THE EFFECT OF A MEAT STRETCHING DEVICE ON THE TENDERNESS OF HOT-BONED BEEF TOPSIDES AND ROSTBIFFS

Johanne M. Taylor[1*], David L. Hopkins[1], and Remy van de Ven[2]

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

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

[*]Corresponding author (phone: +61-2-6349-9741; fax: +61-2-6342-4543; e-mail: johanne.taylor@industry.nsw.gov.au)

***Abstract*— Methods to improve tenderness in meat include mechanical approaches, such as stretching. An experiment was undertaken to assess the impact of SmartStretch™ technology on the tenderness of hot boned beef topsides (m. *semimembranosus*) and rostbiffs (mainly m. *gluteus medius*). Control and stretched primals from the same animals were compared and both shear force and sensory assessment undertaken. There was no effect of stretching on rostbiff or topside shear force (P > 0.05), but the variation for shear force of stretched rostbiff samples was significantly (P > 0.05) reduced compared to unstretched samples. There was no significant (P > 0.05) sensory benefit for either primal from stretching. There was substantial unexplained variation for sensory data and also significant variation between samples contributing to the lack of difference between treatments.**

***Index Terms*—sensory, tenderness, beef, shear force.**

I. INTRODUCTION

Hot-boning of beef has many financial advantages to the beef processing industry. Savings can be made primarily by reduction in storage, refrigeration and transport costs as compared to cold-boned beef (Pisula & Tyburcy 1996). There is however, a negative perception of hot-boning on the consumer acceptance of the product. White O'Sullivan, Troy & O'Neill (2006) found that hot-boning of beef resulted in both higher shear force and poorer sensory tenderness scores. Stretching pre-rigor of hot-boned beef striploins (Toohey, Hopkins, van de Ven, Thompson & Geesink, 2009), sheep meat topsides (Toohey, Hopkins, Lamb, Nielsen & Gutzke, 2008) and sheep meat legs (Toohey, Hopkins, Nielsen & Gutzke, 2009), 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 tenderness and consumer acceptance of stretched and unstretched beef topsides and rostbiffs were compared using SmartStretch™ technology.

II. MATERIALS AND METHODS

Six female cattle with eight permanent incisors and with carcase weights between 175-265kg were used for the experiment. The carcases were hot-boned under the normal operations of the abattoir, involving electrical stimulation of the carcase after death and the hot-boning of the primals within an hour of death. Twelve topsides (Anon. HAM No. 2000) and 12 rostbiffs (Anon. HAM No. 2110) were removed on the chain and the fat, sinew and epimysium removed. The m. *adductor* was removed from the topside and discarded. The remaining m. *semimembranosus* was then trimmed to 17cm wide and the pairs of samples from each animal were allocated at random to two treatments: i) vacuum packed control or ii) SmartStretch™ and packaged using a SmartStretch/Shape prototype under development by Meat and Livestock Australia and Meat and Wool New Zealand (Toohey & Hopkins, 2009). The rostbiffs were likewise allocated to the control or SmartStretch™ treatments. The samples were frozen (~-22ºC in a plate freezer) within 2 hours of death and stored frozen until sampling.

The length of the topsides and the rostbiffs was measured and those that were stretched were re-measured after stretching. pH and temperature measurements were taken at the caudal end of each primal within 1.5 hours of death and prior to treatment. 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). Muscle temperature was measured using a stainless steel cylindrical probe attached to the same meter. The pH meter was calibrated before use using buffers of pH 4.0 and pH 6.8 at room temperature.

The samples were split and the caudal portion of each sample used for sensory assessment in a method adapted from Gee & Ross (2006). The samples were defrosted in a refrigerator for 36 hours and three 15mm slices of each sample taken across the primal. Two sensory sessions, one for each cut (topside and rostbiff), were conducted on two consecutive days, with twenty tasters (n = 20) used for each session. Some of the tasters were common to both sessions.

