THE EFFECT OF SMARTSTRETCH™ TECHNOLOGY ON THE TENDERNESS OF BEEF TOPSIDES AND CUBE ROLLS

Edwina S. Toohey[1], Matthew J. Kerr[2], Remy van de Ven[3] and David L. Hopkins[2*]

[1]Industry & Investment NSW (Primary Industries), PO Box 865 Dubbo, NSW 2830

[2]Industry & Investment NSW (Primary Industries), Centre for Sheep Meat Development, PO Box 129, Cowra NSW 2794

[3]Industry & Investment NSW (Primary Industries), Orange Agricultural Institute, Forest Road, Orange NSW 2800

[*]Corresponding author (phone: +61-2-6349-9722; fax: +61-2-6342 4543; e-mail: David.Hopkins@industry.nsw.gov.au)

***Abstract*—Methods to improve tenderness include mechanical and chemical approaches and the former category includes the use of stretching techniques. Two experiments were undertaken to investigate the effectiveness of SmartStretch™ technology for improving the tenderness of hot boned beef m. *semimembranous* (SM; Experiment 1) and cuberolls (where the m. *Longissimus;* LL) was tested (Experiment 2). For work on the SM, three levels of stretch were used resulting in either a 52, 41 or 34% increase respectively in the length of the SM. For the cuberoll three treatments were applied 1) no stretch and 2) two levels of stretch resulting in 8.5 and 9.3% increase in length respectively. The shear force results showed that only ageing was signficant (P < 0.05). Although significant changes in SM dimensions were achieved in experiment 1 there was no significant tenderness benefit from increasing the degree of stretch. Much smaller changes in dimensions were found for the LL in experiment 2. The results for the SM suggest that there is a lower limit beyond which further stretching will not reduce shear force and the least stretch treatment was above that limit. By contrast the results suggest that the degree of stretch achieved in the LL of the cube roll did not reach a required minimum to illicit an improvement in tenderness. This cut is composed of more than one muscle and this may limit the ability to stretch the cut and thus the LL. All initial a* (redness) values were significantly higher than the final values and similary ratio 630/580nm values declined significantly due to ageing. The ratio values also showed that there were significant stretch treatment effects in experiment 1 so as the level of stretch increased the level of initial browning declined.**

***Index Terms*—stretching, meat colour, tenderness, topside, cuberoll**

I. INTRODUCTION

The challenge the meat industry faces when increasing processing efficiency is to maintain or enhance eating quality and this is particularly relevant to the use of warm or hot boning, where the former can be defined as boning with a muscle temperature below 30°C. Previous work in beef has shown that hot boning increases the toughness of loin and topside cuts compared to cold boning (White, O'Sullivan, Troy & O'Neill, 2006) and in sheep warm boning produced meat with a low consumer compliance (Toohey & Hopkins, 2006), but interventions such as wrapping warm boned meat can increase eating quality when combined with ageing (Toohey, Hopkins & Lamb, 2008). The aim of this study was to evaluate the effect of both stretching and ageing, using SmartStretch™ technology (Toohey, Hopkins, Nielsen & Gutzke, 2009), on meat tenderness of hot boned m. *semimembranosus* (SM) from beef topsides and m. *longissimus* (LL) from beef cube rolls.

II. MATERIALS AND METHODS

Experiment 1

To test the effect of SmartStretch™ technology on hot boned m. *semimembranosus* (SM) from beef topsides (Anon. 1998, HAM No. 2000) 24 cows from various consignments were selected. Left and right topsides were collected pre-rigor and the SM was removed and randomly allocated to one of three treatments: treatment 1 (SM cut to 31-32 cm circumference), treatment 2 (SM cut to 28-29 cm circumference) or treatment 3 (SM cut to 25-26 cm circumference) respectively. The SM muscles were ejected from the SmartStretch™ machine into the packaging unit with a circumference of 24 cm. Each SM was cut in half and the portions were randomly allocated to either freezing on day 0 or ageing for 7 days post treatment. The length and circumference were measured pre- and post-treatment. Samples for ageing were held at 4-5°C for 7 days and then frozen and stored in a -22ºC freezer.

