REDUCING THE INFLUENCE OF ANIMAL VARIATION AND AGEING ON BEEF TENDERNESS

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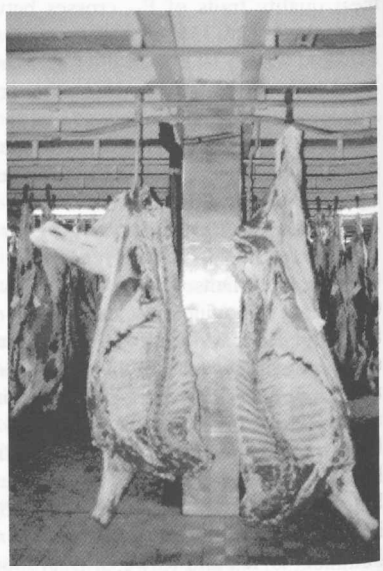
Background



Tenderness is the most important attribute for beef meat acceptability and is dependent on a number of biological factors such as genotype, age, sex, feeding, muscle type etc. The effects from many of these factors on meat quality are not fully understood. In addition, their influences are difficult to measure on arrival at the abattoirs or during slaughter. It is also from an industrial point of view impossible to perform individual treatments for carcasses or for a group of carcasses differing in characteristics. Tenderness is also highly affected by the conditions at the abattoir such as stressful handling, chilling regimes, the use of electrical stimulation and ageing. It is not only the temperature and air speed in the coolers that has an impact on the chilling rate. The chilling is also effected by carcass characteristics including weight, muscularity and fatness. It is well known that a to fast chilling results in cold shortening, in small and surface located muscles. A to slow chilling can similarly result in warm shortening and in addition reduced ageing capacity (Devine, Wahlgren & Tornberg, 1999). To obtain the highest tenderness for all carcasses, different chilling regimes ought to be used. The chilling regime used, however, is often a compromise of weight loss, cooler space, hygiene and quality. This results in a certain unknown fraction of carcasses that have been exposed to detrimental conditions as regards tenderness. The main issue for the industry is to minimise the size of this fraction. Electrical stimulation has been used to reduce cold shortening by an accelerated rigor development. However, inducing a very fast pH-fall in combination with slow chilling is detrimental for beef tenderness (Wahlgren, Devine & Tornberg, 1997). Pelvic suspension (PS) of beef carcasses has been shown to counteract muscle shortening and improves tenderness (Herring, Cassens & Briskey, 1965; Joseph & Connolly, 1977). PS has been used in this study to evaluate how both the animal-to-animal variations and ageing time can be reduced.

Objective

The present study evaluates how the influence of animal-to-animal variations on beef tenderness is affected by pelvic suspension (PS). Five important beef muscles from the hindquarter (*m. semimembranousus,* SM, *m. longissimus dorsi*, LD, *m. gluteus medius,* GM, *m vastus lateralis*, VL and *m. biceps femoris*, BF) were studied. Other important parameters including ageing time, muscle shortening, weight loss during ageing, drip loss and usefulness of the cuts as consumer portioned steaks were evaluated. The study was performed as a M. Sc. thesis at Lund University (1997) under full industrial conditions.

Material & Method

Six young bulls (carcass weight 298±18kg) of Swedish Lowland breed were slaughtered at Swedish Meats abattoir at Kävlinge. The animals came from the same producer and were slaughtered within two hours of arrival, to reduce the impact of stress The carcasses were ES 30 min *p.m.* (85V, 6ms, 12Hz for 48s) and chilled according to the conventional chilling regime used at the abattoir (-5°C for 1hour followed by 2-4°C). Alternate left/right carcass side was suspended with a hook in the pelvic bone (PS) right after grading (1hour *p.m.*) or in the Achilles tendon (AT). Rigor development was followed by pH measurements; 1, 3, 5, 8, 10 and 22 hours *p.m.*. The carcasses were kept at 2-4°C until deboning (one day *p.m.*). To facilitate deboning the PS suspended carcass sides were resuspended by the AT. All cuts were divided in to four parts along the muscles to evaluate whether position on the cuts effected tenderness. After vacuum packaging the samples were aged at 4°C. The tenderness of all muscles samples was evaluated after 2, 7 and 14 days *p.m.* by Warner- Bratzler shear (WBS) force measurements. Meat samples (3.5cm thickness), cut across the muscle direction, were vacuum packed and cooked in a 74°C water bath for 80 min. After chilling to room temperature in ice water, slices 15 mm x 6.5 mm (approximately 1 cm^2 cross section), were sheared in an Instron® Universal testing machine equipped with a modified Warner-Bratzler shear blade. An average of ten replicates per sample sheared across the fibre direction was used in the data analysis. Weight loss during ageing was measured after 2, 7 and 14 days *p.m.* Drip loss was measured after 7 days *p.m.*. Muscle shortening was measured indirectly by sarcomere length measurements (SL). Samples were collected, fixed in a borate solution containing 2.5%. The SL were measured with an image analysing program of pictures taken with a camera connected to a light microscope.

