THE EFFECT OF SUSPENSION METHOD AND CHILLING REGIME ON PORK TENDERNESS

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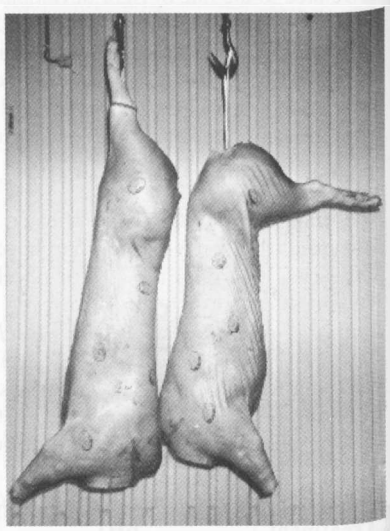
Background

Tenderness is considered by the consumer to be one of the most important quality criterion for meat. To be able to measure, predict and control meat tenderness considerable effort has been invested by researchers and by the industry. Processing conditions can often be specified such as correct chilling regimes and appropriate ageing duration can be used to get a specified degree of tenderness. However, many of the industrial conditions are often chosen because of other determining factors such as line speed, cooler space, chilling losses etc.. The normal processing conditions for pork can be described by high line speeds (up to 600 carcasses per hour), blast coolers and short ageing times. Factors that can have a negative effect on meat tenderness by an increased rigor shortening and reduced ageing capacity (Devine, Wahlgren & Tornberg, 1999). Pelvic suspension has been suggested to have a beneficial effect on tenderness of different species and chilling regimes (Joseph & Connolly, 1977; Møller, Kirkegaard & Vestegaard, 1987, Dransfield, Ledwith &Taylor, 1991).

Objective

The present study evaluates how pork tenderness is effected by different chilling regimes and how pelvic suspension (PS) hinders rigor shortening and assures the tenderness of *m. semimembranousus* (SM) and *m. longissimus dorsi* (LD). The study was performed under fully industrial conditions.



Material & Methods

Ninety-six pigs (carcass weight 65-72 kg) were slaughtered at Gilde Hedemark og Oppland Slakterier BA at four different occasions. Every single carcass side were allocated to a treatment where PS or conventional suspension (CS) were combined with one of four chilling regimes; ***slow*** (2-4°C, **T1**), ***medium-slow*** (-7°C for 50 min., **T2**) ***medium-fast*** (-11°C for 50 min., **T3**) and ***fast*** (-22°C for 50 min., **T4**). At each occasion a number of carcass sides, exposed to T1, were included to provide a standard baseline of tenderness between the different sittings for the sensory evaluations. The carcasses were kept at 2-4°C until +7°C was obtained in the ham (approximately 22 hours *p.m.*). Rigor development was monitored by pH measurements in the LD and SM muscle 1, 4, 8 and 22 hours *p.m.*.Chilling loss (%) and ultimate-pH was recorded before deboning. The weight loss during ageing, drip loss and sensory evaluation were measured after designated ageing at 4°C on LD (3 and 9 days) and SM (8 days). The anterior and posterior part of the LD was used alternately for the sensory evaluations. Meat samples with a thickness of 1.5 cm were cooked in a water bath to 70°C and served immediately to a trained panellist. The 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 factor evaluated. Shortening of the LD and SM muscles was determined by sarcomere length measurements (SL). Samples were collected and fixed in a borate solution containing 2.5% glutaraldehyde. The SL was measured with an image analysing program of pictures taken with a camera connected to a light microscope.

Results & Discussion

The four chilling regimes encompassed a large temperature range for the LD muscle during the first ten hours *p.m.*, ***Figure 1***. The difference was 20°C after two hours *pm* and after 10 hours *pm* the difference was reduced to 3°C. The temperature difference in the SM muscle never exceeded a 4°C range. The weight loss during chilling was significantly larger for the slow chilling regime compared to the fast chilling regime ($p<0.0001$), Table 1. The chilling losses were reduced with decreasing temperature, where the fast chilling regime gave least chilling loss. Neither suspension method, meat % nor carcass weight had a significant effect on weight loss during chilling. No clear answer was found regarding the origin (location within the carcass) of the increased chilling losses, since the weight of the cuts was significantly influenced by other parameters such as carcass weight and the technique used by the butchers.

