INTERRELATIONSHIP BETWEEN MYOFIBRIL FRAGMENTATION AND TENDERNESS FOR BEEF MEAT.

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...MARY

...effect of different pre-rigor and conditioning temperatures on the myofibrillar fragmentation (MF) and tenderness, evaluated by ...mental and sensory measurements, has been studied. The MF was followed by measuring the length, using an image analysis ...m, of myofibrils on micrographs instead of absorbance measurements (MFI). In experiment 1 the influence of different pre-rigor ...eratures from 1 to 10°C on MF and shear force for M. *longissimus dorsi* (LD), during storage at 4°C, was investigated. Sensory ...erties were assessed 14 days post mortem. In experiment 2 the influence of different temperatures during conditioning, varying ...2 to 8°C, on MF and tenderness of LD and M. *semimembranosus* (SM), excised 24 h post mortem, was studied.

...re was a significant decrease in length of the myofibrils between 2 and 14 days post-mortem at all four temperatures in experiment ...However, at three of the temperatures, no decrease in the shear force was registered. The only correlation between myofibrillar ...th and shear force was found at the pre-rigor temperature of 4°C (r=0.77**). This means that no overall correlation (r=0.12) ...ween length and shear force was found. Moreover, although there was no difference in length at day 14, tenderness was greater with ...er pre-rigor temperature. In experiment 2 no reduction of myofibrillar length as a function of time or temperature was found. ...derness, on the other hand, increased with time and temperature. These results suggest that the fragmentation of the myofibrils is ...a crucial factor determining tenderness, since no correlation was found between the length of myofibrils and shear force or ...erness in both types of experiment.

...RODUCTION

...LLER et al (1973) were the first to observe a correlation between the fragmentation of myofibrils and shear force. The method was ...her exploited by OLSON et al. (1976), measuring the turbidity of a suspension of myofibrils of known protein concentration, and ...named myofibril fragmentation index (MFI). Several investigators have since found correlations with shear force and/or tenderness ...h MFI (DAVIS et al, 1980; WHIPPLE et al, 1990; CULLER et al, 1978; OLSON & PARRISH, 1977; CROUSE et al, 1991; ...ACKELFORD et al, 1991). However, the method of MFI has problems connected to measuring absorbance of a suspension, thus ...ing no control of multiple scattering and aggregation of myofibrils. To avoid this, we have followed the MF by measuring the ...th, using an image analysis system, of myofibrils on micrographs. With this method we have studied the effect of different pre-rigor ...d conditioning temperatures on the MF, shear force and tenderness of different beef muscles.

...TERIAL AND METHODS

...experiment 1 LD was removed 25 minutes post mortem from young bulls of the Swedish Lowland breed and samples for shear-force ...d MF measurements were cut. The rest of the muscle and the samples were vacuumpacked and brought to a temperature of 1, 4, 7 or ...°C in a water-bath. After the completion of rigor, the muscles were stored at 4°C for up to 15 days. Shear force and MF ...surements were made at 3, 8 and 15 days post-mortem. Sensory properties were assessed after 15 days.

...experiment 2 LD and SM was excised 24 h post mortem. Each muscle was cut into 3 pieces and vacuumpacked and then stored at ...ferent temperatures and time (7, 14 and 21 days at 2 and 4°C and 3, 8 and 14 days at 6 and 8°C). On each occasion MF was ...asured and tenderness was assessed by a trained panel.

Myofibrillar fragmentation (MF): 5 g of meat, cut into small pieces, was homogenized together with 50 ml of isolation medium (I-medium: OLSON et al, 1976) in an omni-mixer for 60 s at 11000 rpm. The homogenate was centrifuged at 2°C for 15 min at 1000 g. The sediment was brought to suspension in 25 ml of I-medium and was then further diluted with I-medium (1:25). Micrographs were then taken of the suspension at a total magnification of 1340. The length of the myofibrils, up to 60 myofibrils from 4 to 6 different pictures, was determined using an image analysis system.

Shear-force: Prior to analysis, the samples, 3 cm thick, were cooked in vacuum-bags in a water-bath at 74°C for 60 minutes, and were then rapidly chilled in ice. Pieces with a cross-section area of 0.67x1.5 cm were cut. The method and the Warner-Bratzler shear device used was described by BOUTON and HARRIS (1978).

