final report

Project code: A.SCT.0014

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Date submitted: September 2006

PUBLISHED BY
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Evaluation of high frequency immobilisation (table) in sheep slaughter to maximise retail shelf life

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

Abstract

From both kills the chumps and LL were removed from the left side of the carcase and in addition to this the LL was also removed from the right side of the carcase. Samples for colour measurements (3 cm steak) were taken from each of the chumps where possible. Either the left or right portion of the LL was aged for 1 or 7 day and this allocation was a performed randomly to ensure portion location was not confounded with ageing period. From these different portions a 1 and 7 day aged tenderness sample was taken, a 1 gram sample for final pH (7 day aged), a sample for sarcomere length, drip loss and a slice (3 cm) for colour measurements.

3.3.4 Final pH

A 1 gram sample was taken from the 1 day aged LL and 7 day aged LL for determination of a 24 h and a final pH. This was determined using an iodoacetate method adapted from that described by Dransfield *et al.* (1992) and as described by Hopkins and Toohey (2006).

3.3.5 Shear force testing

From the LL 1 and 7 day samples were taken, frozen at -20°C and subsequently tested for peak shear force as described by Thompson *et al.* (2005).

3.3.6 Meat colour

The meat colour reflectance of the LL and chump from both kills were measured with an initial colour measurement on 1 day aged samples followed by measurements taken once a day for 7 days resulting in 7 measurements per sample. For the initial measurement a fresh surface was prepared by cutting in a transverse direction across the sample and then these were positioned randomly on black plastic trays and over wrapped with polyvinyl chloride clear film and placed under continuos lighting (1050 Lux) in a chiller at 4ºC. After 30-40 min from cutting, a colour reading was taken. A Hunter Lab MiniScan XE spectrophotometer (Hunter Associates, Reston, VA, Model D45/0-s 6 mm port with 5 mm area viewing) set for *L** values indicating lightness/darkness (higher = lighter meat), *a** values (higher = redder meat) and *b** values (higher = yellowier meat) with a D65 at 10 degrees illuminate was used. The MiniScan was calibrated using both white and black tiles.

3.3.7 Sarcomere length

Sarcomere length was tested using laser diffraction as described by Bouton *et al.* (1978).

3.3.8 Drip loss

This method has been adapted from that described by Christensen (2003). Approximately a 2cm thick sample was taken from the LL ~ 28 hours after death. A cylindrical cut was made using a blade knife 25mm in diameter. This sample was placed into a meat extract collecting tube (which captures juices in the bottom of the tube) where an initial tube weight was recorded using calibrated 4 decimal place electronic scales (weight A). The tube + sample weight (weight B) were recorded to 4 decimal places and the samples were then stored at approximately 4ºC for 48 hours. After 48 hours the

meat samples were removed from the tubes and placed into a tared weigh boat and weighed to 4 decimal places (weight C).

Drip loss (%) = (B – A – C) (100)

Drip loss results were only recorded for kill 2 in this study.

3.2 Statistical analysis

Carcase and meat quality traits were analysed using a residual maximum likelihood (REML) procedure (Genstat 7.1, 2004), which contained a fixed effect for treatment (immobilisation, no immobilisation); to estimate the means and standard errors of the differences with kill day and consignment as a random terms. For GR, carcase weight was used as a covariate and for initial pH, initial temperature was used as a covariate. If significant variance due to kill day was detected then this was fitted in the model as a fixed effect so as to estimate means.

The rate of pH decline relative to time from the first measurement post-mortem for each carcase was described using data for 7 different sample points using linear regression (Genstat 7.1, 2004). This was used to predict temperature at pH 6.0 (for 63 carcases), pH at 25 & 18 ºC and the slope.

4 Results and Discussion

4.1 Carcase, pH & temperature traits

There was no difference between immobilised and non-immobilised carcases for any traits measured in Table 1 including; weight, GR, sarcomere length, initial pH, 1 day pH (28 h), 7 day aged pH, rate of pH decline, predicted temperature at pH 6.0, predicted pH at 18ºC or predicted pH at 25 ºC (Table 1). It should be noted that there was a significant difference between kill days for most traits measured in Table 1.

Table 1. Predicted means (a.v. s.e.d.) of carcase weight, GR, sarcomere length, drip loss % (kill 2 results only), pH, rate of pH decline linear, predicted temperature @pH 6.0, predicted pH at 18 ºC and predicted pH at 25 ºC for kill 1 & 2.

