PE4.14 Impact of a meat stretching device on sheep meat quality 42.00

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***Abstract*— The challenge the meat industry faces when increasing processing efficiency is to maintain or enhance eating quality. The aim of this study was to evaluate the effect of both stretching, using a pre-production prototype device, and ageing on meat tenderness of warm tunnel boned legs from sheep carcases. To test this effect 40 sheep from several consignments were assessed over two days. Left and right legs were collected pre-rigor and randomly allocated to one of four treatments; 0 days ageing + stretch, 0 days ageing + no stretch, 5 days ageing + stretch and 5 days ageing + no stretch. There were significant differences in shear force for the *biceps femoris* (BF) for the stretch treatment ($P = 0.001$), aging treatment ($P < 0.001$) and the interaction between both of these treatments ($P < 0.045$). In addition to this there was also a significant effect of age ($P < 0.001$) and it's interaction with stretch treatment ($P < 0.05$) for m. *semimembranosus* (SM) shear force. Meat stretched using the prototype device had longer sarcomeres ($P < 0.001$) for both the SM and m. *semitendinosus* (ST) muscles. There was no effect of stretching on myofibrillar degradation measured using particle size analysis (PSA) or histology, but there was an ageing effect ($P < 0.001$). The meat stretching treatment was shown overall to result in a significant improvement in tenderness.**

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***Index Terms*— pH, stretch, tenderness**

I. INTRODUCTION

The adoption of hot or warm boning in the Australian sheep meat processing industry has been limited to the use of adult sheep meat. A perceived negative effect on meat quality is one of the reasons this process is not more widely used. The only published data on eating quality of sheep meat processed through this system shows a low level (~14%) of consumer compliance [1]. In contrast, when adult sheep were processed at the same abattoir, but cold boned and chilled for 7 days a high level (86%) of consumer compliance was achieved [2]. In follow up work where hot boned loin meat was wrapped and aged for 7 days, there was a 14% and 24% improvement respectively in the overall liking and tenderness scores compared to product unwrapped and frozen at 1 day [3]. However in a more recent study using the same pre-production prototype device as used in the study reported here it was concluded that meat tenderness of the SM was significantly improved by applying the stretch treatment, such that after 0 days of ageing the stretch caused a 46% reduction in shear force and 38% after 5 days ageing [4]. This accelerated tenderisation achieved by a pre-rigor stretching device could remove the need for aged chiller storage to achieve acceptable tenderness levels. The aim of this study was to evaluate the effect of stretching, using a pre-production prototype device, and ageing on meat tenderness of warm tunnel boned legs from sheep carcases.

II. MATERIALS AND METHODS

Forty sheep from different consignments were assessed. The sheep were of varying backgrounds, typical of the animals processed at the abattoir. All carcases were exposed to a full suite of electrical stimulation [5]. Both the right and left legs (HAM. 4820) were collected and tunnel boned ($n = 80$). Using a randomised complete block design with 10 replicates, the treatments were randomised to a leg within an animal. The treatment combinations used were; 0 days ageing + stretch, 0 days ageing + no stretch, 5 days ageing + stretch and 5 days ageing + no stretch. Stretch treatments were achieved using a meat stretching prototype (licensed as Smart Stretch) under development by Meat & Livestock Australia and Meat & Wool New Zealand.

The time from slaughter to when the muscles were put into their treatments was approximately 2 hours. The 5 day aged samples were chilled at 4°C. The 0 and 5 day aged samples were frozen (-22ºC) and stored until sampling. Some descriptive measurements were taken on each of the legs including initial length and initial circumference. Legs

that underwent the stretch treatment were re-measured after being stretched.

The pH and temperature were measured in both the left and right SM and ST approximately 1.5h post death. Muscle pH was measured using a 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). While muscle temperature was measured using a stainless steel cylindrical probe attached to the same meter. The pH meter was calibrated before use and at regular intervals using buffers of pH 4 and pH 6.8 at room temperature.

Frozen samples were tempered for approximately 6h after which time sarcomere, particle size, final pH and shear force samples were cut whilst the meat was still predominantly frozen. Sarcomere length was measured using laser diffraction [6] on 0 day aged SM and ST samples.

