A HIGH RIGOR TEMPERATURE, NOT SARCOMERE LENGTH, DETERMINES LIGHT SCATTERING PROPERTIES AND MUSCLE COLOUR IN BEEF *STERNOMANDIBULARIS*.

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I. INTRODUCTION

Meat colour is determined not only by the quantity and oxidative status of myoglobin, but also by the structural opacity and light scattering properties of the muscle fibres [1]. Light scattering is the deflection of light photons by particles in the medium which it transverses and in muscle is likely to be various structural elements, such as different regions of the sarcomere [2]. As both sarcomere length and rigor temperature will change the structure of the sarcomere, we hypothesize that (a) stretching muscles during rigor will generate a structure which favours light scattering by increasing the length of the I-band via longer sarcomeres, and (b) a high rigor temperature would facilitate the development of these structural alterations and also promote light scattering.

II. MATERIALS AND METHODS

M. *sternomandibularis* beef muscles were collected from both sides of 4 carcasses at 10 min post-mortem (PM). Muscles were cut into 3 equal length sections, yielding a total of 6 individual sub-samples per carcass. These samples were randomly allocated to one of 6 treatments in a 2 x 3 design; pre-rigor stretching; stretched or unstretched and pre-rigor temperature, 5, 15 or 35 °C. Muscles were stretched (~40 %) by clamping to a plastic tray, wrapped, then placed in relevant incubation temperatures for 16 to 20 h. The 5 °C treatment samples were kept at 5 °C until 30 h PM, to allow the muscle to reach final pH prior to processing. The pH of the muscle was measured and muscles were unwrapped and the colour was bloomed at 5 °C for 60 min. Triplicate colour measurements (lightness, redness and yellowness; L*, a* and b* values) were made perpendicular to the muscle fibre axis using a Minolta CR400 chromameter. Sarcomere lengths were measured on isolated myofibrils, as described in Hughes, *et al.* [3] Muscle fibre widths and global brightness, as an indicator of light scattering, were measured using reflectance confocal laser scanning microscopy (rCLSM) [3].

Data analysis was conducted using Genstat 15th edition (VSN International Ltd, Hemel, Hempstead, U.K.). A linear mixed model of analysis of variance was used to examine the data, with the sample within carcase as a random effect and rigor temperature (5, 15 and 35 °C) and the muscle configuration (stretched and unstretched) as fixed effects.

III. RESULTS AND DISCUSSION

The stretching treatment was successful, as indicated by the increase in average sarcomere length from 2.06 for unstretched to 2.61 for stretched (P<0.001;**Error! Reference source not found.**). Contrary to our hypothesis, the stretching treatment did not directly impact light scattering values. Stretching would have increased the length of the I-band, but no corresponding increase in global brightness occurred, indicating neither the length of the I-band nor the overlap between thick and thin filaments are solely responsible for light scattering.

Interestingly, both the redness and yellowness values were similar (P>0.05) between all treatments.

A high rigor temperature (35 °C) did generate muscles with a higher lightness (P<0.001) and global brightness values (P<0.05), indicative of more light scattering, compared to lower rigor temperature (5 and 15 °C) muscles. This suggests the lower rigor temperatures muscle fibres had a different structure compared to those from the high rigor temperature, which reduced their ability to scatter light.
Comparing all treatments, the stretched muscles entering rigor at 35 °C had the smallest fibre width accompanied by the highest lightness and global brightness values, suggesting transverse shrinkage of the muscle fibres promoted light scattering. Shrinkage of the muscle fibres creates larger spaces between neighbouring muscle fibres and creates opportunity for more light deflection throughout the muscle structure. In comparison, the unstretched configuration had similar fibre widths (P>0.05) between temperature treatments, indicating longitudinal changes were more important in this configuration. The lighter appearance was possibly a result of myosin denaturation and/or relocation and modification of sarcoplasmic proteins, causing a change in optical protein density along the length of the sarcomere.

Table 1: Effect of rigor temperature (5, 15 or 35 °C) and muscle configuration or config. (stretched or unstretched) on beef M. *sternomandibularis* muscle fibres.

	Stretch			Unstretch			LSD			*P*-Value		
Temperature (°C)	5	15	35	5	15	35	Temp	Config.	Temp x config.	Temp	Config.	Temp x config.
Lightness (L*)	30.4	28.6	32.8	29.2	28.2	31.2	1.35	1.10	1.91	<0.001	0.060	0.664
Redness (a*)	13.5	12.4	13.9	14.3	15.0	13.8	1.63	1.33	2.30	0.958	0.095	0.244
Yellowness (b*)	1.4	1.2	1.5	1.0	1.5	2.0	0.75	0.61	1.06	0.331	0.634	0.472
pH	5.56	5.53	5.47	5.57	5.50	5.47	0.064	0.052	0.090	0.028	0.921	0.769
Global brightness1	119	108	145	110	132	133	16.9	13.3	24.7	0.011	0.734	0.072
Sarcomere length (µm)	2.53	2.68	2.63	2.03	1.94	2.22	0.112	0.091	0.158	0.038	<0.001	0.019
Fibre width (µm)	33.7	35.4	25.3	31.6	33.6	35.0	3.93	3.21	5.55	0.096	0.222	0.008

IV. CONCLUSION

These findings prove that light scattering occurs from more than one region, and that both the transverse and longitudinal properties of the muscle fibres are involved. In terms of application in the meat industry, any optimisation of the temperature during rigor would be opportune for improving the structural attributes of the muscle and avoiding extremes of either excessively pale or dark meat.

ACKNOWLEDGEMENTS

The authors and CSIRO acknowledge funding provided by Australian Meat Processor Corporation (AMPC) and matching funds provided from the Australian Government, via Meat and Livestock Australia (MLA), to support the research and development detailed in this publication. The support of Griffith University is also gratefully acknowledged. We also acknowledge the support of FONCyT (PRH-PICT 2013-3292).

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