Treatment	***Immobilisation^***	***No Immobilisation^***	*av. s.e.d*
Carcase Weight (kg)	22.0a	22.6a	*1.25*
GR (mm)*	12.4a	12.1a	*1.45*
Sarcomere length (μm)	1.75a	1.74a	*0.05*
Drip loss % (kill 2 only)	0.73a	1.87a	*0.52*
Initial loin pH**	6.30a	6.26a	*0.09*
28 hour pH	6.16a	6.19a	*0.08*
7 day aged pH	5.95a	5.93a	*0.08*
pH slope (rate of pH decline)	0.0197a	0.0167a	*0.0036*
Pred temp @ pH 6.0 exp[#]	17.8a	19.8a	*3.71*
Pred pH @ 18 ºC	6.09a	6.04a	*0.10*
Pred pH @ 25 ºC	6.22a	6.15a	*0.08*

Means followed by a different letter in a row (a, b) are significantly different ($P < 0.05$), ^electrical treatment is a high frequency immobiliser table. *Adjusted to a hot carcase weight of kg 25.2, ** adjusted for initial temperature 35.3 ºC, [#]predicted values for 63 animals.

4.2 Shear force testing

There was no significant difference between treatments for shear force or cooking loss percentage. However tenderness was significantly different between 1 and 7 days ageing (39N & 22N respectively).

4.3 Objective colour scores

There was no significant difference ($P > 0.05$) between treatments for initial loin and chump or final loin meat colour based on, *L**, *a**, *b**, ratio or Chroma values (Table 2). However the final chump *L**, *a**, *b** and Chroma values were different ($P < 0.05$) between treatments with immobilised carcases having lower *L** values, higher *a** values, higher *b** values and higher chroma values.

Table 2. Predicted means and standard error of difference between immobilised and non immobilised carcases for chump and loin initial (1 day aged) and final (7 days aged) *L, *a**, *b**, ratio and chroma values for kills 1 and 2.**

	Initial			Final		
	Immobilised	Non immobilised	*av. s.e.d*	Immobilised	Non immobilised	**av. s.e.d**
Chump						
*L**	33.8a	34.6a	*2.1*	35.2a	38.6b	*2.3*
*a**	10.1a	10.0a	*0.8*	7.8b	7.0a	*0.6*
*b**	10.6a	10.2a	*0.8*	11.4b	10.5a	*0.4*
Ratio	3.5a	3.4a	*0.3*	1.6a	1.6a	*0.2*
Chroma	13.3b	12.0a	*1.0*	13.8b	12.7a	*0.9*
Loin						
*L**	30.8a	32.2a	*1.8*	35.2a	36.8a	*2.2*
*a**	9.4a	9.2a	*1.0*	7.7a	7.7a	*0.7*
*b**	10.1a	9.8a	*1.1*	10.8a	10.0a	*0.9*
Ratio	3.5a	3.45a	*0.2*	1.8a	1.7a	*0.1*
Chroma	13.9a	13.6a	*1.2*	13.4a	12.8a	*1.0*

Means followed by a different letter in a row (a, b) are significantly different ($P < 0.05$).

The wavelength ratio of 630nm/580nm is a good reflection of the level of metmyoglobin formation. As can be seen for the loin there was no difference in the rate of formation of this pigment based on the ratio values between treatments (Figure 1).

