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IS THERE A MUSCLE-SPECIFIC RESPONSE TO THE VERY FAST CHILLING OF WHOLE LAMB CARCASSES?

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I. INTRODUCTION

Australian lamb carcasses are conventionally chilled for 24 h at 2–4°C, under a relative humidity > 90% and air speed of 0.2 m/s. This ensures that carcasses achieve a core temperature < 7°C within 16 h post-mortem, and achieve a degree of rigidity that assists during boning out [1]. It does, however, represent a cost to industry because of the associated and extensive chilled storage facilities. To reduce the (in)direct costs of conventional chilling, alternative methods have been explored. One method uses 'very fast chilling' (VFC) technology to significantly reduce carcass chilling times to ~ 7 h and thereby, carcasses could be boned out or dispatched on the same day as slaughter [1]. Recently, several studies have investigated the effect of VFC on meat and found that VFC enhanced meat tenderness and extended its shelf life - the latter being the result of reductions to the total bacterial count via VFC effects on enzymatic reactions and microbial growth [2]. Some additional benefits of VFC include a reduction to the running and capital costs of chilling equipment and improvements to operational efficiency [3]. However, no systematic study has been conducted on the changes in meat quality across different lamb muscles after VFC has been applied to the carcass. To support industry adoption, further research is needed to determine the effects of VFC on meat quality across the cuts of a lamb carcass. Therefore, this study aimed to investigate the effects of VFC on meat colour, ultimate pH, purge and drip losses, sarcomere length (SL) and shear force (SF) in various lamb muscles, and provide both theoretical and experimental insights to support the development of VFC technology.

II. MATERIALS AND METHODS

Shortly after slaughter, 48 grass-fed crossbred Dorper carcasses (15–35 kg hot carcass weight (HCW), age: 9-11 months old) were selected from a commercial abattoir (Mildura, AUS). These were suspended by their Achilles, not exposed to electrical stimulation, and transported to FreshXpress facility (Mildura, AUS) in a refrigerated container. Upon arrival, ~ 45 min post-mortem, the carcasses were divided into blocks of two based on their similar HCW and randomly allocated into either conventional group (n = 24; CON) or very fast chilling group (n = 24; VFC). CON carcasses were held under conventional chilling conditions (temperature: 4°C, relative humidity: 92%, and air speed: 0.2 m/s for 24 h). VFC carcasses were held under VFC conditions (temperature: -20°C, relative humidity: 92%, and air speed: 3 m/s) for 5 h before they were transferred into conventional chilling conditions for the subsequent 19 h. At 24 h post-mortem, all the carcasses were boned out and three muscles (*longissimus lumborum* (LL), *semimembranosus* (SM) and *triceps brachii* (TB)) of each carcass were collected. The muscles were vacuum packed separately and transported to the UNE Meat Science lab (Armidale, AUS), where they were aged at 2-4 °C.

At 5 days post-mortem, a fresh cut surface was prepared, bloomed for 30 min, and its colour measured at three sites per muscle sample with a Chroma Meter CR-400 (aperture: 8 mm, Konica Minolta, Osaka, JAP). Sample pH and temperature were measured using a TPS WP-80 pH and temperature meter (TPS Australia, Brisbane, AUS) calibrated at 2-4 °C using pH 4.0 and pH 6.8 standard buffers. Purge and drip losses were determined according to the methods of Holman et al [4]. Two sets of LL, SM and TB samples were frozen for SF and SL measurements. After freezing, SF samples were measured using the method described by Holman et al [4]. The peak SF was determined as the average of six repeated measurement. Sarcomere length was determined using a laser diffraction unit according to Bouton et al [5], with the final SL reported as the average of eight repeated measurements.

Data were analysed in *R* using multiple linear mixed models fitted with treatment, muscle and their interaction as fixed effects, and with HCW block as a random effect. Results were considered statistically significant at $p<0.05$.

III. RESULTS AND DISCUSSION

The purge (8.03%) and drip losses (0.93%) for the VFC group were higher than those in the CON group (5.58% and 0.69% respectively) (Table 1). Samples from the VFC group had significantly shorter sarcomere lengths (1.68 µm) than those from the CON group (1.75 µm). Treatment group did not have any significant effect on colorimetric parameters, ultimate pH or temperature.

