final report

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HW Greenham SmartStretch™ and SmartShape™ meat product development for Australian and export markets – Milestone 1

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Milestone

Market evaluation of pre-commercial products, organoleptic qualities, shelf-life testing and product integrity. This shall include sensory evaluation of meat by researchers from Industry & Investment, NSW.

Abstract

Two visits were made to HW Greenham and Sons hot-boned beef plant at Tongala in northern Victoria. The first visit introduced the SmartShape™ machine to the plant, involved the training of one dedicated operator and allowed the collection of samples for sensory assessment. The second visit involved troubleshooting problems the staff were having, collection of samples for in-house assessment and demonstrating the machine with cold-boned product. Sensory assessment of stretched versus unstretched topsides and rostbiffs was conducted, along with shear force measurements. There was no significant difference between the stretched and unstretched samples, although the variance of shear force for stretched rostbiff samples was significantly ($P < 0.05$) reduced compared to unstretched samples. Trends identified suggest that further assessment should be conducted on a larger number of rostbiff samples as there may be a tenderness benefit of stretching this cut.

Project objectives

By 15 November 2010:

- Support the MLA-Greenhams MDC project for SmartShape-Stretch.
- Support the market evaluation and production of pre-commercial SmartShape-Stretch products at Greenhams Victoria and/or Tasmania. This shall include organoleptic qualities, shelf-life testing, product integrity and sensory evaluation of meat by researchers from Industry and Investment, NSW.
- Support the design, build, installation, commissioning, and maintenance of the SmartShape-Stretch systems at Greenhams.
- Identify any changes to the SmartStretch and SmartShape technology required.

Success in achieving milestone

The requirements of the milestone have been met, with successful training and instruction of Greenhams staff in the operation of the SmartStretch™ machine. Sensory testing was successfully achieved given the constraint on the number of samples which could be tested. In a short time the data from the sensory testing was collated, analysed and a paper written for an International conference. This work should direct future sensory work that Greenham's may wish to conduct. This first phase of the project has identified an issue with the splitting of packaging which requires further investigation.

Training and demonstration

Site visit to HW Greenham and Sons, Tongala Victoria

Wednesday 10th and Thursday 11th March 2010

Attendees: Barry Lee (Connectia International), George Waldthausen (MLA), David Carew (MLA), Darren Maloney (Operations Manager, HW Greenham and Sons), Phil Green (Greenleaf Enterprises), Steve Bonner (Greenleaf Enterprises), Peter Greenham Jnr (HW Greenham and Sons), Johanne Taylor (I&I, NSW)

Products collected for further assessment:
Six stretched pieces of each of the following cuts were collected -

- Rostbiff (HAM 2110)
- Cube roll (HAM 2244)
- Outside flat (HAM 2050)
- Knuckle (HAM 2070)
- Topside (HAM 2001), adductor removed and m. *semimembranosus* trimmed to 17cm width.

The company collected 22 boxes of cube rolls subsequent to this visit.

Feedback: The company was very interested in pursuing SmartStretch™ technology as a value add to their existing hot-boned product. To that end a SmartStretch™ operator, Ben Mathes, was trained.

There had been a proposal to collect both striploins and tenderloins for stretching. Both were considered non-viable products by the company and were not collected.

Samples of rostbiff and topside were collected from 6 carcases for sensory testing. Within each carcase one of each cut was stretched and the other taken as a control (non-stretched). The sensory testing was originally planned to take place in conjunction with a company client, Beak and Johnston (March 2010), but they withdrew their support. The testing was subsequently conducted using Industry & Investment, NSW staff at Orange on April 14th and 15th 2010.

Figure 1: Cube roll

Figure 2: Stretching a cube roll

Figure 3: Stretched cube roll

Outcomes: Samples were prepared for further evaluation and the machine left on site for 3 weeks.

Further issues: The Company reported the failure of one rubber after 1 day of operation in plant and the failure of a second rubber after a further day and a half of operation. The company also reported that they were running out of packaging. This could have been taken as an indicator of a large volume of product being treated, but constant failure in the packaging was also reported.

There was extensive discussion with Fix-All Services over this issue. It was determined that the rubber was failing because it was constantly being over stretched on the expand phase of operation. Suggestions for combating this problem were sought and received and were trialled during a follow-up trip to Greenhams on 30th and 31st March 2010.

Site visit to HW Greenham and Sons, Tongala Victoria

Tuesday 30th and Wednesday 31st March 2010

Attendees: Peter Greenham Jnr and Robert Ryan (HW Greenham and Sons), Johanne Taylor (I&I, NSW)

Products collected for further assessment:
12 boxes each containing a stretched example of the following four cuts was produced:

- Rostbiff (HAM 2110)
- Cube roll (HAM 2244)
- Outside flat (HAM 2050)
- Inside meat (HAM 2035)

Cold-boned product (ex HW Greenham and Sons, Smithton, Tasmania) SmartShaped:

- Rostbiff (HAM 2110)
- Cube roll (HAM 2244)
- Outside flat (HAM 2050)

Feedback: There were two purposes for visiting the plant at this time. The first was to assist with the preparation of hot and cold-boned product for further assessment by the company and the second was to ensure that there were no further breakages of the machine and/or to troubleshoot any problems as they arose.