The shear force samples were tested for peak shear force (N) adapted from the method previously described [7]. Samples from the SM and BF taken for Warner Braztler shear force testing were used to measure the amount of cooking loss. An initial weight was recorded to two decimal places (this weight was close to 65g) then the samples were cooked for 35 minutes at 70ºC. Once the samples were cooled to room temperature they were blotted dry using paper toweling and re-weighed; cooking loss percentage was calculated using the difference.

Particle size analysis as described by [8] was conducted on 2g samples taken from the SM. In addition, 1g histology samples were taken from the lateral side of the SM at 0 and 5 days. The muscle was fixed in a solution of 2.5% glutaraldehyde in 2% paraformaldehyde in 0.1M phosphate buffer and was used to determine the number of breaks in muscle fibres. The method for determining fibre breaks was adapted from that reported by [9]. This involves the fixing, embedding and staining of muscle samples.

Purge was measured in 5 day aged leg samples only. The initial frozen leg weight was first recorded then samples were thawed at a room temperature of 21.7ºC. Once samples had thawed (muscle temperature of approximately 2ºC) they were blotted dry using paper towelling and re-weighed to get a final leg weight. The total purge percentage was calculated using the following formula; Purge loss (%) = 100 – (Final leg weight/Initial leg weight × 100).

A linear mixed model using restricted maximum likelihood (REML) within ASReml [10] was used to analyse all data. The model contained fixed effects for stretch treatment (no stretch or stretch), ageing time (0 or 5 days) and their interactions. Random terms used in the model were consignment, replicate and animal.

III. RESULTS AND DISCUSSION

Initial pH and temperature of the SM and ST was measured and on average the muscles were still in the pre-rigor phase with a mean pH of 6.16 at 27.7 ºC and 6.30 at 24.7 ºC respectively. Leg length increased on average by 14% (s.e.±5%) and circumference decreased by 45% (s.e.±10%) after the stretching treatment had been applied. Based on these results it is evident that the stretch treatment significantly altered the shape of the legs.

There was a significant effect on shear force of the biceps femoris (BF) due to Smart Stretch treatment (P = 0.001), aging treatment (P < 0.001) and the interaction between both of these treatments (P = 0.045) (Table 1). The un-aged control group (no stretch) meat had the highest shear force value (49.2) which was significantly different to all the other treatment combinations (P < 0.050), indicating it was the toughest. The benefits of Smart Stretch diminished after 5 days of ageing with no significant difference between stretch treatments for BF shear force; these samples resulted in the lowest shear force values.

There was also a significant effect of age (P < 0.001) for SM shear force with an interaction with stretch (P < 0.05). The results from the SM shear force followed the same trend as the BF with the toughest meat resulting from the un-aged (0 day aged) control group (no stretch). The benefits of the stretching treatment also diminished for SM shear force after 5 days of ageing with no significant differences between stretch treatments. Hence irrespective of stretching treatment, 5 day aged samples resulted in the lowest shear force values (Table 1).

It can be concluded that after 0 days of aging the Smart Stretch technology caused a reduction of 18.4% in BF shear force and 16% in SM shear force when these muscles are processed in a whole leg scenario. However in an earlier study which examined the effect of the stretching treatment

on the SM muscle only, a reduction in shear force of 46% was found [4]. In that study even after 5 days of aging there were still large benefits evident, with a reduction in SM shear force of 38%. Based on this it can be concluded that greater benefits from the stretching treatment are achieved in a single SM muscle compared to applying the stretch treatment to the whole leg.

Table 1. Predicted means (av. s.e.d.) of *biceps femoris* (BF) and m. *semimembranosus* (SM) shear force in Newtons according to treatment groups.

Treatments	Shear force BF		Shear force SM	
	Smart Stretch	Control	Smart Stretch	Control
0 days aged	40.1b	49.2c	50.9b	60.6c
5 days aged	31.8a	34.8a	41.2a	38.3a
Ave SED	*2.24*		*3.39*	

Means followed by a different letter within rows and columns for a trait are significantly different $P = 0.05$.

Smart Stretch resulted in a lower cooking loss for the BF ($P < 0.05$). There were also significant differences between aging periods ($P < 0.05$) with 0 day aged product having a lower cooking loss percentage (Table 2). In contrast the results for SM cooking loss showed that 5 day aged samples had a lower cooking loss percent ($P < 0.05$) when compared to 0 day aged samples and there was no significant difference between stretching treatments.

