SARCOMERE LENGTH AS INDICATOR OF TENDERNESS IN BOVINE *M. LONGISSIMUS DORSI* EXPOSED TO DIFFERENT POST MORTEM TREATMENTS

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Background

For the majority of consumers tenderness is the most important quality attribute of beef. The final tenderness is influenced by pre-slaughter factors as breed, feeding and age, but post-slaughter conditions are probably more important for the ultimate quality, (Dransfield, 1994). Some of these parameters are ageing time, chilling rate and electrical stimulation. Ever since Locker (1960) showed that muscle shortening affected meat tenderness, there has been a considerable research effort in this field. Several studies have focused on the relationship between muscle shortening and tenderness. Yu and Lee (1986) suggested that sarcomere length could be used as an indicator of tenderness for muscles with the same ultimate pH. Smulders et. al. (1990) found that sarcomere length and tenderness was highly correlated in slow glycolysing muscles, while they found no such correlation for the fast glycolysing muscles.

Objectives

The purpose of this study was to investigate the potential of sarcomere length as indicator of tenderness in *M. longissimus dorsi* when the muscles were exposed to different *post mortem* treatments.

Materials and methods

Both the left and right *M. longissimus dorsi* from 48 carcasses were used in this study. Half of the samples were given low voltage electrical stimulation (90 V, 15 Hz, 20 sec, MITAB, Sweden) approximately 10 minutes after stunning. The current was applied through a clip in the nostrils and by shackling of one leg.

The loins were excised around 1 hour after stunning and packed in polyethylene bags before they were transported to the research facility. During the one hour transportation the air temperature was kept at 15°C. The muscles were cut in two equal sized pieces at arrival. One front- and one tail-section (from different sides) were stored at 4°C, and the two other sections were stored at 15°C for the first 24 hours and thereafter aged at 4°C for 6 more days.

Samples for Warner-Bratzler (WB) shear force were collected 2 and 7 days *post mortem* from both chilling regimes. The sensory analyses were performed on samples aged for 7 days. Sarcomere length was measured on samples excised from the carcass 2 days *post mortem*. These samples were fixed in a borate solution containing 2.5% glutardialdehyde and homogenised with a Polytron PT3000 homogeniser. The sarcomere lengths were measured with an image analysing program (Image-Pro Plus 4.0, Media Cybernetics, Silverspring, Maryland, USA) of pictures taken with a camera (Hitachi KP-D50 Color Digital, Hitachi Denshi Ltd, Japan) connected to a light microscope (Leica DMLB, Leica Mikroskopie & Systeme GmbH, Wetzar, Germany). From every sample there were taken pictures of 10 different myofibers, and in each picture was the average of 10 sarcomeres used for the calculation of sample sarcomere length.

The preparation of samples for sensory and WB measurements were a slight modification of the procedure described by Rødbotten et. al. (2000). Approximately 3.5cm thick slices of the muscles were vacuum-packed in polyethylene bags, heat-treated in water bath at 70°C for 50 minutes. The samples, which were evaluated by the sensory assessors, were cooled in ice water for 20 minutes, thereafter conditioned at room temperature for 20 minutes before they were served to the taste panel. The meat slices were cut into pieces of 1cm thickness along the fibre direction. The second cut was also done in the fibre direction to give samples with a cross-sectional area of 1 x 1 cm^2. The approximate length of the samples was 2 cm. Structures of visible fat and sinew were avoided. The sensory attributes tenderness (whole chewing process), hardness (first bite; across the fibre direction) and juiciness were evaluated by 10 trained assessors using a sensory profile method (ISO 6564-1985). Prior to the session, the panel was trained on samples covering the actual tenderness range (ISO/DIS 8586-1, 1989). At each session the samples were randomised over treatments and assessors. The sensory intensity scale was continuous ranging from tough (1) to tender (9) for tenderness, soft (1) to hard (9) for hardness and dry (1) to juicy (9) for juiciness. Intensity score over assessors were used in the data analysis.

The samples used for the WB shear force analysis were cooled in ice water for 50 minutes after the heat treatment. They were stored overnight at 0°C and tempered to room temperature for 2 hours before measurement. WB shear force analysis was performed on samples of the same geometry as the sensory samples. Ten parallels were sheared at right angles to the fibre direction with the WB shear-press device in an Instron Materials Testing Machine (Model 4202, Instron Engineering Corporation, High Wycombe, UK). The averages of the maximum force from these 10 parallels were used in the data analysis. Both sensory and WB analyses were performed on fresh samples (not frozen/thawed).