Each session was conducted over a 75 minute interval during which time each taster tasted six portions of meat, one from each of six cook batches. Each cook batch comprised five slices, one from each of five of the twelve samples. Slices were cooked at ~220ºC for between 5 and 6 minutes to a medium degree of doneness on a clam-grill. Following cooking each slice was cut into four portions and the twenty portions per cook batch were allocated to the 20 tasters for scoring, one portion per taster. Tasters scored each sample for tenderness, flavour and juiciness and provided an overall liking score, all on a 0-100 scale. The allocation of samples to cook batch and subsequent allocation of portions to taster was designed to balance the treatments (Control and Stretched) and samples to cook batches and to tasters and also to balance any carry over treatment effects from the previous portion tasted. The design for each session was generated separately using DiGGer (Coombes, 2009).

The cranial portion of each sample was used for shear force testing. Samples (~100gm) were cut using a bandsaw and cooked from frozen in plastic bags in a water bath at 71ºC for 45 minutes. These were then cooled in cold water for 30 minutes, removed from plastic and patted dry with a paper towel. The sample was cut into ten 10mm by 10mm slices and shear force measured using a G2 Tenderometer™ (Cummings, Pitt, Simmons, Johnson, McGurk & Daly, 2008).

Linear mixed model methods were used to analyse, separately, the sensory data for the 2 primals. For analysis of each of response variables, tenderness, flavour, juiciness and overall liking, the model included as fixed effects the stretch treatment of the current and previous sample tasted and the interaction between these two factors. Animal, sample, cook batch, interaction between sample and cook batch, position on the grill during cooking and taster were included as random effects. The model for shear force included the cooking loss, the primal, the stretch treatment and the interaction between the primal and stretch treatment as fixed effects and animal, interaction between animal and primal and samples within primal as random effects. Cooking loss was included as a co-variate. Differences between predicted means were based on the LSD. 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 interference.

III. RESULTS AND DISCUSSION

There was no significant difference between the control and stretch treatment for either primal from the sensory analyses. The predicted means and average standard errors for each treatment on each muscle are given in Table 1. As expected for any tests involving people, the results were highly variable. Variation across samples and the taster were the two largest sources of variation, whilst cook batch and cooking position on the grill contributed little to the variation. There was a lot of unexplained variation in the responses.

On average, the initial pH of the samples collected was 5.7 at 36.9ºC, suggesting that the muscles were close to rigor at the time of stretching. Electrical stimulation is used to reduce pH rapidly during chilling, thereby reducing cold induced shortening, enabling the freezing of primals in a hot boning plant soon after boning (Hwang, Devine & Hopkins, 2003). Muscles close to rigor may not stretch significantly as actomyosin bonds that are formed at rigor prevent filament movement (Hopkins & Thompson, 2002). There was an average 21% increase in length achieved with stretching across primals.

Table 1. Predicted means *(av s.e.)* of tenderness, flavour, juiciness and overall scores for each treatment as related to the previous treatment.

				Topside					
Previous Treatment	**Treatment**	**Tenderness**		**Flavour**		**Juiciness**		**Overall**	
Control	**Control**	38.2	*(7.5)*	52.1	*(5.3)*	53.4	*(8.0)*	46.2	*(6.7)*
Control	**Stretch**	36.6	*(7.0)*	47.7	*(4.6)*	46.1	*(7.4)*	44.4	*(6.1)*
None	**Control**	19.9	*(9.3)*	42.6	*(6.9)*	48.3	*(10.9)*	22.2	*(8.4)*
None	**Stretch**	25.5	*(8.2)*	47.3	*(6.0)*	56.6	*(9.9)*	38.2	*(7.3)*
Stretch	**Control**	37.8	*(7.0)*	56.6	*(4.6)*	50.5	*(7.4)*	48.3	*(6.1)*
Stretch	**Stretch**	33.4	*(7.8)*	50.0	*(5.7)*	48.3	*(8.3)*	42.8	*(7.0)*
	Mean	31.9	*(7.8)*	49.4	*(5.5)*	50.5	*(8.6)*	40.3	*(6.9)*
				Rostbiff					
Control	**Control**	37.6	*(7.8)*	48.4	*(5.6)_*	45.9	*(6.8)*	44.7	*(7.0)*
Control	**Stretch**	50.7	*(7.2)*	50.6	*(4.9)*	50.7	*(6.2)*	50.7	*(6.5)*
None	**Control**	33.2	*(10.4)*	37.5	*(7.2)*	36.8	*(10.1)*	34.3	*(8.7)*
None	**Stretch**	34.8	*(9.4)*	50.3	*(6.4)*	36.7	*(8.9)*	43.2	*(7.7)*
Stretch	**Control**	37.2	*(7.2)*	44.8	*(5.0)*	44.8	*(6.2)*	39.7	*(6.5)*
Stretch	**Stretch**	50.1	*(8.1)*	49.0	*(6.0)*	46.4	*(7.3)*	52.2	*(7.3)*
	Mean	40.6	*(8.3)*	46.7	*(5.8)*	43.6	*(7.6)*	44.1	*(7.3)*