Sensory analysis: The muscle was cut into 1.5 cm thick slices, which were packed in heat resistant plastic bags. The meat was cooked in a water-bath at 74°C for 60 minutes. Sensory analysis was performed by a trained expert panel of 15 women and men. Tenderness was judged on a scale from 1 to 9 (1 = very tough and 9 = very tender).

Statistical analyses: The data were analysed with Systat (Systat, 1987), using Student´s t-test and linear regression analysis.

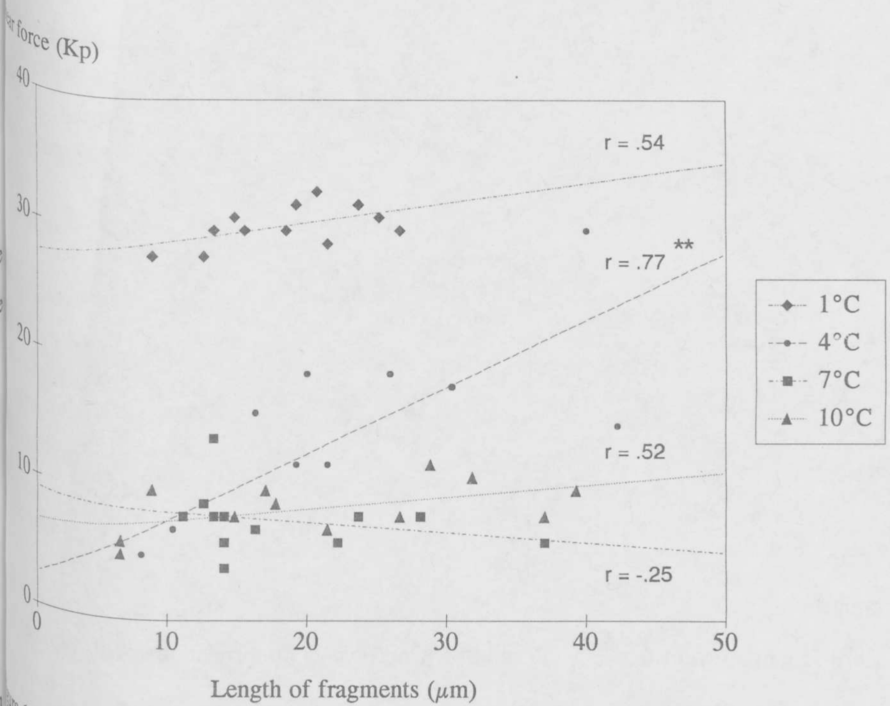
RESULTS AND DISCUSSION

Experiment 1: Results presented in Table 1 show the effect of pre-rigor temperature and conditioning time at 4°C on the fragmentation of the myofibrils.

Table 1. Mean values (m) and standard deviations (s) of the length (μm) of the myofibrillar fragments (n=4) at different days post-mortem, when entering rigor at varying constant temperatures. The levels of significance are; $p \leq 0.05$: *, $p \leq 0.01$: **, $p \leq 0.001$: ***