Experiment 2

To evaluate the effect of both stretching and ageing, using SmartStretch™ technology, on meat tenderness of hot boned cube rolls (Anon. 1998, HAM No. 2240) beef carcases from 24 cows from various consignments were selected. These were not the same animals as sampled for Experiment 1. Left and right cube rolls were collected pre-rigor and randomly allocated to one of three treatments: treatment 1 - sample vacuum packed, no stretch (control), treatment 2 - (25-26 cm circumference) or treatment 3 - (27-28 cm circumference) respectively. Cube rolls stretched using the SmartStretch™ machine, were ejected into packaging with a circumference of 24 cm. Each cube roll was cut in half and the portions were randomly allocated to either freezing on day 0 or ageing for 14 days post treatment. The length and circumference were measured pre- and post-treatment. Samples for ageing were held at 4-5°C for 14 days and then frozen and stored in a -22ºC freezer.

The initial pH and temperature were measured for each m. *semimembranosus* (SM) of each animal as soon as the muscle was collected (Experiment 1) and for each m. *longissimus* (LL) of each animal as soon as the cube rolls were collected (Experiment 2). Muscle pH was measured using a glass combination Ionode intermediate junction pH (potassium chloride) electrode (TPS Pty Ltd., Brisbane, Queensland) attached to a data recording pH meter (TPS WP-80). 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.

Sample from both experiments was subsequently removed from the packaging and 65 g cooking blocks for tenderness testing were cut, using a band saw, from the SM in experiment 1 and from the LL of the cube roll in experiment 2. Shear force testing was conducted using the method previously described by Hopkins *et al.* (2009). Sarcomere length was measured using laser diffraction as described by Bouton *et al.* (1978) on samples aged for 0 days in both experiments. Slices of frozen SM and LL (3 cm thick) were taken from each sample, placed on trays and allowed to thaw overnight in a chiller set at 3-4°C. The following day a fresh surface was cut on each sample and these were then placed individually on black foam trays (13.5 cm x 13.5 cm) and over wrapped with PVC food film wrap (15 µm thickness). After a blooming period of 30-40 min, each sample was measured (initial colour values) with a Hunter Lab meter (Models 45/0-L) with an aperture size of 25 mm. The instrument was calibrated with black and white tiles using Illuminant D-65, with 10 degree standard observer. Samples were displayed in a chiller at 3-4°C under lighting (1000 lux) and measured once a day for 4 days (final colour value). Each sample was measured twice at each measurement time and the two values averaged. Data for a* (redness), and ratio (630/580nm) which is indicative of the development of metmyoglobin will be shown here.

Linear mixed model methods were used to analyse, separately, the data from the two experiments. For analysis of initial pH, initial temperature, percentage increase in muscle length, percentage decrease in circumference and sarcomere length all measured prior to allocation of ageing treatments within samples, the model included stretch treatment as a fixed effect and an animal effect as a random effect. The model for shear force, measured on each portion assigned an ageing treatment, included stretch treatments, ageing treatments and the interaction between these two factors as fixed effects and included as random effects terms for animal, sides within animal and cook batch. Colour and ratio measures were analysed using repeated measures analyses and included fixed effects for stretch treatment, ageing, time and interaction of these terms whilst random effects included terms for animals, sides within animals and allowing for correlations for results over time on the same sample. All models were fitted using the statistical package ASReml (Gilmour, Gogel, Cullis & Thompson, 2006) which uses REML based methods and incorporates adjusted Wald statistics (Kenward & Roger, 1997) to test significance of fixed effects under small sample inference.