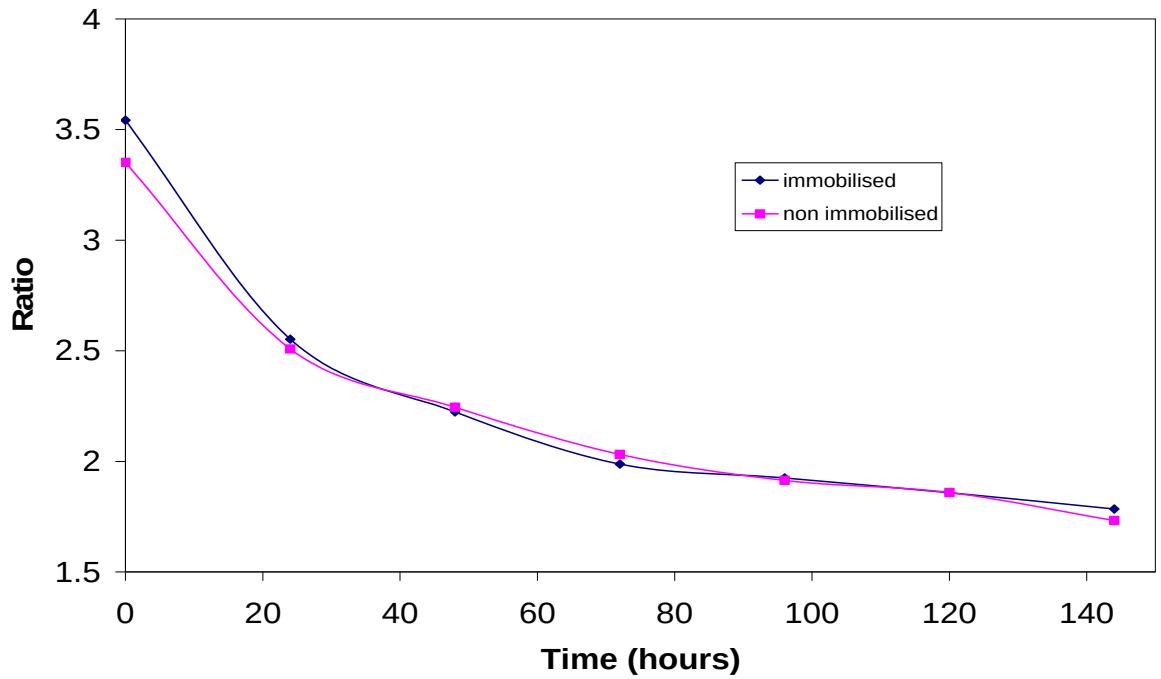

Figure 1. Change in the spectral ratio 630/580 nm of the loin during display for 7 days.

The chump also showed that there was no difference in the rate of formation of this pigment based on the ratio values between treatments (Figure 2).

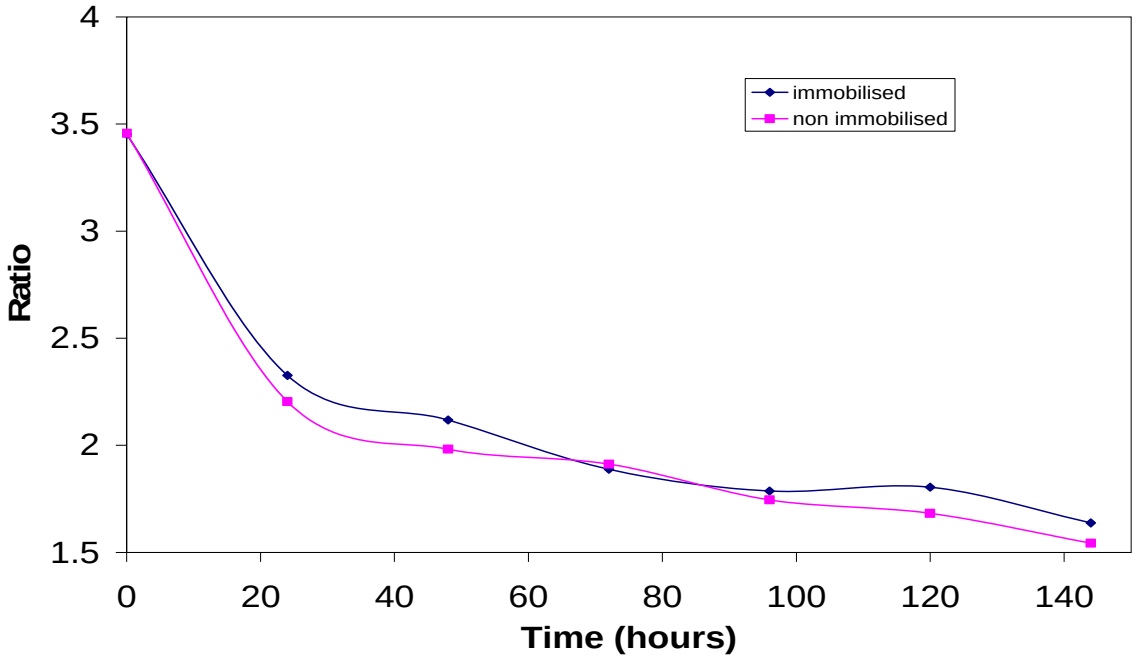

Figure 2. Change in the spectral ratio 630/580 nm of the Chump during display for 7 days.