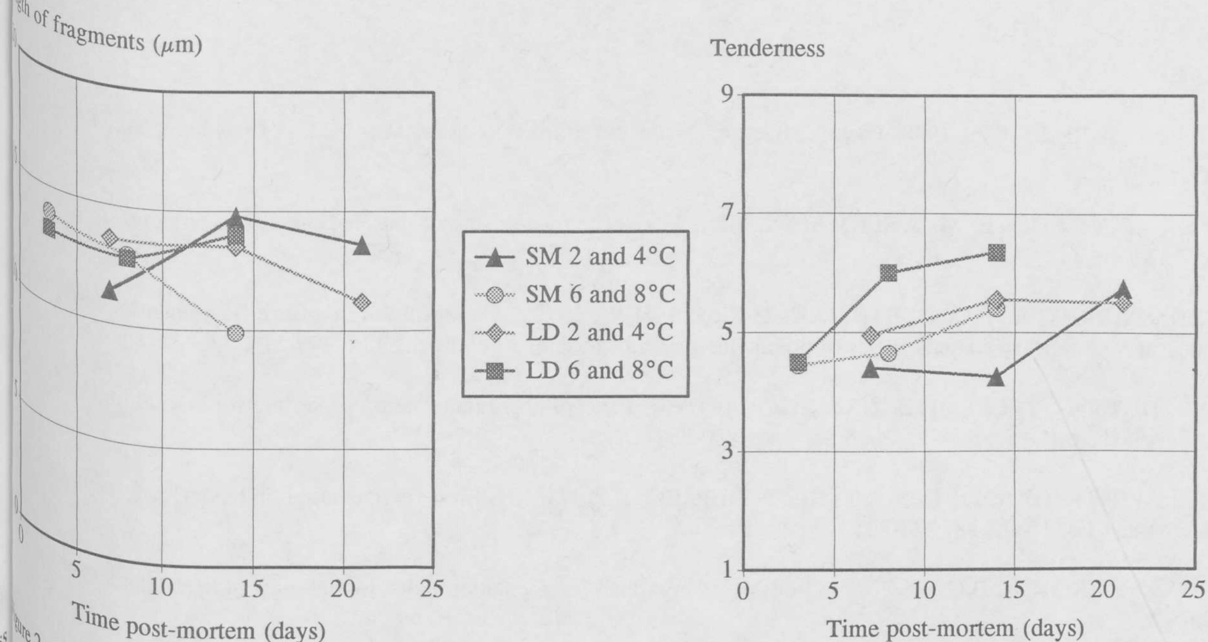
Pre-rigor temperature	Days post-mortem 3 m	s	8 m	s	15 m	s	Sign level 3-8	8-15	3-15
1°C	24.4	2.4	18.5	2.1	12.4	2.6	*	**	***
4°C	34.6	7.6	19.3	2.3	12.1	1.3	**	**	**
7°C	25.4	9.9	16.7	3.8	12.5	1.3	ns	ns	*
10°C	32.9	6.1	18.8	9.7	12.4	7.2	*	ns	*

As shown in the Table, there was a significant decrease in length as a function of time, but no effect of pre-rigor temperature on the length was observed. However, at three of the rigor-temperatures, no decrease in shear force was registered, when MF was lowered (Figure 1), because for neither the 1°C samples nor the 7 or 10°C samples the shear force values decreased with time (results not shown). The only correlation between length and shear force was found at the pre-rigor temperature of 4°C (r=0.77**). This means that no overall correlation (r=0.12) between MF and shear force existed in this investigation. Moreover, sensory evaluated tenderness after 15 days post-mortem increased with higher pre-rigor temperature: i.e. 3.3, 4.6, 5.9 and 5.7 at 1, 4, 7 and 10°C, respectively, even though there were no differences in myofibrillar length (Table 1).



re 1. Shear force values versus length of myofibrillar fragments of meat entering rigor at different constant temperatures of 1, 4, 7 and 10°C, respectively.

eriment 2. In contrast to experiment 1, no significant decrease in MF-length with time was observed, according to Figure 2. The ults from 2 and 4°C as well as 6 and 8°C conditioning temperature are shown together since no differences, both in MF and derness, were found between these temperatures. The length of the myofibril fragments was already short on the first observation. wever, tenderness increased with both time and conditioning temperature.



ure 2. Length of myofibril fragments (left) and sensory evaluated tenderness (right) at different conditioning temperatures versus time for two beef muscles (LD and SM).

e increase in tenderness during a fortnight is significant for LD (***) at 6 and 8°C as well as between 7 and 14 days at 2 and 4°C). For SM conditioning gives rise to a significant tenderization (***) at 2 and 4°C between 14 and 21 days and at 6 and 8°C a week ter. No significant effect of time was found for MF-length. Therefore there was no correlation between MF and tenderness cording to Figure 3.