Results from a previous study showed that there was a notable difference between stretching treatments for cooking loss in the SM with lower percentages lost with the stretch treatment [4], which supports the findings of the current experiment for the BF. However it was observed, but not quantified in the previous study that there were varying amounts of initial purge and it was speculated that the stretch treatment may have lost more initial purge. Hence in the current experiment the percentage of purge lost after 5 days of ageing was measured and there was a significant difference ($P < 0.001$) between stretching treatments with the stretch treatment having a greater purge loss. This can potentially negate the differences found in cook loss.

Table 2. Predicted means (av. s.e.d.) of m. *biceps femoris* (BF) and m. *semimembranosus* (SM) cooking loss percentage and 5 day aged purge percentage according to treatment groups.

Treatments	BF cooking loss %	SM cooking loss %	5 day aged purge %
Stretching			
Stretch	15.6a	19.8a	1.82a
Control	17.4b	20.9a	1.61b
Ave S.E.D.	*0.79*	*0.75*	*0.07*
Ageing			
0 day aged	15.5a	21.2b	
5 day aged	17.4b	19.6a	
Ave S.E.D.	*0.78*	*0.76*	

Means followed by a different letter within rows and columns for a trait are significantly different $P = 0.05$.

There was a significant difference ($P < 0.05$) in sarcomere length between stretched and control samples for both the SM and ST. Stretched SM had a sarcomere length of 1.82µm versus control at 1.61µm and for the ST it was 2.12µm versus 1.89µm. These results support previous findings for wrapped meat which was shown to be useful in controlling sarcomere shortening [11]. This wrapping method is a similar concept to the current stretch treatment as the aim is to restrain and hence potentially stretch the de-boned muscle to prevent the muscle fibres contracting or shortening. Additionally a recent study which examined the SM muscle put through same stretching treatment under the same conditions also supports the results of the current study [4].

Samples were taken from the SM to examine the structure of the myofibres. There was no effect of stretching on myofibrillar degradation of the SM measured as breaks in fibres, but there was a significant ($P < 0.001$) effect of ageing, with no interaction between stretching and ageing (Table 3). There was also no effect of stretching on the distortion of fibres, but again a significant effect of ageing ($P < 0.001$) with a reduction in distortion due to ageing. There was no interaction between stretching and ageing.

Table 3. Predicted means (av. s.e.d.) for the percentage of breaks in fibres (break ratio) and the percentage of either wavy or bent fibres (distorted ratio) for the m. *semimembranosus* (SM) according to treatment groups.

Treatments	Break ratio	Distorted ratio
Stretching		
Stretch treatment	13.5a	45.8a
Control	19.0a	47.0a
Ave S.E.D.	*4.41*	*4.33*
Ageing		
0 day aged	4.0a	70.6b
5 day aged	28.5b	22.2a
Ave S.E.D.	*4.41*	*4.33*

Means followed by a different letter within rows and columns for a trait are significantly different $P = 0.05$.

There was no effect of stretching on myofibrillar degradation of the SM measured using particle size analysis, however there was a significant difference between aging treatments. This difference was such that 0 day aged samples had a predicted mean particle size of 190 µm and at 5 day aged it was 140 µm with an average standard error of difference of 8.3µm. This and the results from the fibre histology indicate that the stretching device does not result in accelerated proteolysis. These outcomes are supported by the earlier results [4]. It is of interest that the distortion of fibres decreases with ageing; this suggests that the fibres sampled at day 0 were not fully in rigor and that with ageing this process progressed leading to a straightening of fibres.

IV. CONCLUSION

Meat tenderness of the SM and BF was improved significantly by applying the stretch treatment, such that after 0 days of ageing the stretch caused an 18.5% and 16% reduction in shear force respectively. However, the benefits of the stretch diminished after 5 days of aging. Significant differences were found between stretch and control for sarcomere length of the SM and ST such that the stretch treatment produced longer sarcomeres. These results indicate that the fibres have been physically disrupted by the stretch treatment but the histology results do not suggest that stretch causes more distorted fibres. Both the PSA and histology results indicate that the stretch treatment does not cause any acceleration of proteolysis. Based on these results, this study has highlighted the potential role of stretching in the improvement of sheep meat quality and consumer satisfaction for short aged product.

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