B/15 Shear value of beef longissimus dorsi in relation to muscle fiber size and type

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Summary

Variation in Warner-Bratzler shear force between samples of M. longissimus dorsi from 357 young bulls of Danish dairy breeds were related to size and type of muscle fibers and carcass characteristics. The shear values were strongly correlated with average fiber diameter (r = o.39), av. white fiber diameter (r = o.44) av. intermediate fiber diameter (r = o.34), and to a lesser extent to av. red fiber diameter (r = o.12). Percent red fiber in the muscle was slightly positively correlated to shear value (r = o.13). The intramuscular fat content was correlated to shear value (r = o.22) but not to fiber diameters except av. red fiber diameter (r = o.16). White fiber diameter and shear value were positively correlated with net gain in carcass weight during growth and percent lean in loin and hind leg.

Tenderness of beef muscles depends on technological factors like carcass position during post-mortem chilling, rate of chilling and length of ageing time. Tenderness depends also on animal husbandry factors as breed, sex, nutritional status and age of animal at slaughter. The reason why some of these factors affect tenderness is poorly understood. This applies for example to the variation in tenderness of M. longissimus dorsi due to breed and variation within a breed. The purpose of this paper is to report some relationships between muscle fiber appearance and tenderness measured as the Warner-Bratzler shear value of M. longissimus dorsi from young bulls slaughtered at 45o kg liveweight after identical feeding regimen. Differences in average size have been found earlier to account for some of the variation (Wismer-Pedersen 1969) and this investigation constitutes an extension of this finding to the relationship with the different fiber types.

Materials and methods.

The experimental material consisted of cuts from M. longissimus dorsi between 8th and 10th rib from 357 young bulls. The bulls were of Danish Red dairy breed (RDM), Danish Black Pied dairy breed (SDM), Danish Red Pied dairy breed (DRK) and Jersey x Charolais crosses (Ch.) and slaughtered at 450 kg liveweight after identical feeding regimen.

The cuts were excised 24 hours post mortem. A sample from the center of the excised muscle cut was fixed in 10% formalin. After thorough fixation thin muscle slices were cut at a right angle to the fiber direction and stained with Sudan Black B as described by Chäffelle and Putt (1951). Measurement of the diameter of 100 random selected muscle fibers were made for each muscle and the fibers classified as [1] red fibers, [2] white fibers and [3] intermediate types. The Warner-Bratzler shear value was determined after 9 days ageing of the meat at 2-4°C in cry-o-vac bags. Before measurement the cuts were deep-fat fried at 150°C until a center temperature of 70°C was reached. The measurements were made on cores of ½ inch diameter drilled parallel to the fibers. The shear value was calculated on basis of 10 measurements. The results were data processed and compared with other observations on the carcasses in the testing routine of the Egtved station as described by Nielsen et al. (1968).

Results and discussion.

On figure 1 is shown the distribution of the shear values over the loins from the young bulls. The shear value cover a rather broad range from real tender to rather tough meat consistency.

On figure 2 is shown the distribution of the three fiber types in rather tough muscles. The figure is constructed by use of data from two muscles with shear values of 17-18 lbs. In figure 3 is shown corresponding distribution in tender muscles. The figure refer to data from two muscles with shear values between 5 and 6 lbs. The tough muscles have on an average larger fiber diameters

than the tender muscles and the distribution of the fiber diameters is broader. Analysis on data from all the bulls showed that the average fiber diameter is highly correlated with the average diameters of the red, white and intermediate fibers. The coefficients of correlation are however highest with the diameters of the white and intermediate fibers as seen in table 1. The standard deviation of the total average is strongly correlated with the average diameters of white and intermediate fibers, but not with red fiber diameter and only slightly with percent red fibers in the fiber population. These results suggest that large average diameters is due to increased size of white and intermediate fibers.

In table 2 is shown the correlation coefficients between shear values, intramuscular fat content and the fiber diameters. From the coefficients in the table it is apparent that the shear value is highly correlated with the diameters of the white and intermediate fibers. Due to the relationships mentioned above are the coefficients with average fiber size and standard deviation also considerable. The intramuscular fat content is not correlated with the fiber measurements except with the red fiber diameters. It is however negatively correlated with the shear value. The correlation is on the same level as in other studies (Blumer 1963, Wismer-Pedersen et al. 1973).