III. RESULTS AND DISCUSSION

For the traits, initial pH, initial temperature, % increase in length, % decrease in circumference and sarcomere length the only significant treatment effects observed were for % increase in length ($P < 0.05$) and % decrease in circumference ($P < 0.001$) of the SM muscle and for sarcomere length ($P < 0.05$) and % decrease in circumference ($P < 0.001$) in the LL muscle. The predicted means and average standard errors for each treatment on each muscle are given in Table 1.

Table 1. Predicted means (av s.e.) of initial pH, initial temperature, % increase in length, % decrease in circumference and sarcomere length for each stretch treatment in experiments 1 and 2.

	Experiment 1 (SM)				Experiment 2 (LL)			
Treatment	**1**	**2**	**3**	***Av s.e.***	**1**	**2**	**3**	***Av s.e.***
Initial pH	5.94	5.91	5.98	*0.07*	6.15	6.21	6.12	*0.06*
Initial temperature (°C)	35.6	36.6	36.9	*0.76*	36.2	35.3	36.4	*0.5*
Increase length (%)	51.9a	41.1b	34.0b	*2.77*	*	8.5	9.3	*1.8*
Decrease circumference (%)	28.8a	18.8b	11.1c	*0.52*	*	2.35a	7.31b	*0.74*
Sarcomere length (µm)	2.24	2.28	2.20	*0.08*	1.62b	1.81ab	1.94a	*0.07*

Means, within a muscle, having a different letter (a, b, c) are significantly different ($P = 0.05$)

The shear force results showed that of the fixed effects, the treatment x ageing interaction effects were not significant (*P* > 0.05) in experiments 1 and 2, neither was treatment (*P* > 0.05), whilst ageing was (*P* < 0.05; Table 2).

Table 2. Predicted shear force means (N) and (standard errors) for each stretch and ageing treatment.

Treatments	Experiment 1 (SM)		Treatments	Experiment 2 (LL)	
	0 day	**7 day**		**0 day**	**14 day**
1 (52% Stretch)	57.2 (2.9) a	52.9 (2.9) b	**1 (no Stretch)**	60.9 (4.0) b	39.3 (4.0) a
2 (41% Stretch)	57.3 (2.9) a	53.1 (2.9) b	**2 (8.5% Stretch)**	60.2 (3.8) b	37.3 (3.8) a
3 (34% Stretch)	55.1 (2.9) a	50.9 (2.9) b	**3 (9.3% Stretch)**	60.6 (3.8) b	36.7 (3.8) a

Means, within a muscle, having a different letter (a, b) are significantly different (*P* = 0.05)

Although significant changes in SM dimensions were achieved in experiment 1 there was no significant tenderness benefit from increasing the degree of stretch. Much smaller changes in dimensions were found for the LL in experiment 2. Based on previous work by Hwang, Gee, Polkinghorne & Thompson (2002) and Simmons, Cairney, Auld, Nagle & Mudford (1999) the results for the SM suggest that there is a lower limit beyond which further stretching will not reduce shear force. The work by Simmons et al. (1999) studied beef *Longissimus thoracis* muscles by stretching the muscles to 20, 40 and 60% using clamps and then comparing these to un-stretched muscles and it was shown that the 20% stretch produced a significant reduction in shear force, but the 40% and 60% stretching did not further reduce shear force. In the current study we conclude that the stretching threshold was achieved using SmartStretch™ with treatment 3 (the lowest degree of stretch treatment based on percentage increase in length). It is suggested that the minimum stretch treatment (34% increase in muscle length) obtained using the SmartStretch™ technology would produce a significant improvement in tenderness of hot boned beef SM compared to a non stretched SM, based on previous results for sheep (Toohey et al., 2008), however this needs to be validated. By contrast the results suggest that the degree of stretch achieved in the LL of the cube roll did not reach a required minimum to illicit an improvement in tenderness. This cut is composed of more than one muscle and this may limit the ability to stretch the cut and thus the LL. Given the wide use of this cut for value adding in hot boning plants this result must be validated.