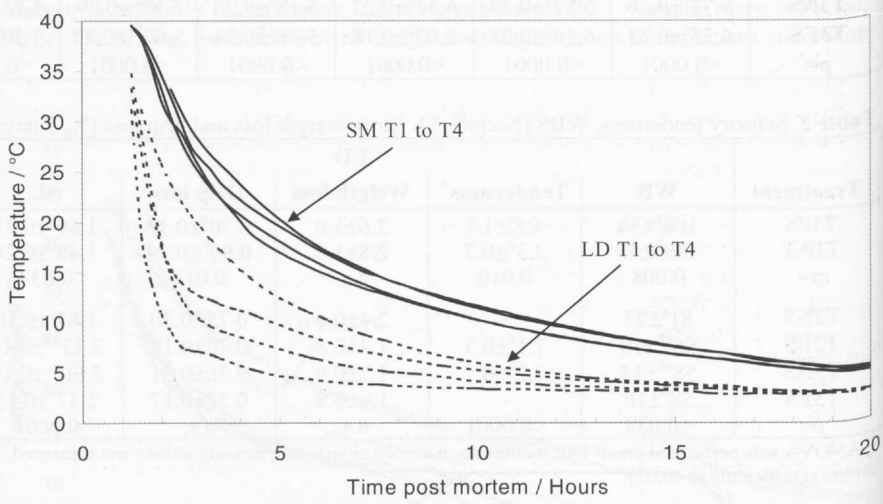


Figure 1. Temperature profiles for SM and LD muscles as a function of chilling regime.

The fast chilling regime (T4) resulted in a significant slower rigor development for the LD compared to T1 and T2, **Table 1**. The group exposed to the medium-slow chilling regime had a larger proportion of animals with DFD character for both LD and SM. Suspension method did not affect rigor development ($p<0.05$). However, pelvic suspension resulted in significant ($p<0.01$) lower storage losses for LD 9 days *p.m.* (8.9% vs. 10.8%) and for SM 8 days *p.m.* (2.6% vs. 3.2%). In addition, pelvic suspension resulted in a lower drip losses for the SM muscles (6.4% vs 7.4%, $p<0.05$) while only ageing time had significant effect on the drip loss of the LD muscles (6,8% vs 3.1% 3 and 9 days *p.m.*, respectively). ***Sensory analysis*** showed high and significant correlation's ($p<0.0001$) between tenderness and hardness ($r= -0.99$ and -0.98 for LD and SM, respectively). Suspension method had a significant effect on tenderness and muscle shortening for both LD and SM muscles, **Table 2**. For **SM muscles**, pelvic suspension improved the tenderness by almost one sensory unit whereas only small and non-significant effects from chilling regime were observed. This can be explained by the small difference in temperature profiles observed in the SM muscle where the temperature of the SM never went under 10°C before 10 hours *p.m.* or before pH went under 6.0. The SM muscles

were therefore never exposed to cold shortening conditions even when exposed to the fast chilling regime. The tenderness differences between SM muscles from PS and CS carcasses are most probably due to an effective stretching of the muscles in the ham induced by pelvic suspension. The longer SL of pelvic suspended SM muscles substantiates this. For **LD muscles** suspension method, chilling regime and ageing had a significant effect on the tenderness. Conventional suspended carcasses exposed to T2, T3 and T4 showed similar tenderness three days *p.m.*. When these chilling regimes were used PS improved tenderness with 0.8 sensory units. With additional ageing for a total of nine days tenderness was improved further and the beneficial effect of PS was still evident. When the slow chilling regime was used the ultimate tenderness was already achieved after three days without additional ageing being needed. PS improved the tenderness also when slow chilling regime was used. The use of blast chillers, with air temperature below 0 °C was shown to have a negative effect on the tenderness of LD for small sized muscles located close to the carcass surface. This effect is due to cold shortening (shorter SL-values) for T3 and T4 as compared with LD muscles exposed to the slow chilling regime (T1). PS counter act the effect of fast chilling by stretching. However, it can not hinder the muscle shortening when the contraction forces supreme the stretching forces from the back leg. Most probably are there small amounts of muscle contraction present even when the slow chilling regime were used. A small but significant effect was observed in sensory analysis of juiciness of the LD muscles three days *p.m.* This is probably not due to effect of the chilling regime (***Table 2***) but more likely it can be explained by the higher fraction of DFD carcasses characteristic of this chilling regime.

Conclusions

Pelvic suspension of pork carcasses improves the tenderness significantly. Chilling regime has a larger impact on LD than SM muscles. If a chilling regime should be chosen from a sensory standpoint with tenderness as the determining attribute, then a slow chilling regime should be used. This chilling regime will result in a superior tenderness early *p.m.* If a faster chilling regime is chosed then pelvic suspension would be required to assure the tenderness of pork.

Table 1. Chilling loss (%) and pH (mv±std) as a function of chilling regime. Values with different subscript differs significantly.