The relative diameters of the three fiber types are in accordance with the general observation that red fibers have the smallest and white fibers the largest diameters (Close 1972). The group of intermediate fibers comprise the true intermediate fibers as well as some red and white fibers which were misplaced at the miscroscopic examination of the muscle slices because their appearance were not clear red or white. It is not clear why large white fibers should occur more frequently in loins with high shear values. A possibility exist that white fibers may contract to a greater extent than red fibers during onset of rigor mortis and consequently appear with large diameters. Earlier studies have shown a negative relationships between shear values and

sarcomere length on similar samples from young bulls (Juel Møller 197o). However both shear values and diameters of white fibers are strongly correlated with carcass and growth characteristics of the bulls as seen from the figures in table 3. The table show generally that fast growing bulls with large percentage of lean meat in the most valuable part of the carcass have tendency to yield loins with high shear values. These loins will predominantly have large white fibers whereas diameters of red fibers will be average. The table also show strong negative correlation between intramuscular fat content and the adventageous carcass and growth characteristics of the bulls.

Meaty animals may be expected to have a tendency to develop muscles with large muscle fibers. Ashmore, Tompkins and Doerr (1972) suggest that this takes place by transformation of fast red fibers to larger white fibers with less capacity of sustained activity. Our results do not support this suggestion as table 3 show positive correlation coefficients between percentage red fibers and meatiness. However the activity of the fibers may be expected to decrease with increasing diameter because of limiting capacity for diffusion and cellular exchange of metabolites and waste products. This may entail different post-mortem behavoir.

Whether the association between white fiber size and shear value of the meat is a direct one or circumstantial remains to be elucidated.

Acknowledgement

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Table 1. Coefficients of correlation between diameters of the muscle fiber types and percent red fibers.

	standard deviation	av. red fiber d.	av. white fiber d.	av. interm. fiber d.	pct. red fibers
Average musclefiber diameter	o.58	o.66	o.92	o.76	o.oo
Standard deviation of average muscle diameter		o.o9	o.64	o.55	o.12
Average red fiber diameter			o.44	o.4o	o.o3
- white fiber -				o.66	o.22
- interm. fiber -					o.18

Coefficients above o.11 are statistically significant at the $P < o.o5$ level

Coefficients above o.15 are statistically significant at the $P < o.o1$ level.

Table 2. Coefficients of correlations between shear value, intramuscular fat and muscle fiber observations.

	shear value	pct. fat content
Average musclefiber diameter	o.39	o.o3
Standard deviation	o.37	-o.o8
Av. red. fiber diameter	o.12	o.16
Av. white fiber diameter	o.44	-o.o3
Av. interm. fiber diameter	o.34	-o.o4
Percent red fibers	o.13	-o.11
Intramuscular fat content	-o.22	

Coefficients above o.11 are statistically significant at the P<o.o5 level

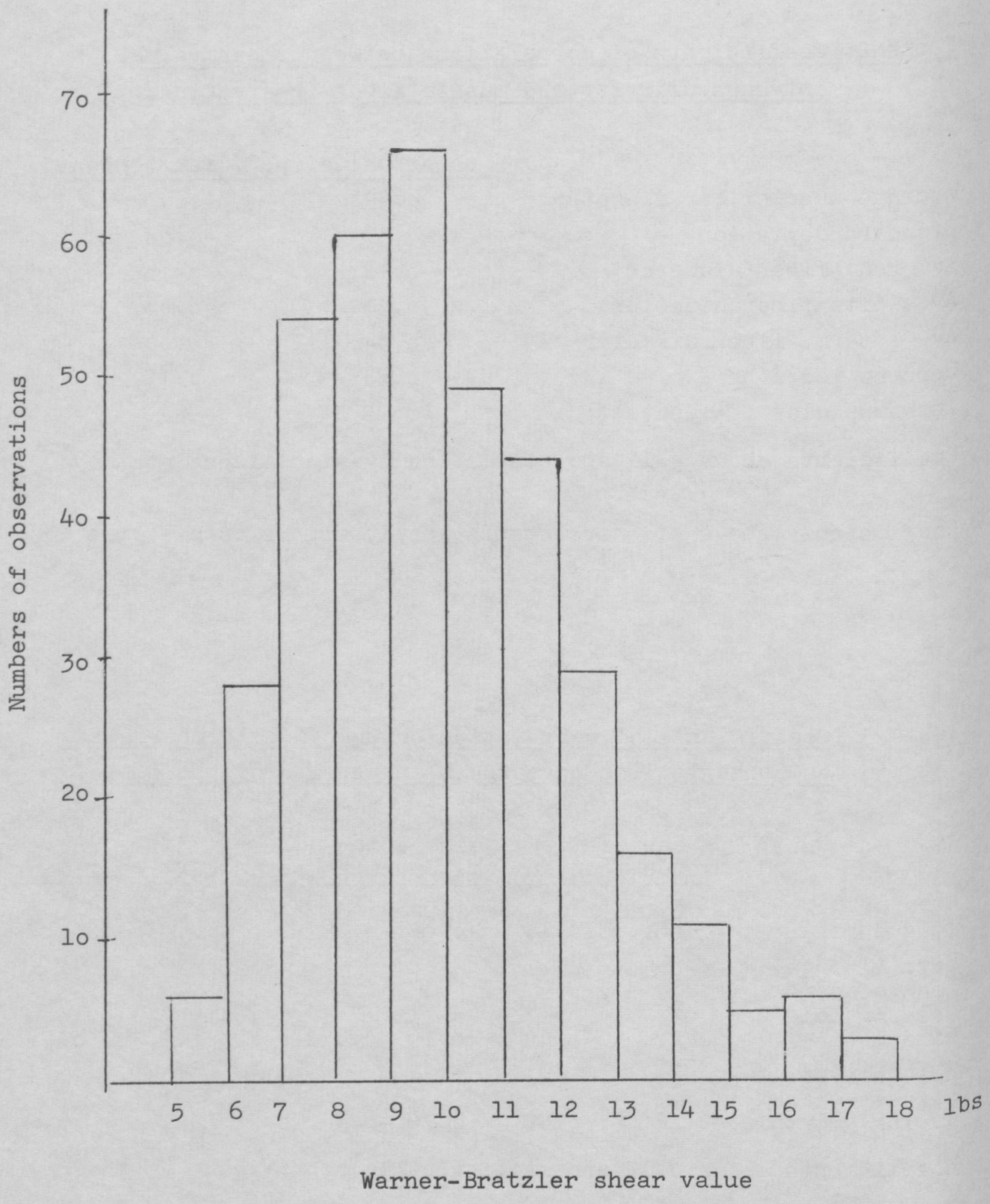
Coefficients above o.15 are statistically significant at the P<o.o1 level.