Muscle was an important variable, given that it affected all the meat quality parameters investigated (p≤0.001). Specifically, the TB was found to have the highest *L** (40.4), pH (5.92), and sarcomere length (1.90 µm) and lowest temperature, purge and drip losses (3.53°C, 5.35% and 0.27% respectively) when compared to the LL and SM. The SM had the highest *a**, temperature and drip loss, while the LL had the highest purge loss (8.20%).

Table 1 – Physio-chemical characteristics of *longissimus lumborum* (LL), *semimembranosus* (SM) and *triceps brachii* (TB) muscles from the conventional (CON) and very fast chilled (VFC) lambs

		Treatment (T)		Muscle (M)			SEM	P value		
		CON	VFC	LL	SM	TB		T	M	TxM
Colour parameters	*L**	37.7	37.4	36.5^{b}	35.7^{c}	40.4^{a}	0.24	0.279	<0.001	0.259
	*a**	24.4	23.8	22.4^{c}	25.5^{a}	24.3^{b}	0.18	0.869	<0.001	0.158
	*b**	12.1	11.6	10.7^{c}	12.7^{a}	12.2^{b}	0.15	0.784	<0.001	0.056
	Chroma	27.2	26.5	24.9^{c}	28.5^{a}	27.2^{b}	0.22	0.836	<0.001	0.104
	hue	26.3	25.9	25.4^{b}	26.4^{a}	26.6^{a}	0.14	0.718	0.001	0.095
Ultimate pH		5.78	5.79	5.70^{b}	5.74^{b}	5.92^{a}	0.01	0.619	<0.001	0.984
Temperature (^{0}C)		4.43	4.51	3.93^{b}	5.95^{a}	3.53^{c}	0.12	0.642	<0.001	0.659
Purge loss (%)		5.58^{B}	8.03^{A}	8.20^{a}	6.93^{b}	5.35^{c}	0.27	<0.001	<0.001	0.806
Drip loss (%)		0.69^{B}	0.93^{A}	0.78^{b}	1.38^{a}	0.27^{c}	0.08	0.002	<0.001	0.302
Shear force (N)		45.1	44.0	44.4^{b}	53.9^{a}	34.2^{c}	1.14	0.655	<0.001	0.003
Sarcomere length (µm)		1.75^{A}	1.68^{B}	1.58^{b}	1.64^{b}	1.90^{a}	0.02	0.031	<0.001	0.176

SEM: standard error of the mean; A-B or a–c in the same rows in each factor with different letters are significantly different (p<0.05)

In the present study, there was a significant effect of treatment and muscle interaction on SF (p<0.05, Figure 1). The TB recorded the lowest values in both the CON and VFC treatments. Conversely, the highest SF values were found in the SM in both treatments and the LL in the CON treatment, and there was no significant difference in SF among them.

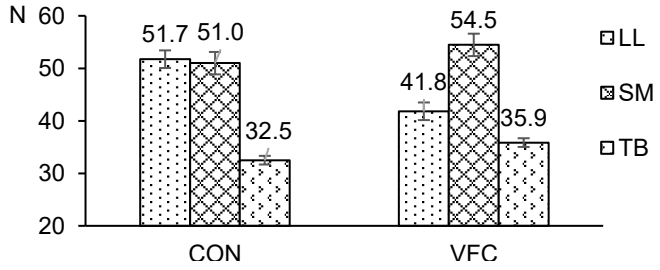


Figure 1 - Treatment and muscle interaction effects on the shear force of *longissimus lumborum* (LL), *semimembranosus* (SM) and *triceps brachii* (TB) muscles from the conventional (CON) and very fast chilled (VFC) lambs

CONCLUSION

It was apparent that VFC improved tenderness for the LL muscle. The VFC resulted in lamb meat having higher levels of purge loss and drip loss, and shorter sarcomere length. The chilling regime did not negate ultimate pH, colour, and SF of the meat in the SM and TB muscles. Muscle significantly affected all of the measured lamb quality parameters. The results also show that SF may be attributed not only to SL but also to entrinsic characteristics of the specific muscle such as fibre composition, proteolytic enzyme activity and connective tissue content. Collectively, these findings provide a basis for improving meat quality during the chilling process and support the promotion of VFC technology within the meat industry. However, further research is needed to identify the optimal parameters of VFC for regulating the development of rigor mortis and meat aging across different species.

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