Table 3. Predicted means and (standard errors) for initial and final a* colour values, and ratio values (630/580nm) for aged samples for each stretch treatment in experiments 1 and 2.

Treatments		**Experiment 1 (SM)**		
	0 day aged		7 day aged	
	Initial	Final	Initial	Final
		a*		
1 (52% Stretch)	20.7 (0.5) e	15.8 (0.5) ab	20.6 (0.5) de	15.9 (0.5) ab
2 (41% Stretch)	20.3 (0.5) cde	16.2 (0.5) ab	20.3 (0.5) cde	16.3 (0.5) b
3 (34% Stretch)	19.1 (0.6) cd	15.1 (0.5) ab	19.0 (0.6) c	15.2 (0.6) a
		Ratio 630/580nm		
1 (52% Stretch)	7.4 (0.3) c	3.5 (0.2) a	7.4 (0.4) c	3.7 (0.2) a
2 (41% Stretch)	7.0 (0.4) bc	3.7 (0.2) a	6.8 (0.4) bc	3.7 (0.2) a
3 (34% Stretch)	6.2 (0.4) b	3.3 (0.3) a	6.1 (0.4) b	3.3 (0.3) a
		Experiment 2 (LL)		
	0 day aged		14 day aged	
		a*		
1 (Control)	18.4 (0.4) ef	16.4 (0.6) bcd	19.7 (0.4) ghi	14.9 (0.6) a
2 (8.5% Stretch)	19.1 (0.4) fgh	17.1 (0.6) de	20.4 (0.4) i	15.5 (0.6) abc
3 (9.3% Stretch)	18.7 (0.4) fg	16.7 (0.6) cd	20.0 (0.4) hi	15.1 (0.6) ab
		Ratio 630/580nm		
1 (Control)	7.3 (0.4) c	3.8 (0.3) b	7.2 (0.4) c	2.9 (0.2) a
2 (8.5% Stretch)	7.8 (0.4) c	4.0 (0.3) b	7.6 (0.4) c	3.1 (0.2) a
3 (9.3% Stretch)	7.3 (0.4) c	3.8 (0.3) b	7.1 (0.4) c	2.9 (0.2) a

For each trait within each muscle, means not having a trailing letter in common are pairwise significantly different *P* = 0.05.

For colour values a* and ratio 630/580nm there were significant differences between initial and final values within ageing periods in both experiments (Table 3). This resulted in all initial a* values being significantly higher than the final values irrespective of ageing treatment, meaning that the samples lost reddeness while displayed. There were also significant differences between stretch treatments for a* values in experiment 1 with treatment 1 having significantly higher initial values than treatment 3. There was an inconsistent effect between treatments in experiment 2. The ratio values also decreased between initial and final readings irrespective of ageing treatment in both experiments meaning that as the display time increased the metmyoglobin formation or browning of the meat increased reflected by the decrease in ratio values. The ratio values also show that there were significant stretch treatment effects in experiment 1 so as the level of stretch increased the level of browning declined, but only for intial readings. The results for experiment 2 are not that informative given the level of stretch achieved. Work by Morrissey, Jacob & Pluske (2008) suggested that when the ratio value falls below 3.5 for lamb topside that consumers consider the meat to be more brown than red. Recent work using lamb loins (Khliji, van de Ven, Lamb, Lanza & Hopkins, 2010) showed that when the wavelength ratio (630/580 nm) values are equal to or greater than 3.3, on average consumers will consider the meat as acceptable. These ratio thresholds need to be increased to 6.8 to provide 95 percent confidence that a randomly selected consumer will consider a sample as acceptable (Khliji et al., 2010). If these levels apply to beef then most of the meat in both experiments would be unacceptable after the period of display, with no difference between treatments. The results indicate, however that higher levels of stretch will produce topside that is more acceptable in terms of colour stability at least on initial display.