Results and discussion

All the parameters (sarcomere length, WB shear force and the sensory attributes) shown in Table 1 were significantly different for the two chilling regimes. Table 2 shows the correlation coefficients between sarcomere length and some of the measured parameters. In the moderately chilled subset the correlation coefficient was –0.32 between sarcomere length and WB shear force measured 2 days after slaughter, while it was –0.73 for the fast chilled subset. There was a larger range in WB values for the fast chilled samples, but this was probably not the reason for the higher correlation coefficient. The ranges of WB values was nearly equal at 2 and 7 days *post mortem*, but sarcomere length did not explain more than 19% of the variation in WB shear force after 7 days for the fast chilled subset. The ranges in sarcomere length were approximately equal for the two subsets. There was a clustering of samples with sarcomere lengths around 1.8μm in the moderately chilled subset, while the sarcomere lengths in the fast chilled subset were more uniformly distributed between 1.3 and 1.9 μm.

Half of the samples were given low voltage electrical stimulation, but the average pH_1 value was only 0.1 units lower for the electrically stimulated samples compared to the unstimulated carcasses. Experience has shown that there is a day to day variation for low voltage electrical stimulation. Probably was the small reduction in pH_1 a result of this variation. Sarcomere length explained 62% of the variation in WB shear force after 2 days for the fast chilled samples, which did not receive electrical stimulation, while 44% were explained for the electrically stimulated samples. There was an opposite effect for the moderately chilled samples. The correlation coefficient was –0.36 for the electrically stimulated samples, whereas the coefficient was –0.21 for the non-stimulated samples. However, when all samples from both chilling regimes were pooled together, sarcomere length explained 85% of the variation in WB shear force for the subgroup which had $pH_1 > 6.75$ (n=28). On the other side there was no correlation for the 18 samples that had $pH_1 < 6.5$. Electrical stimulation (or enhanced glycolysis) seems to affect the relationship between sarcomere length and WB shear force, but there was no significant effect of electrical stimulation in neither sarcomere length nor WB values within the two chilling regimes. These results are in agreement with the observations of Smulders et. al., who reported high correlation between sarcomere length and tenderness for samples with slow glycolysis, but no correlation at all for the fast glycolysing samples, (Smulders *et al.*, 1990). They used several modifications of electrical stimulation and the carcasses were relatively fast chilled. In the present study we were not able to find a limit in either pH_1 or pH_6 values where the samples could be divided into a highly- and a non-correlated subgroup.

The sensory attributes tenderness and hardness were highly negatively correlated, which also was reflected in their correlation coefficients to sarcomere length. The correlation coefficients between sarcomere length and the three sensory properties were not different for electrically- and non-stimulated samples. There were no discrepancy between this result and the effect of electrical stimulation described above, because these measurements were separated in time by 5 days. Sensory juiciness did not correlate to sarcomere length in neither of the chilling regimes.

Conclusion

Sarcomere length accounted for 62% of the variation in WB shear force 2 days *post mortem* in fast chilled samples, which did not receive electrical stimulation. 10% of the variation in WB shear force were explained by sarcomere length for moderately chilled samples. In the subset of slow glycolysing samples ($pH_1 > 6.75$), sarcomere length accounted for 85% of the variation in WB shear force.

References

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Table 1 Range and mean values for some quality parameters

		Fast chilling		Moderate chilling		
		Range	Mean	Range	Mean	p=
Sarcomere length	(μm)	1.35 – 1.88	1.63	1.54 – 1.96	1.79	<0.0001
WB 2 days p.m.	(kg cm^{-2})	5.16 – 17.14	7.93	4.49 – 11.32	7.29	<0.0001
WB 7 days p.m	(kg cm^{-2})	3.20 – 14.15	8.14	2.80 – 9.27	4.88	<0.0001
Sensory tenderness		1.41 – 7.60	3.71	2.73 – 8.33	6.30	<0.0001
Sensory hardness		2.52 – 8.55	6.28	1.82 – 7.59	3.79	<0.0001
Sensory juiciness		5.39 – 7.18	6.34	5.16 – 7.74	6.68	0.0003

Table 2 Simple correlation coefficients between sarcomere length and some other measured properties

	Fast chilling		Moderate chilling	
WB 2 days p.m.	-0.73	(<0.001)	-0.32	(0.027)
WB 7 days p.m.	-0.44	(0.002)	-0.39	(0.007)
Sensory tenderness	0.54	(<0.001)	0.31	(0.030)
Sensory hardness	-0.56	(<0.001)	-0.33	(0.024)
Sensory juiciness	0.19	(0.193)	-0.09	(0.562)