Table 3. Coefficients of correlation between muscle charistics and observations on carcass and growth of the bulls.

	shear value	fat content	av. fiber diameter	red fiber diameter	white fiber diameter	interm. fiberd.	pct. red fibers
Area of m. long dorsi	o.o8	-o.14	-o.o4	-o.o9	-o.o2	-o.o3	o.16
pct. of total lean of carcass in loin and hind leg	o.27	-o.49	o.19	-o.o7	o.27	o.18	o.14
net gain in carcass weight during growth	o.26	-o.45	o.14	-o.1o	o.21	o.14	o.oo

Coefficients above o.11 are statistically significant at the P<o.o5 level

Coefficients above o.15 are statistically significant at the P<o.o1 level.



Figur 1. Diagram of variation of the Warner-Bratzler shear value of the loins from the young bulls.

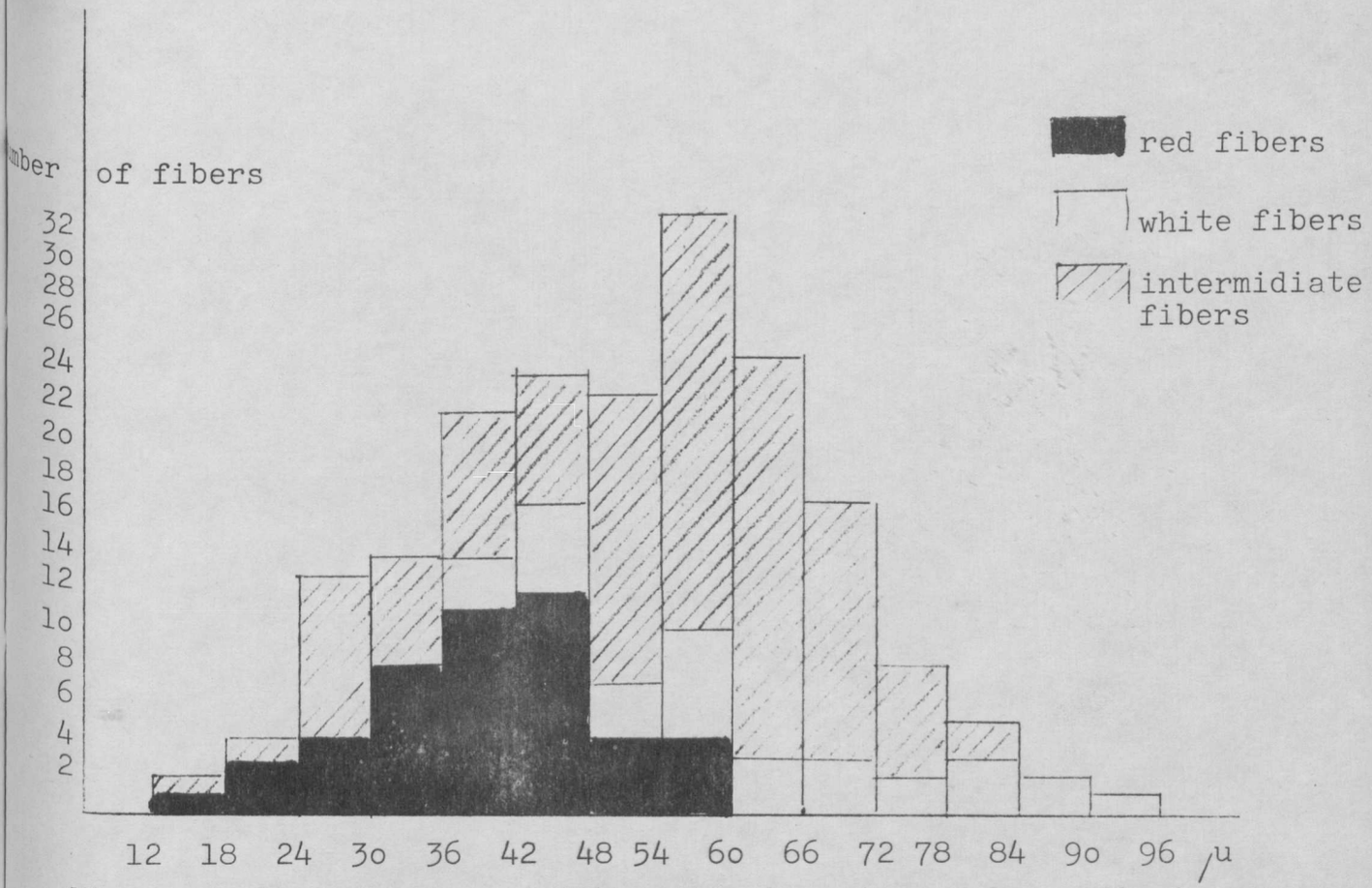


Figure 2. Distribution of fiber diameters in muscles with shear values 17-18 lbs.

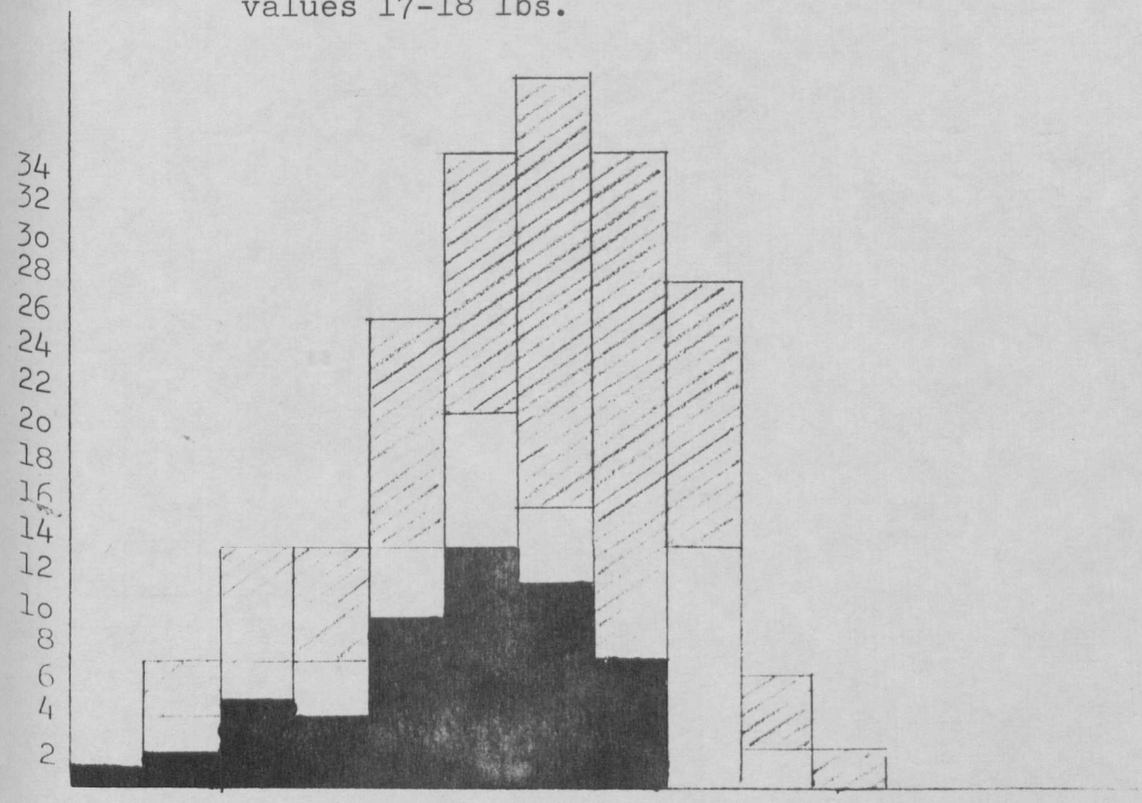


Figure 3. Distribution of fiber diameters in muscles with shear values 6-7 lbs.