The decision by consumers to purchase meat is influenced by meat colour more than any other trait, because colour is considered an indicator of freshness [17]. Meat on retail display will begin to brown within 1–7 days and retailers often price discount red meat after 2 days on display [18]. This is at significant cost to industry. Here time on display affected the colour of the meat, with stretch treatment having little effect. Consumers find meat unacceptably brown if the 630/580nm ratio falls below 3.3 [19]. After one day on retail display 37% of the samples were unacceptable to consumers, with 67% of the samples being unacceptably brown after two days on retail display regardless of stretch treatment. Overall stretching, as a value adding process, will not impact on colour significantly and will not impact on consumer perceptions of colour in their purchase decision based on the results of this study.

IV. CONCLUSIONS

Regardless of the changes in sarcomere length resulting from stretching to increase primal length by 7% there was no reduction in shear force with 0 days ageing. There was, however a significant reduction after 5 days of ageing, which is unusual compared to previous studies. Important presentation traits were affected by stretching in different ways – cooking loss was improved and purge loss was worsened (consistent with previous work), although there was little effect on colour. The increased purge loss may impact on the retail presentation of stretched meat, although colour, being unaffected by stretching, will not. Overall while there may be some benefit to be gained from stretching the loin, the lack of consistency with

previous results suggests that further studies would be required before making that conclusion.

The physical damage observed in the samples was unusual compared to previous work. The inconsistent behaviour of the rubber along its length, resulting from inconsistent rubber wall width, may have contributed to excessive force being applied to samples, which tore some samples to pieces during the ejection process. This suggests that the reconfiguration of the technology to process the mutton loin was not successful and that reconfiguration of the technology is not simple. Further testing would be required before attempting to process this cut again.

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