The machine was operated strictly to the instructions provided by Fix-All Services. This caused some other issues, particularly as they relate to OHS and operating the machine in a commercial environment. The rubber opening sizes were insufficient for the product sizes being assessed, which caused the operators to force product into the rubber. Other issues related to packaging, which split at inopportune times.

The company remains interested in the SmartShape™ system, but needs to see the rubber splitting and packaging issues resolved before they are willing to conduct further in-house trials.

The company requested the removal of the SmartStretch™ machine at the end of the visit.

Sensory Testing

Aim
The aim of this experiment was to establish whether or not there was a sensory or measured tenderness benefit gained from SmartStretching hot-boned beef primals.

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.

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.

Figure 4. Frozen stretched and control samples labeled at the cranial (G2

Tenderometer) and caudal (Sensory assessment) ends

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. Consumers were also asked to give a regard score for each sample – unsatisfactory, good every day, better than every day and premium quality. 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).

Figure 5: One of the sensory testing participants, Dr Murray Fletcher, Orange Agricultural Institute.

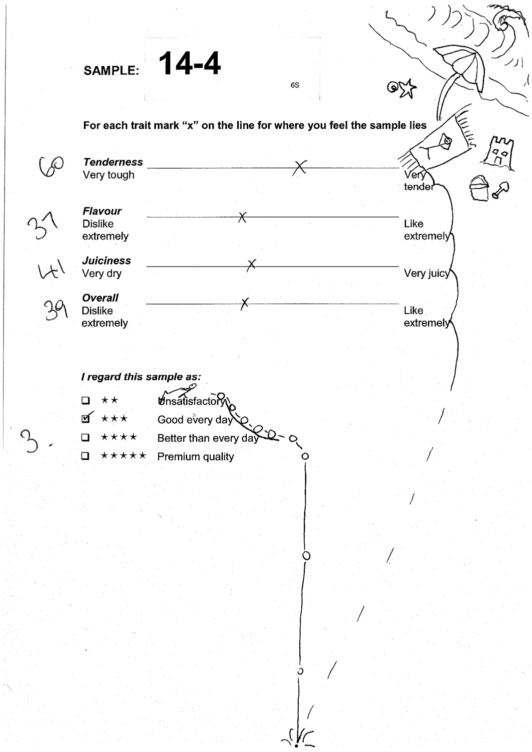


Figure 6: Completed sensory test survey sheet from a good humoured participant.

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 71°C 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.

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)*

There was no significant difference in the responses to the statement "I regard this sample as..". The number of responses for each cut and treatment are presented in Table 2. Of interest are the absolute values for the rostbiff stretch samples with two thirds of the responses indicating that this cut was "good every day" and over eighty percent of responses being favourable. This is in stark contrast with the other three cuts and treatments where almost half of all responses regarded the sample as unsatisfactory. This suggests that there could be a sensory benefit to the rostbiff from stretching. This needs to be validated by further study and a larger sample set.

Table 2. Number of responses for each cut and treatment for "I regard this sample as.."

	Unsatisfactory	Good every day	Better than every day	Premium quality
Topside-Control	27	24	7	1
Topside-Stretch	26	27	6	0
Rostbiff-Control	28	25	7	0
Rostbiff-Stretch	11	39	8	1

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 was 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 3.

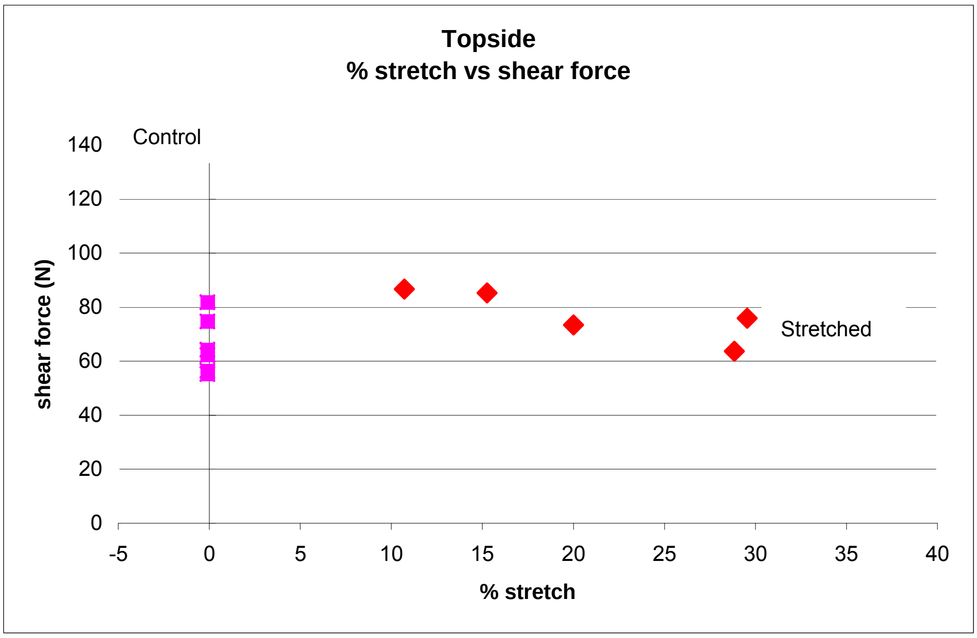
Table 3. Predicted mean (*av s.e.*) shear force (N) according to treatment.