From the results in the present study it was shown that immobilisation had no significant effect on all pH and temperature traits in any practical way. There was notable variation between kill days for most of the traits measured. This difference would have been driven by the variation in animals processed over these two days largely due to the fact that the processor purchases a large percentage of saleyard lambs, whereas direct purchase may help to reduce this variation.

Sarcomere length results indicated that no shortening had occurred and that there was no significant difference between treatments. As a shear force value of 40N is suggested as the upper tenderness/toughness threshold for consumer acceptability based on the recent work of Hopkins *et al.* (2006a), the mean value of 39 N for samples after 1 day of ageing and 22 N after 7 days of ageing in the present study indicates that most if not all samples would have an acceptable degree of toughness after 7 days of ageing. This improved tenderness with increased ageing period found in the present study supports numerous previous reports (e.g. Pearson and Young 1989).

There was no significant difference ($P > 0.05$) between immobilised and non immobilised initial loin and chump or final loin meat colour. However the chump final L^*, a^*, b^* and Chroma values showed that chumps from non immobilised carcases had a lighter meat colour, but those from immobilised carcases had a redder and yellowier colour. It is contended that these differences would not translate into a meaningful consumer response. Previous work by Toohey and Hopkins (2006) determined that if chumps have measured ratio values of less than 3.3 then they would be considered unacceptable (browny red). In the present study the 3.3 value was used as the threshold to predict the time at which the meat would become unacceptable for both the loin and chump. The results show that there was no significant difference between stimulation treatments with the loin having a predicted acceptable display life time of -0.07 hours (immobilised) and 0.69 hours (non immobilised) and the chump having a predicted display life time of 2.09 hours

(immobilised) and 1.86 hours (non immobilised). This is an important finding which indicates no difference in the formation of metmyoglobin according to treatment.

5 Success in Achieving Objectives

The objective of this study was to evaluate the high frequency immobilisation table. This was achieved by examining pH and temperature profiles, objective meat colour, meat tenderness and sarcomere length. From the results it has been shown that the high frequency immobiliser table **alone** has minimal impact on any of the traits measured.

6 Impact on Meat and Livestock Industry – now & in five years time

This project has confirmed that the high frequency immobilisation table **alone** has minimal impact on pH and temperature traits objective meat colour, meat tenderness and sarcomere length. However the **advantage** of the high frequency immobilisation table is that it enables abattoir workers to begin processing the carcases safely within approximately 30 seconds of death with no apparent negative effect on meat quality traits.

7 Conclusions and Recommendations

The results obtained from this study show that there were minimal effects of the immobilisation treatment on pH and temperature, objective meat colour, meat tenderness and sarcomere length which does confirm some previous anecdotal evidence. There is no doubt that the high frequency immobilisation table has benefits in that it enables abattoir workers to begin processing the carcases safely within approximately 30 seconds of death with no apparent negative effect on meat quality traits. Therefore immobilisation as tested here can be promoted confidently to industry as a method to improve OH&S without a detrimental effect on meat quality.

The full suite of electrical inputs used by Fletcher's is a complex system and there is a potential need for further optimisation of each electrical component to determine the individual and cumulative impact on meat quality traits and how best to manage the electrical inputs for different types of carcases. Given we have only tested one component of the system we can not establish whether the total system has improved say meat colour. There may well be benefits for colour from the application of electricity for electronic bleeding as shown by Hopkins *et al.* (2006b), but this would need to be tested separately to establish the magnitude of this benefit. It is clear from this study that the high frequency immobilisation table does not impact appreciably on meat colour. Given the uniqueness of the multiple component system installed at Fletcher's it would seem prudent to examine the medium frequency immobilisation module and the electronic bleeding/stimulation modules at the start of the chain. This could be achieved by switching off these modules in a programmed way and then measuring pH and colour.

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9 Acknowledgements

The technical assistance of Tracy Lamb, Megan Moppett, and David Stanley (NSW DPI) is gratefully acknowledged. The study was funded by NSW Department of Primary Industries, Meat and Livestock Australia, and the Australian Sheep Industry Cooperative Centre. The valuable support and assistance of the management and staff of Fletchers International abattoir (Dubbo) was

paramount in the successful completion of this project and this is appreciated and acknowledged. This support was particularly important with respect to the removal of the carcases from the chain subsequent to stunning and exsanguination and then the subsequent return of the carcases to the chain after reflex kicking had ceased. In addition to this the support and advice from Paul Keane and Chris Mudford from Realcold Milmech Pty Limited is also gratefully acknowledged.