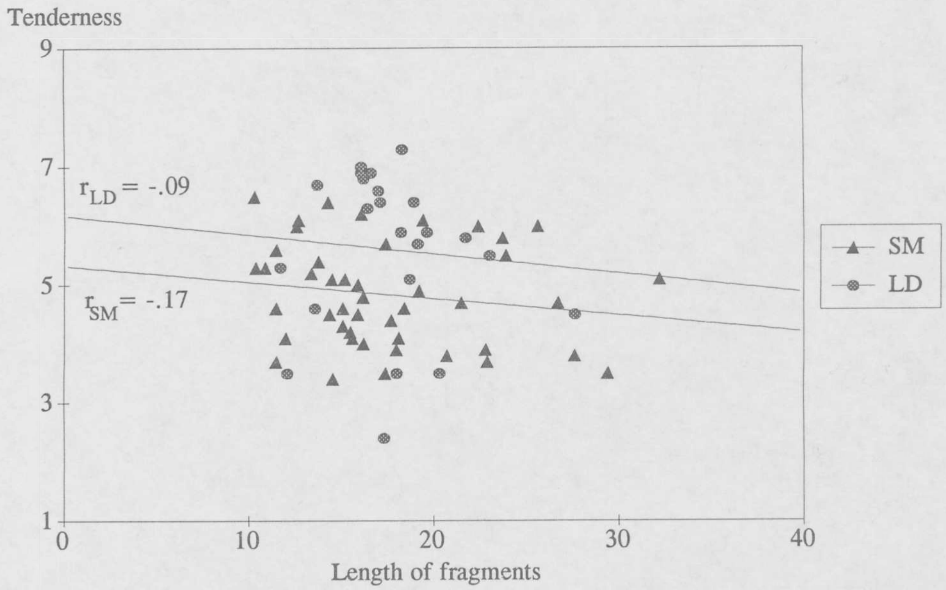


Figure 3. Tenderness versus length of myofibril fragments (μm) for both LD and SM. Coefficients of correlation are also given.

CONCLUSIONS

* For LD, which was exposed to different constant pre-rigor temperatures in the cold shortening region, a significant decrease in myofibril length was found during conditioning for up to 15 days post-mortem at 4°C.
* For both LD and SM, excised 24 h post-mortem, no significant decrease was found in myofibril fragment length during conditioning for up to 21 days at varying constant temperatures from 2 to 8°C.
* No correlation was found between the length of myofibril fragments and shear values or sensory evaluated tenderness.
* These results suggest that the fragmentation of the myofibrils is not a crucial factor for determining tenderness.

REFERENCES

BOUTON, P.E. & HARRIS, P.V., 1978. Factors affecting tensile and Warner-Bratzler shear values of raw and cooked meat. J. Text. Studies, 9, 395-413

CROUSE, J.D., KOOHMARAIE, M. & SEIDEMAN, S.D., 1991. The relationship of muscle fibre size to tenderness of beef. Meat Sci., 30, 295-302

CULLER, R.D., PARRISH Jr, F.C., SMITH, G.C. & CROSS, H.R., 1978. Relationship of myofibril fragmentation index to certain chemical, physical, and sensory characteristics of bovine longissimus muscle. J Food Sci., 43, 1177-1180

DAVIS, G.W., DUTSON, T.R., SMITH, G.C. &CARPENTER, F.J., 1980. Fragmentation procedure for bovine longissimus muscle as an index of cooked steak tenderness. J Food Sci., 45, 880-884

MØLLER, A.J., VESTERGAARD, T. & WISMER-PEDERSEN, J., 1973. Myofibril fragmentation in bovine longissimus dorsi as an index of tenderness. J Food Sci., 38, 824-825

OLSON, D.G. & PARRISH Jr, F.C., 1977. Relationship of myofibril fragmentation index to measures of beefsteak tenderness. J Food Sci., 42, 506-509

OLSON, D.G., PARRISH Jr, F.C. & STROMER, M.H., 1976. Myofibril fragmentation and shear resistance of three bovine muscles during postmortem storage. J Food Sci., 41, 1036-1041

SHACKELFORD, S.D., KOOHMARAIE, M., WHIPPLE, G., WHEELER, T.L., MILLER, M.F., CROUSE, J.D. & REAGAN, J.O., 1991. Predictors of beef tenderness: development and verification. J Food Sci., 56, 1130-1135

SYSTAT, Inc., 1987. The System for Statistics, Evanston, Illinois, USA

WHIPPLE, G., KOOOHMARAIE, M., DIKEMAN, M.E. & CROUSE, J.D., 1990. Predicting beef-longissimus tenderness from various biochemical and histological muscle traits. J Anim. Sci., 68, 4193-4199