Chilling regime	pH 1		pH4		pH 8		pH22		Chilling loss
	LD	SM	LD	SM	LD	SM	LD	SM	
T1	6.26±0.30	6.30±0.24	5.98^{a}±0.29	5.96±0.25	5.88^{a}±0.27	5.81^{a}±0.17	5.58^{a}±0.12	5.60^{a}±0.11	2.0^{a}±1.1
T2	6.24±0.17	6.29±0.20	6.03^{a}±0.24	5.92±0.26	5.84^{a}±0.17	$5.75^{a,c}$±0.20	5.67^{b}±.15	5.71^{b}±0.11	1.7^{ac}±0.3
T3	6.22±0.24	6.23±0.25	$6.09^{a,b}$±0.22	5.91±0.27	5.82^{a}±0.19	5.67^{c}±0.16	5.56^{a}±0.07	5.57^{a}±0.08	1.6^{c}±0.7
T4	6.28±0.24	6.31±0.30	6.16^{b}±0.28	6.04±0.33	6.01^{b}±0.29	5.92^{b}±0.19	5.60^{a}±0.10	5.58^{a}±0.14	1.0^{b}±1.5
p=	n.s.	n.s.	<0.0001	n.s.	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Table 2. Tenderness, juiciness and sarcomere length (µm) as function of treatment, chilling regime, suspension method and ageing time.

Treatmen	LD					SM		
	3 days *p.m.*		9 days *p.m.*			8 days *p.m.*		
	Tenderness	Juiciness	Tenderness	Juiciness	SL	Tenderness	Juiciness	SL
T1PS	6.4^{a}±1.2	3.8±0.5	6.4^{a}±1.1	3.7±0.3	1.90^{a}±0.16	5.8^{a}±0.3	3,9±0,5	2.10^{a}±0.35
T1CS	5.9^{ac}±0.9	3.7±0.4	5.8±1.2	3.4±0.4	1.79±0.05	4.7±0.8	3,8±0,4	1.91±0.58
T2PS	5.0±0.9	4.1±0.5	5.9±1.4	3.6±0.3	n.m.	5.4±1.2	3,9±0,3	n.m.
T2CS	4.5^{bc}±1.3	4.2±0.6	4.7^{b}±1.3	3.5±0.2	n.m.	4.5^{b}±0.5	3,8±0,3	n.m.
T3PS	5.5±1.2	3.6±0.3	5.8±1.1	3.4±0.4	1.86±0.11	5.9^{a}±0.7	3,6±0,3	2.16^{a}±0.10
T3CS	4.4^{b}±1.3	3.7±0.3	5.3±1.1	3.3±0.2	1.74^{b}±0.12	4.9±0.8	3,6±0,2	1.77^{b}±0.14
T4PS	5.3±1.0	3.7±0.3	5.5±1.0	3.6±0.5	1.85±0.07	6.0^{a}±0.4	4,1±0,3	2.05^{a}±0.12
T4CS	4.5^{b}±0.8	3.8±0.4	5.0±1.1	3.6±0.2	1.74^{b}±0.10	5.1±0.9	3,8±0,5	1.82^{b}±0.07
p=	0.0002	0.051	0.031	0.158	0.0020	0.0004	0.185	0.0023
Chilling								
T1	6.1^{a}±1.4	3.7^{a}±0.5	6.2^{a}±1.1	3.5±0.4	1.85±0.13	5.3±0.8	3.8±0.5	2.01±0.27
T2	4.7^{b}±1.1	4.1^{b}±0.5	5.3^{b}±1.5	3.6±0.3	n.m.	5.0±1.0	3.8±0.3	n.m.
T3	4.9^{b}±1.4	3.7^{a}±0.3	$5.5^{a,b}$±1.1	3.4±0.3	1.80±0.13	5.4±0.9	3.6±0.3	1.96±0.23
T4	4.9^{b}±1.0	3.7^{a}±0.3	5.3^{b}±1.0	3.6±0.4	1.80±0.10	5.5±0.8	4.0±0.4	1.94±0.15
p=	0.0004	0.0049	0.019	0.117	n.s.	0.151	n.s.	n.s.
Suspension								
PS	5.6^{a}±1.2	3.8±0.4	5.9^{a}±1.2	3.6±0.4	1.87^{a}±0.12	5.8^{a}±0.7	3.9±0.4	2.10^{a}±0.22
CS	4.9^{b}±1.2	3.8±1.4	5.3^{b}±1.2	3.5±0.3	1.76^{b}±0.09	4.8^{b}±0.8	3.8±0.4	1.83^{b}±0.11
p=	0.005	0.334	0.009	0.136	0.0001	0.000	0.353	<0.0001

a, b, n.s. non significant, n.m.; not measured, values in same column with different subscript differs significantly

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