Results & Discussion

The pH measurements indicated a slower rigor development in the PS carcass sides, both 5 and 8 hours *p.m.* as compared with AT (5.59 vs 5.69, p= 0.045 and 5.53 vs 5.61, p=0.017, respectively). Even if the tendency of slower pH fall was present in all PS muscles it was only significant for VL (5 hours *p.m.*) and GM (8 hours *p.m.*, Table 1). Weight loss during storing was significantly lower for cuts from PS carcasses both 7 and 14 days *p.m.*. Drip loss 7 days *p.m.* was also significantly lower for meat from PS carcasses. However, the difference is to small to have any impact on the meat quality. PS resulted in 41% larger SL-values as compared with AT suspension. The data indicates that PS resulted in a stretching of all muscles studied (Table 2). The largest increase was found in BF followed by the other muscles in the back leg. The least stretching effect was observed in the LD. PS significantly improved the tenderness early p.m. for LD, SM, VL and GM muscles (Table 2). The effect decreased during ageing but was still significant for LD and SM after 14 days. In addition to the improved tenderness, PS greatly reduced highly the tenderness variations and lowered the variability observed between the animals. The WBS and SL data for LD indicates that a degree of muscle shortening of the AT suspended carcass sides occurred even if the temperature in the LD never was below 10°C before the pH fell below 6.0. The tenderness of BF was not affected by suspension methodsuggesting that the tenderness of BF is more influenced by intrinsic factors other than muscle contraction.

ANOVA showed that the tenderness of the cuts from AT suspended carcasses were significantly influenced by ageing time ($p=0.0011$), muscle ($p=0.0016$) and the animal to animal variations ($p=0.016$). Whereas the tenderness of the PS suspended cuts was solely explained by muscle type ($p<0.0001$). This means that PS diminishes both the influence from animal-to-animal variations of tenderness as well as the need for prolonged ageing. The tenderness of the cuts from PS carcasses are determined solely by muscle type and not by other non-measurable intrinsic factors. In addition to the objective measurements a subjective evaluation was performed to classify the usefulness of the beef cuts as raw material for consumer portioned steaks. The cuts from PS carcasses were judged as superior because of a more parallel alignment of muscle fibres along the whole muscle. Cuts from AT suspended carcasses included areas where the muscle fibres had different directions forming structures similar to a whirl and the meat was therefore harder to cut.

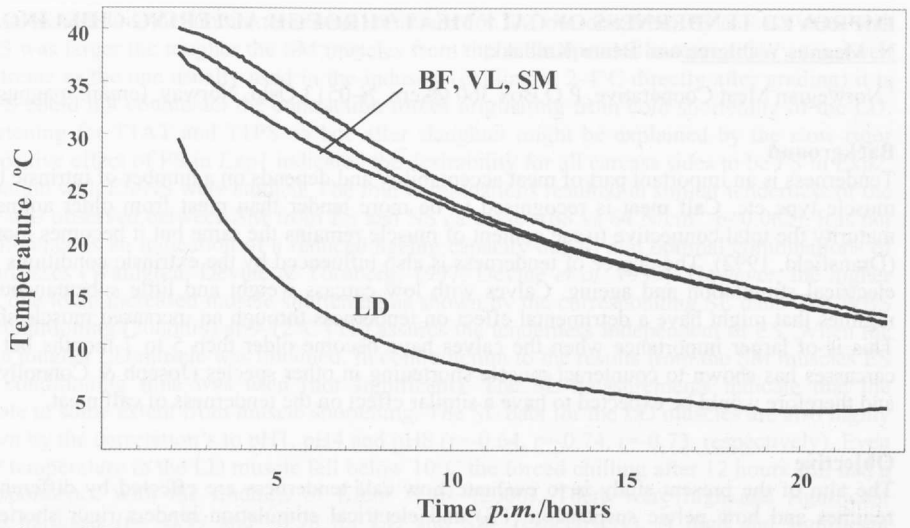


Figure 1. Temperature profiles for LD, BF VL and SM muscles as a function of chilling regime.

