OBSERVATIONS ON MEAT TENDERNESS IN BOVINE M. LONGISSIMUS DORSI

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The quantitative and qualitative characteristics of connective tissue have been signated "the background tenderness" of meat (Marsh 1966). The differences of the muscles a carcas is determined to a certain extent by the quantity of connective tissue (Ramsbottom and Strandine 1945) but also by the chemical and structural differences in the connective tissue (Herring et al. 1967, Ritchey and Hostetler 1964).

In muscles poor of connective tissue a connection between the degree of muscle fibre contraction and the meat tenderness has been proved by Locker (1960). Later on the post mortem contraction of the muscle fibres showed to be influenced by carcas position (Herring et al. 1965), red fiber content (Beecher et al. 1965), time course of rigor mortis (Stouffer et al. 1965) and especially the coaling down temperature immediately after time of slaughtering (Locker and Hagyard 1963, Marsh 1966).

The background for knowledge of the various facts involved in the variations of meat tenderness is a series of experimental tests, and also test materials of some heterogeneous however, which makes it difficult to transfer the conclusions to more uniform materials.

In spite of extensive standardizations concerning feeding and environments during growth and also concerning the slaughtering procedure, young bulls showed considerable differences in tenderness of m. longissimus at the progeny test stations for meat production in Denmark. Therefore, it was an object to find the reason for this in histological and chemical analyses which in previous tests have proved to be of consequence to the meat tenderness.

Materials and Methods.

The test material was young bulls which under uniform environmental conditions were feeded according to the same feeding plan and killed at 450 kg live weight under standardized conditions. Cutting up of the carcasses took place 48 hours after slaughtering and longissimus dorsi from 8. - 10. rib was taken out of the right side of each carcass for analyses and determination of the Warner-Bratzler shear value. The shear force results 9 days after slaughtering formed the basis for a selection of two groups of 16 animals with tenderness values under 8,0 lbs. and above 10 lbs. respectively.

3 days after slaughtering samples for messurering the diameter of muscle fibres and sarcomer lengths were taken out the center part of the sectional area at the 8th rib. After fixing in a 6 pct. glutaraldehyd solution a microtom cryostat was used for sections, and the diametres of 80 muscle fibres chosen at random were measured. The number of striations on a length unit of 40 of 25 muscle fibres chosen at random was counted for measuring of sarcomer lengths.

The extraction of protein components was carried out after 10 days of aging at 2 to 4°C of the meat samples which were cut out of the center part of the sectional area at the 8th rib. The protein components including sarcoplasma, myofibrillar and stromaprotein were extracted according to a technique invented by Helander in 1957.

The tenderness of meat was determined by the Warner-Bratzler device after deep fat frying in 150°C till a center temperature of 70°C. After determination of the tenderness

the cut samples were cooled down and kept at 18 degrees centigrade below zero for approx. 2 months, and then used for a collagen solubility test according to Hill (1966). The amount of extractable protein in 0,6 M KCL was determined at the same time. Finally, we implemented electron microscopi on the glutaraldehyd fixed samples of m. longissimus dorsi from 5 animals. Additionally these samples were fixed in a 1 pct. osmie acid and embedded in vestopal.

Results and discussion.

The average results and the calculations of standard deviations and correlation coefficients will be seen in table 1. From this it appears that the diametres of fibres were significantly smaller in samples with tenderness values under 8,0 lbs, r= 0,32 P 0,05. The variations in sarcomer lengths were not significant but showed a tendency towards smaller contraction in the group which had low tenderness values. The connection between fibre diamteres and sarcomer lengths was high significant (r=0,75 P 0,01) and, therefore, the fibre diametres were corrected according to the formular: fibre diameter corr. = fibre diameter x $\frac{\text{sarcomerlength}}{2,34}$ according to Bendall (1967). Now the corrcted average fibre diameter showed to be most the same in the two tenderness groups. Therefore, when thick fibres generally result in higher tenderness this may - to some extent - be due to the fact that the thick fibres have had a wider diameter because of greater contraction.

The extraction of protein components showed a significantly (P 0,05) lower content of soluble myofibrillar protein in the low tenderness group while the content of soluble sarcoplasma protein and remaining fraction the stroma protein, did not show any significant differences between the groups. The lower contents of soluble myofibrillar protein in the low tenderness group seem to be conflicting with previous investigations (Hegarty et al. 1963, Goll et al. 1964, Penny 1968). The divergence may be due to different concentrations of salt solutions for extraction. In our experiments we have used 1,1 M KL for extraction of the myofibrillar proteins, and, therefore, they are rather a quantitative expression of the concentration of myofibrils. A higher concentration of myofibrils in the muscle fibres seems to involves increasing tenderness. No relation between size of muscle fiber diametres and content of solube myofibrillar protein was proved. Analyses of the fried meat did not show any dignificant differences in the solubility of collagen.

The samples for these analyses were placed around the center parts of the frying samples where the temperature is approx. 70°C after deep-fat frying. It may, therefore be expected that the gelatinization of the collagen has not influenced the total content of collagen to any appreciable extent. Therefore, according to the analysis criterium used, the differences of tenderness between the two groups will not be due to any qualitative difference in the structure of collagen. The homogeneous mass of soluble protein under extraction with 0,6 M KCL proves that thedifferences in tenderness have not been caused by different degrees of denaturation or coagulation of protein under heat treatment.

The results of measurements of sarcomer lengths and lengths of myosin filaments and actin filaments are to be seen on a photo blow up (21200 times) and in table 2. Also, the lengths of the actin overlap zones in the middle of the sarcomer were measured. The results are all stated as the average of 20 individual measurements.

