IMPROVED TENDERNESS OF CALF MEAT THROUGH ALTERING CHILLING REGIME AND CARCASS SUSPENSION

N. Magnus Wahlgren and Bente Kalbakk,

[1] Norwegian Meat Cooperative, P.O.Box 360 Økern, N-0513 Oslo, Norway, (email: magnus.wahlgren@gilde.no)

Background

Tenderness is an important part of meat acceptability and depends on a number of intrinsic biological factors such as breed, age, sex, feeding, muscle type etc. Calf meat is recognised to be more tender than meat from older animals (Shorthose & Harris, 1990). With increasing maturity the total connective tissue content of muscle remains the same but it becomes more firm due to an increased number of cross-links (Dransfield, 1992). The degree of tenderness is also influenced by the extrinsic conditions in the abattoir such as chilling regime, the use of electrical stimulation and ageing. Calves with low carcass weight and little subcutaneous fat are particularly susceptible to fast chilling regimes that might have a detrimental effect on tenderness through an increased muscle shortening (Devine, Wahlgren & Tornberg, 1999). This is of larger importance when the calves have become older then 5 to 7 months but still are defined as calves. Pelvic suspension of carcasses has shown to counteract muscle shortening in other species (Joseph & Connolly, 1977; Møller, Kirkegaard & Vestegaard, 1987) and therefore would be expected to have a similar effect on the tenderness of calf meat.

Objective

The aim of the present study is to evaluate how calf tenderness are effected by different chilling regimes and how pelvic suspension (PS) and electrical stimulation hinders rigor shortening and therefore assures the tenderness of *m. semimembranousus* (SM) and *m. longissimus dorsi* (LD). The study was performed under full industrial conditions.

Material & Methods

Thirty-two calves (age 5-7 month, carcass weight 110-145 kg) were slaughtered at Gilde Fellesslakteri BA, Gol at two occasions. In the first experiment (**Exp1**) the regular conditioning programme for beef carcasses without stimulation (NS) was used (6-9°C for 12 hours followed by 2-4°C, **T1**). Alternate left or right carcass sides were suspended from the pelvic bone (PS) or from the Achilles tendon (AT). In the second experiment (**Exp2**) half of the carcasses were electrically stimulated (ES) 20 min *p.m.*(85V peak, 6ms duration, 12Hz for 48s) and PS was used for all carcass sides. Alternate left or right carcass side was exposed to 9-12°C for 12 hours (**T2**) or for 20 hours (**T3**). Rigor development was followed by pH measurements in the LD and SM muscles 1, 4, 10, 22 and 46 hours *p.m.*. The carcasses were kept at 2-4°C until deboning (one day *p.m.* for Exp 1and two days *p.m.* for Exp2). Tenderness of all LD and SM samples were evaluated 7days *p.m.* by Warner-Bratzler shear (WBS) force measurements. Meat samples (3.5cm thickness), cut across the muscle direction, were vacuum packed and heated at 74°C for 80 min and kept at -1.5°C until the day of analysis. Before WBS measurements, the samples were conditioned at 20°C and sample the final size (1.7cm x0.7cm) was prepared. An average of ten replicates per sample cut across the fibre direction was used in the data analysis. Weight loss during ageing and drip loss after complete ageing was measured 7 days *p.m.*. A number of samples (frozen and stored at -20°C, 3 months) were also evaluated by sensory analysis. These samples were cut into 1.5cm thick steaks and thawed at 4°C. After cooking in a water bath to 70°C the meat was served warm to a trained panellist. Sensory attributes evaluated were tenderness, hardness and juiciness using a hedonic scale from 1 to 9 (where 1 was low and 9 was high of the attribute evaluated). Muscle shortening of the LD and SM muscles was measured indirectly by sarcomere length measurements (SL). Samples were collected, fixed in a borate solution containing 2.5% glutaraldehyde. The SL was measured with an image analysing program from pictures taken with a camera connected to a light microscope.

Results & Discussion

One animal in Exp1 showed stressful behaviour and developed DFD and was excluded from the data analysis. The three chilling regimes led to differences especially after 12 hours *p.m.*, ***Figure 1***. The temperature in the centre of LD muscles was never below 10°C before 10 hours *p.m.*.This should mean that the carcasses were not exposed to cold shortening conditions. However, the rigor development observed in Exp1 was surprisingly slow, ***Table 1***. This, in combination with the fast temperature falls 12 hours *p.m.* could result in cold shortening. The rigor development of NS carcasses in Exp2 was significant faster than in Exp 1. ES accelerated the pH fall additionally. The weight loss obtained during ageing of LD was significantly effected by treatment, ***Table 2***. The meat in Exp1 showed a significant heigher weight loss than Exp2 (2.7 vs 1.8%, p=0.0002). Muscle shortening (SL) showed a significant correlation with the weight loss obtained during