IV. CONCLUSION

SmartStretch™ technology has potential to improve the tenderness of hot boned SM and thus, add significant value to the topside, but the benefits for the cube roll are more problematic, due it seems to the diffculty of stretching this cut. The evidence indicates that higher levels of stretch will produce meat that is more acceptable in terms of colour stability at least when initially displayed. This will be an added bonus if the tenderness benefits of stretching cuts like the topside can be validated.

ACKNOWLEDGEMENTS

The financial support provided by Meat and Livestock Australia, Meat and Wool New Zealand, Industry & Investment NSW and MIRINZ Inc is greatly acknowledged. The technical assistance of Matthew Kerr, Tracy Lamb and Fumie Chiku (I&I NSW) with the collection of samples and laboratory testing is gratefully acknowledged. The support from the management and staff of the cooperating abattoirs was invaluable to the completion of the stretching experiment and this is gratefully acknowledged.

REFERENCES

Anonymous (1998). Handbook of Australian meat. 6th edn. Authority for Uniform Specification Meat and Livestock, Brisbane, Australia.

Bouton, P.E., Harris, P.V., Ratcliff, D., & Roberts, D.W. (1978). Shear force measurements on cooked meat from sheep of various ages. *Journal of Food Science*, 43, 1038-1039.

Gilmour, A.R., Gogel, B.J., Cullis, B.R. and Thompson, R. (2006). ASReml User Guide Release 2.0. VSN International Ltd, Hemel Hempstead, HP1 1ES, UK.

Hopkins, D.L., Toohey, E.S., Lamb T.A., Kerr M.J., van de Ven R., & Refshauge, G. (2009). Explaining the variation in shear force using sarcomere length, the rate of rigor onset and pH. In Proceedings 55th International Congress of Meat Science and Technology (Session 4, pp 141-144), Copenhagen, Denmark.

Hwang, I.H., Gee, A., Polkinghorne, R., & Thompson, J. (2002). The effect of different pelvic hanging techniques on meat quality in beef. In Proceedings 48th International Congress of Meat Science and Technology (pp. 220-221), Rome, Italy.

Kenward, M.G., & Roger, J.H. (1997). Small sample inference for fixed effects from restricted maximum likelihood. *Biometrics*, 53, 983-997.

Khliji, S., van de Ven, R., Lamb, T.A., Lanza, M., & Hopkins, D.L. (2010). Relationship between consumer ranking of lamb colour and objective measures of colour. *Meat Science*, 85, 224-239.

Morrissey, E.R., Jacob, R.H., & Pluske, J.M. (2008). Perception of red brown colour by consumers. In Proceedings 54th International Congress of Meat Science and Technology, (Session 9.7 pp. 1-3), Cape Town, South Africa.

Simmons N.J., Cairney J.M., Auld M.M., Nagle T.A., & Mudford C.R. (1999). Effect of pre-rigor stretching of beef M. longissimus thoracis muscles on structural changes and key meat quality attributes. In Proceedings 45th International Congress of Meat Science and Technology (pp. 464-465), Yokohama, Japan.

Toohey, E.S., & Hopkins D.L. (2006). Eating quality of commercially processed hot boned sheep meat. *Meat Science,* 72, 660-665.

Toohey, E.S., Hopkins, D.L., & Lamb, T.A. (2008). The impact of wrapping and ageing hot boned sheep meat on eating quality. In Proceedings 54th International Congress of Meat Science And Technology. (Session 7b.19, pp. 1-3), Cape Town, South Africa.

Toohey, E.S., Hopkins, D.L., Nielsen, S.G., & Gutzke, D. (2009). Impact of a meat stretching device on sheep meat quality. In Proceedings 55th International Congress of Meat Science and Technology (Session 4, pp. 78-82), Copenhagen, Denmark.

White, A., O'Sullivan, A., Troy, D.J., & O'Neill, E.E. (2006). Effects of electrical stimulation, chilling temperature and hot-boning on the tenderness of ovine muscles. *Meat Science*, 73, 196-203.