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 the very tough samples used in this study, 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 and if samples from better quality cattle were used then this would bring tenderness levels back to a zone where consumer discrimination was more likely.

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. This reduction in variance is presented in Figure 7. This shows that the range in shear force for the rostbiff has been halved by 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.



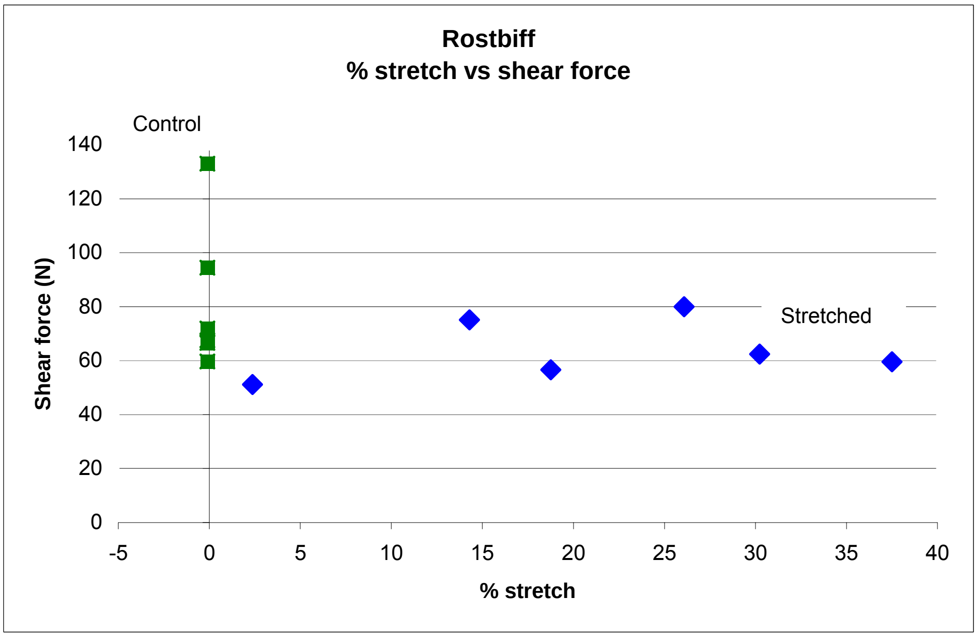


Figure 7: Stretch applied versus shear force measured with the G2 tenderometer for the topside (top) and rostbiff (above) for the control and stretched samples.

The spread of the data also shows that there is a poor relationship between the increase in length of a cut and shear force particularly in the rostbiff, but there are too few data points for meaningful analysis of this relationship.

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.

Although there were no significant differences found in the results the absolute values in the rostbiff for the stretched vs control suggested that this cut could benefit from stretching. Further research with this cut is strongly suggested.

Overall progress of the project

This MDC is adjunct to the project A.QMT.0039. The current progress of that project includes a number of recent demonstrations of the technology to other potential commercial partners and the conduct of three experiments designed to clarify and validate the technology's potential to improve the quality of hot-boned primals.

This project has made progress given some of the operational issues that emerged during this Phase. The next phase requires careful planning to maximise the probability of commercially viable products being produced for Greenhams and this will require consideration of feedback from Beak & Johnson.

Recommendations

Testing of primals from better quality cattle is suggested for consideration for the next phase of the MDC by Greenhams.

The absolute results for the rostbiff for the G2 and sensory testing are encouraging and suggest that, in the next experiment, rostbiffs should be tested rather than cube rolls. This will give the greatest chance of a significant difference between control and stretch.

The current SmartShape/Stretch prototype is not robust and this will limit the perceived commercial applications of the machine in the beef industry. It is recommended that limiters be placed on the machine to minimise the risk of inappropriate operation. It is also recommended that, considering the machine is not really designed for larger sized beef primals, consideration be given to producing a prototype that is larger and more robust to cope with the larger beef primals of interest to the Australian beef industry.

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Appendices

1. Acknowledgements

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