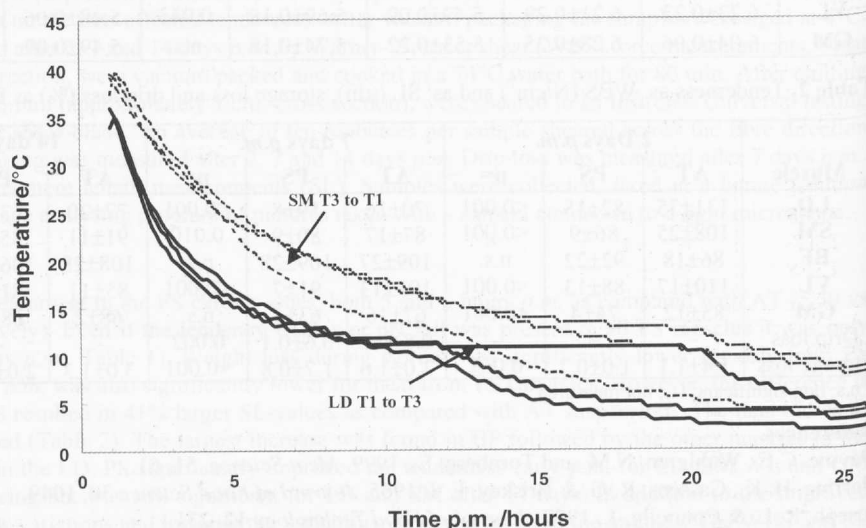

Figure 1. Temperature profiles for SM and LD muscles as a function of chilling regime.

ageing (r=-0.48, p=0.0001). SM muscles from PS carcass sides had significantly lower weight loss 2 days *p.m.* (0.7 vs 0.4%, p=0.001). In addition, PS resulted in significant lower drip loss in the LD (p=0.016, Exp1). **In Exp1** suspension method had a significant effect on the tenderness for both LD and SM muscles, Table 2. The high WBS values from AT suspended carcass sides (T1AT) indicate that muscle shortening have occurred both in LD and SM muscles. This was confirmed by the corresponding SL values. PS reduced the WBS values

with about 40 N/cm^2 for both LD and SM muscles. In addition, the animal to animal variations for SM muscles from PS carcass sides was highly reduced. This indicates that the effect of PS was larger the tougher the SM muscles from the AT suspended carcass sides were. Even if the chilling regime used in Exp1 was not as extreme as the one usually used in the industry (chilling at 2-4°C directly after grading) it is obvious that the stretching forces developed by PS could not counteract the contraction forces originating from cold shortening of the LD. The reason for the unexpected large muscle shortening for T1AT and T1PS so late after slaughter might be explained by the slow rigor development in the carcasses used in Exp1. The positive effect of PS in Exp1 indicated the desirability for all carcass sides to be PS in Exp2. **In Exp2**, two different chilling regimes in combination with ES/NS were studied. The four combinations resulted in similar tenderness of the SM muscle, Table 2. However, a small difference was observed between SM from ES and NS carcasses (68 vs 64 N/cm^2, $p=0.062$). It is not clear from this experiment whether or not this difference is an indication of a reduced ageing capacity due to non optimal combinations of temperature and pH for SM muscles from ES carcasses (Wahlgren, Devine & Tornberg, 1997; Devine *et al.* 1999). However, the higher values for SM muscles from ES carcasses are not due to an increased muscle shortening as shown by the corresponding SL data. The WBS data for the LD muscles shows that a prolonged conditioning (20hours) at 9-12°C (T3) assures the tenderness independent of ES. When the shorter conditioning time was used (12hours, T2) a tougher LD muscle was obtained. In contradiction to the results from the SM muscles ES improved the LD tenderness when the shorter conditioning time was used (not significant). The SL measurements indicate that the differences in LD tenderness, also in Exp2, originate to some extent from muscle shortening. The SL data for the LD muscles are also highly correlated to the rate of rigor development as shown by the correlation's to pH1, pH4 and pH8 ($r=-0.64$, $r=-0.74$, $r=-0.73$, respectively). Even though more than 12 hours have passed before the temperature in the LD muscle fell below 10°C the forced chilling after 12 hours still had a negative effect on tenderness. This is in correspondence with the findings of Klont *et al.* (2000). There were high and significant correlation's ($p<0.0001$) between tenderness and hardness ($r= -0.99$ and -0.98 for LD and SM, respectively). A high and significant correlation between the tenderness and the WBS data are obtained for both LD and SM muscles ($r=-0.78$, $r=-0.76$, respectively). The results from the sensory analysis confirmed the results and conclusions from the WBS measurements.