The shear force results showed that there was no significant reduction in the shear force in the rostbiff resulting from the stretch treatment when cooking loss (average = 18.4%) was included as a covariate, although there is a large absolute difference in the predicted means. There was also no significant reduction in the shear force in the topside resulting from the same stretch treatment, whereas previous work suggested that this same technology had the potential to improve the tenderness of the topside (Toohey, Kerr, van de Ven & Hopkins, 2010). The predicted means and average standard errors for shear force are shown in Table 2.

Table 2. Predicted mean (*av s.e.*) shear force (N) according to treatment.

Treatment	Topside			Rostbiff		
Control	67.3	*(2.6)*	ab	83.1	*(9.6)*	ab
Stretch	73.0	*(2.7)*	b	64.4	*(2.6)*	a

Means without a following letter in common are significantly different P = 0.05.

Perry, Thompson, Hwang, Butchers & Egan (2001) found that the relationship between tenderness and shear force tended to plateau at higher shear forces. Indeed Destifanis, Brugiapaglia, Barge & Dal Molin (2008) suggested that a Warner-Bratzler shear force value exceeding 52.7N is unacceptable to consumers. Work done by Hopkins, Toohey, Kerr & van den Ven (2010) suggests that the Warner-Bratzler shear force is ≈ 0.8 of the G2 Tenderometer shear force. This figure would equate to approximately 66N shear force as measured by the G2 Tenderometer. Rosenvold, North, Devine, Micklander, Hansen, Dobbie & Wells (2008) used a tenderometer value of 60N as the cutoff for consumer acceptability. It is, therefore, not surprising that there was no significant difference found in the sensory tenderness scores with very tough samples, given the results of Perry et al. (2001) which suggest that with very tough meat sensory testers lose the powers of discrimination. In comparison shear force measurements do provide a higher level of discrimination. It is proposed that, based on the shear force results for the rostbiff, a larger sample size may have detected a significant difference between treatments.

Thompson (2002) found that a benefit can be gained through stretching by a reduction in the variation in consumer sensory responses, suggesting a less variable product is gained from stretching. A significant ($P < 0.05$) reduction in the shear force variability was gained by stretching the rostbiff, with the variance component of shear force decreasing from 357.0 (s.e.68.7) to 104.0 (s.e. 11.5) with stretching. Such a reduction lessens the likelihood that consumers will be encounter very tough meat. Reducing variability in the muscle improves consumer confidence in the eating quality of the product.

IV. CONCLUSION

SmartStretch™ technology has the potential to improve the tenderness of hot-boned rostbiffs and reduce variability, which would contribute the value of the cut. Further validation of the results is needed based on a larger sample of primals given the variation found in this study, but the low pH of the meat (due to very effective electrical stimulation) has also likely impacted on the effectiveness of the stretching technology and this must be considered in future work.

ACKNOWLEDGEMENT

The financial support provided by Meat and Livestock Australia and Industry & Investment NSW is greatly acknowledged. The technical assistance of Susan Langfield, Fumie Chiku, Matthew Kerr and Tracy Lamb (I&I NSW) with the conduct of the sensory testing and laboratory testing is gratefully acknowledged. We are incredibly grateful to the staff of I&I NSW at the Orange Agricultural Institute for participating in the sensory testing. The support from the management and staff of the cooperating abattoir was invaluable to the collection of the samples and is gratefully acknowledged.