In table 2 it can be seen that the actin overlap zones were increasing as the sarcomer lengths were decreasing. Therefore, the relation between the sarcomer lengths and the mutual displacements of filaments agreed with the contraction theory (Huxley and Hanson 1960), although not regardless of the observed differences in lengths of actin filaments.

Conclusion.

Based on unfailing standardization of feeding and environment during the growth and slaughtering procedures the results have showed that the generally accepted tenderness factors cannot adequately explain the observed differences in tenderness of m. longissimus dorsi samples from young bulls all killed at the same weight.

Under the given test circumstances it was found that wider muscle fibre diametres and increasing contents of myofibrillar protein involve significantly higher shear force values. A high significant connection was demonstrated between the size of muscle fibre diameter and the sarcomer length. Terefore, a well defined determination of the muscle fibre diameters influence on the tenderness of the meat will involve a correction for differences in contraction degree. In cases where the contraction degree was increasing also the overlap zone of actin filaments increased around the M line.

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TABEL 1.

AVERAGE RESULTS OF ANALYSES I M. LONGISSIMUS DORSI FROM TWO GROUPS OF YOUNG BULLS WITH RESPECTIVELY HIGH AND LOW SHEAR FORCE VALUES.

	W-B shear force 8,0lbs		W-B shear force 10,0 lbs			
	$\bar{x}$	s	$\bar{x}$	s	P	r
Animal age, days	390	17	388	17		- 0,14
Muscle fibre diameter,	39,2	4,70	42,6	3,85	0,05	0,32
do., corr.	31,2	3,65	31,9	3,20		0,08
Sarcomere lehgth,	1,87	0,17	1,76	0,11		- 0,30
In raw meat:						
Sarcoplasma prot. %	6,81	0,46	6,71	0,31		- 0,02
Myofibrillar prot., %	11,57	1,34	12,57	0,85	0,05	0,32
Stroma prot., %	1,32	0,42	1,51	0,67		0,15
In cooked meat:						
total collagen, %	0,99	0,12	0,99	0,13		0,08
soluble collagen, %	14,29	4,36	15,06	4,67		0,16
soluble prot. in 0,6 M KCL,%	3,06	0,26	3,06	0,40		0,08
Number of animals	16		16			

TABEL 2.

MEASURMENTS OF FILAMENTS AND SARCOMER I M. LONGISSIMUS DORSI FROM 5 YOUNG BULLS

	Length in of							
	Sarcomere		Myiosinfilam.		Actinfilam.		Actinoverlap.	
11	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
2	1,55	0,045	1,32	0,030	1,10	0,026	0,64	0,035
3	1,64	0,038	1,30	0,021	1,15	0,024	0,62	0,028
4	1,71	0,036	1,31	0,023	1,14	0,020	0,57	0,030
7	1,76	0,041	1,34	0,027	1,16	0,025	0,56	0,031
	2,03	0,048	1,35	0,032	1,20	0,035	0,38	0,041

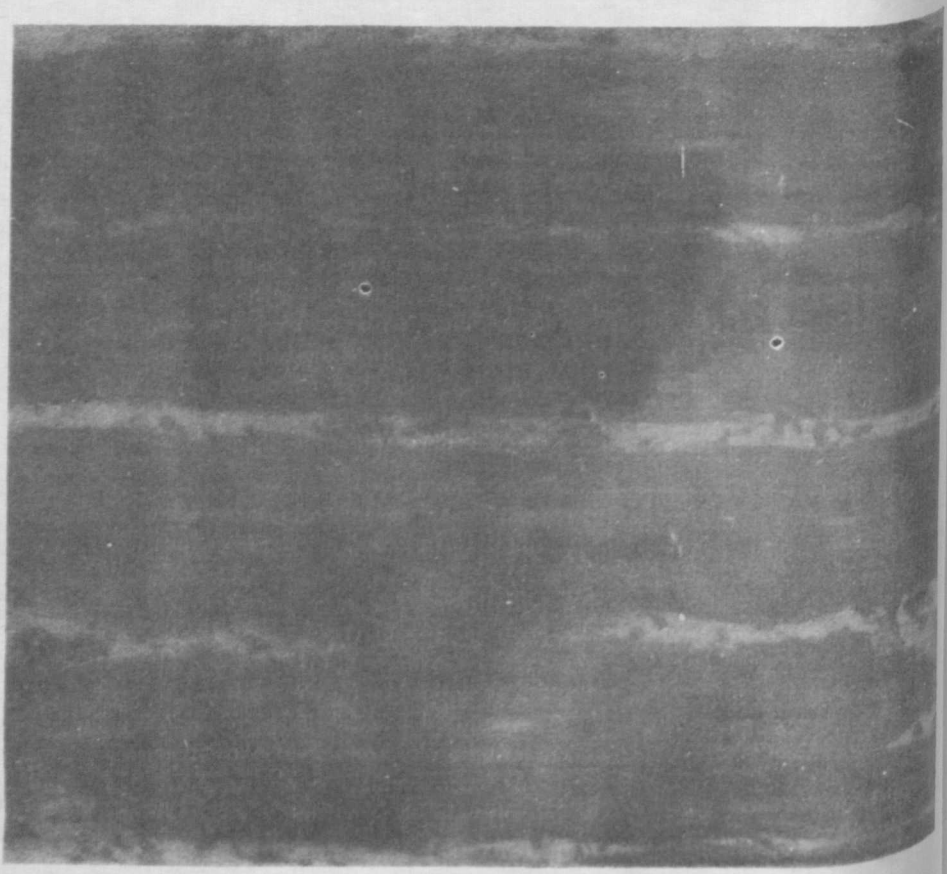

Fig. 1. Myofibrils (x 21200) from m.longissimus dorsi showing the zone of double overlap by actinfilaments.