Conclusions

The tenderness of calf meat is effected by a number of processing factors. In this study the rate of rigor development, chilling regime, ES and suspension method were shown to have a significant effect on tenderness and muscle shortening. To reduce the effect of the animal to animal variations, regarding the rate of development, a prolonged conditioning at 9 to 12°C, PS or ES were shown to have beneficial on the tenderness of LD muscles. However, ES showed a slight detrimental effect on the tenderness of SM muscle. ***To obtain optimal and guaranteed tenderness on both muscle types we recommend that pelvic suspension in combination with conditioning at 9-12°C for 20 hours is chosen.*** Moreover, the results indicate that the stretching forces originating from pelvic suspension could not suppress the contraction forces originating from cold shortening of LD muscles completely. When a faster chilling regime is chosen the calves must be ES to minimise the effect of animal variations on tenderness originating from the rate of rigor development. Maximum tenderness of the SM muscle is unfortunately then not obtained.

Table 1. pH (mv±std) as a function of Chilling regime. Values in same column with different subscript differ significantly.

Treatment	pH1		pH4		pH 8		pH22	
	LD	SM	LD	SM	LD	SM	LD	SM
T1	7,04^a±0,27	7,07^a±0,25	6,79^a±0,24	6,63^a±0,28	6,32^a±0,25	6,06^a±0,28	5,59^a±0,13	5,51±0,14
T2NS	6,73^b±0,17	6,44^b±0,27	6,45^b±0,23	6,16^b±0,34	5,99^b±0,19	5,64^b±0,23	5,44^b±0,17	5,52±0,14
T2ES	6,30^c±0,26	6,38^b±0,29	6,10^c±0,17	5,86^{bc}±0,26	5,62^c±0,18	5,53^b±0,16	5,40^b±0,13	5,53±0,17
T3NS	6,72^b±0,26	6.57^b±0,24	6,52^b±0,23	6,18^b±0,28	5,87^b±0,29	5,73^b±0,22	5,49^{ab}±0,17	5,53±0,17
T3ES	6,35^c±0,25	6,30^b±0,28	6,03^c±0,18	5,76^c±0,24	5,67^{bc}±0,20	5,50^b±0,21	5,36^b±0,10	5,50±0,15
p=	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0,971

Table 2. Sensory tenderness, WBS (N/cm^2), SL (µm), weigth loss and drip loss (%, 7 days *p.m.*) as function of treatment.

Treatment	LD					SM		
	WB	Tenderness$^+$	Weigth loss	Drip loss	SL	WB	Tenderness	SL
T1PS	108^a±34	4.5^a±1.1	2.6±1.0	0.70^a±0.18	1.69^a±0.27	70^a±6	5.7^a±0.3	2.60^a±0.23
T1AT	149^b±43	3.3^b±0.7	2.8±1.0	0.90^b±0.24	1.48^b±0.24	114^b±26	4.1^b±0.4	1.81^b±0.09
p=	0.008	0.010	n.s.	0.017	0.037	<0.0001	<0.0001	<0.0001
T2NS	81^a±27	-	2.4±0.6	0.75±0.30	1.83^c±0.10	63^a±6	-	2.71^a±0.13
T2ES	66^{ab}±10	7.1^c±0.5	1.4±0.8	0.70±0.18	2.12^{ab}±0.13	67^a±4	-	2.72^a±0.13
T3NS	58^{ab}±14	7.2^c±0.5	1.7±0.9	0.76±0.31	2.00^{bc}±0.19	64^a±9	-	2.71^a±0.08
T3ES	58^b±10	-	1.6±0.8	0.72±0.17	2.37^a±0.13	69^a±11	-	2.77^a±0.02
p=	<0.038	<0.0001	n.s.	n.s.	0.0001	n.s.		n.s.

$^{+)}$ ANOVA was performed on all four treatments, n.s.=non significant; missing value= not measured, values in same group in column with different subscript differs significantly ($p<0.05$)

References

Devine, C.E., Wahlgren, N.M. and Tornberg, E., 1999. Meat Science. 51, 61.
Dransfield, E. 1992. Meat Focus International 237.
Joseph, R. L. og Connolly, J., 1977. Journal of Food Technology 12. 231.
Klont, R.E., Barnier, V.M.H., Dijk, A., Smulders, F.J.M. Hoving-Bolink, A.H., Hulsegge, B. & Eikelenboom, G. 2000 J. Anim. Sci. 1845
Møller, A. J., Kirkegaard, E. og Vestegaard, T., 1987. *Meat Science* 21. 275.
Shorthose, W. R. & Harris, P.V. 1990. *Journal of Food Science* 55, 1.
Wahlgren, N.M., Devine, C.E. & Tornberg, E. 1997. Proc. 47th ICoMST, Auckland, New Zealand, 622