REFERENCES

Anonymous (1998). Handbook of Australian meat. 7th edn. Authority for Uniform Specification Meat and Livestock, Brisbane, Australia.

Coombes, N. (2009). DiGGer: DiGGer design generator under correlation and blocking. R package version 0.2-1. http://www.austatgen.org/files/software/downloads

Cummings, T.L., Pitt, A.W., Simmons, N.J., Johnson, N.V., McGurk, J.M., & Daly, C.C. (2008). A simple and portable electric device to measure cooked meat tenderness. In Proceedings 54th International Congress of Meat Science and Technology (Session 8, Paper 22), Cape Town, South Africa.

Destefanis, G., Brugiapaglia, A., Barge, M.T., & Dal Molin, E. (2008). Relationship between beef consumer tenderness perception and Warner-Bratzler shear force. *Meat Science*, 78, 153-156.

Gee, A., & Ross, I (2006). Protocols for the preparation, fabrication, assembly, cooking, serving, sensory testing and scoring of commercial meat cuts from lamb, yearling and mutton. Cosign Pty. Ltd., Sawtell, NSW, Australia.

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

Hopkins, D.L., & Thompson, J.M. (2002). Factors contributing to proteolysis and disruption of myofibrillar proteins and the impact on tenderisation in beef and sheep meat. *Australian Journal of Agricultural Research,* 53, 149-166.

Hopkins, D.L., Toohey, E.S., Kerr, M.J., & van de Ven, R. (2010). Comparison of the G2 Tenderometer and the Lloyd Texture Analyser for measuring shear force in sheep and beef meats. *Meat Science* (submitted).

Hwang, I.H., Devine, C.E., & Hopkins, D.L. (2003). The biochemical and physical effects of electrical stimulation on beef and sheep meat tenderness. *Meat Science*, 65, 677-691.

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

Perry, D, Thompson, J.M., Hwang, I.H., Butchers, A., & Egan, A.F. (2001). Relationship between objective measurements and taste panel assessment of beef quality. *Australian Journal of Experimental Agriculture*, 41, 981-989.

Pisula, A., & Tyburcy, A. (1996). Hot processing of meat. *Meat Science*, 43, S125-S134.

Rosenvold, Katja, North, Mike, Devine, Carrick, Micklander, Elisabeth, Hansen, Per, Dobbie, Peter, & Wells, Robyn (2008). The protective effect of electrical stimulation and wrapping on beef tenderness at high pre rigor temperatures. *Meat Science*, 79, 299-306.

Thompson, John (2002). Managing meat tenderness. *Meat Science*, 62, 295-308.

Toohey, Edwina, & Hopkins, David (2009). Change in form and function of hot-boned sheepmeat forquarter. In Proceedings 55th International Congress of Meat Science and Technology (pp.486-489), 16-21 August 2009, Copenhagen, Denmark.

Toohey, E.S., Hopkins, D.L., Lamb, T.A.. Nielsen, S.G. and Gutzke, D. (2008). Accelerated tenderness of sheep topsides using a meat stretching device. In Proceedings 54th International Congress of Meat Science and Technology (Session 7B, Paper 18), 10-15 August 2008, Capetown, South Africa.

Toohey, Edwina, Hopkins, D., Nielsen, S., & Gutzke, D. (2009). Impact of a meat stretching device on sheep meat quality. In Proceedings 55th International Congress of Meat Science and Technology (pp.490-493), 16-21 August 2009, Copenhagen, Denmark.

Toohey, E.S., Hopkins, D.L., van de Ven, R., Thompson, J.M., & Geesink, G.H. (2009). Pre-rigor interventions: The effect on myofibrillar degradation and shear force. In Proceedings 55th International Congress of Meat Science and Technology. (pp 83-87), 16-21 August 2009, Copenhagen, Denmark.

Toohey, Edwina S., Kerr, Matthew L., van de Ven, Remy, & Hopkins, David L. (2010). The effect of SmartStretch™ technology on the tenderness of beef topsides and cube rolls. In Proceedings 56th International Congress of Meat Science and Technology, Jeju, South Korea (in press).

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 bovine muscles. *Meat Science*, 73, 196-203.