Conclusions

PS resulted in a more tender LD, SM, VL and GM early *p.m.*; the tenderness of BF was not affected. Cuts from PS carcass sides had initially lower WBS-values compared with AT so that the ageing process started from a higher tenderness level. PS suspended cuts therefore not only became tender earlier than AT suspended cuts but also reached a higher degree of tenderness. The influence of animal-to-animal variations on tenderness was also diminished significantly by PS. In some cases LD, SM, VL and RF from PS carcass sides were more tender and had less animal-to-animal variation when aged 2 to 3 days *p.m.* than corresponding muscles from AT suspended carcass sides aged for 14 days.

The tenderness of beef from PS carcasses are characterised solely by muscle type whereas the tenderness of beef from AT suspended carcasses are characterised by muscle type, animal-to-animal variation as well as ageing duration. In addition, tenderness variability originating from slaughter procedures at different abattoirs with different chilling regimes would be expected to be minimised when carcasses are PS due to its reduced sensitivity to cold shortening conditions. The use of PS therefore has great potential for tenderness assurance for meat distributors, grocery chains or individual retail shops with meat originating from numbers of different abattoirs.

Table 1. pH (mv±std) as a function of muscle and suspension method. Values in same column with different subscript differ significantly.

Muscle	pH1		PH5			pH 8			pH22	
	AT	PS	AT	PS		AT	PS		AT	PS
LD	6.11±0.15	6.23±0.25	5,62±0,07	5,59±0,11	n.s.	5,54±0,07	5,57±0,134	n.s.	5,44±0,04	5,44±0,03
SM	6.21±0.12	6.36±0.22	5,55 ±0,26	5,69±0,23	n.s.	5,52±0,197	5,58±0,14	n.s.	5,45±0,02	5,46±0,05
BF	6.30±0.09	6.46±0.16	5,74±0,12	5,72±0,24	n.s.	5,64±0,08	5,67±0,08	n.s.	5,51±0,05	5,55±0,10
VL	6,23±0,22	6.21±0,29	5,49±0,09	5,69±0,18	0,043	5,48±0,06	5,54±0,11	n.s.	5,58±0,16	5,50±0,04
GM	6,04±0,06	6,28±0,25	5,53±0,22	5,74±0,18	n.s.	5,49±0,09	5,71±,14	0,011	5,49±0,05	5,51±0,07

Table 2. Tenderness as WBS (N/cm^2) and as SL (µm), storage loss and drip loss (%) as function of suspension method time *p.m.*

Muscle	2 Days *p.m.*			7 days *p.m.*			14 days *p.m.*			SL(µm)		
	AT	PS	p=	AT	PS	p=	AT	PS	p=	AT	PS	p=
LD	131±35	82±18	<0.001	70±16	59±8	<0.001	72±20	63±4	0.003	1,75±0,	2,23±0,	0.002
SM	108±25	86±9	<0.001	87±17	80±9	0.010	91±11	85±9	0.050	1,84±0,	2,92±0,	<0.001
BF	86±18	92±22	n.s.	109±27	109±28	n.s.	108±28	106±26	n.s.	1,82±0,	3,02±0,	<0.001
VL	110±17	88±13	<0.001	103±13	91±7	<0.001	85±11	81±7	n.s.	1,97±0,	3,01±0,	<0.001
GM	85±12	74±4	<0.001	67±16	63±4	n.s.	68±2	68±7	n.s.	1,96±0,	2,79±0,	<0.001
Drip loss	-	-	-	0.8±0.2	0.6±0.1	0.002	-	-	-	-	-	-
Storage loss	1.4±1.1	1.0±0.7	0.067	3.0±1.6	1.7±0.8	<0.001	3.0±1.3	2.0±1.3	0.002	-	-	-

*) n.s. non significant, (-); not measured.

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