# Distribution of muscle fiber diameter length values in relation to muscle fiber histochemical type

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Several early workers (Lörinz and Biró, 1959; Herring et al, 1967; Wismer-Pedersen et al, 1973) attempted to correlate muscle fiber diameter with meat texture. Others (Cassens and Cooper, 1971; Klosowska et al, 1979) suggested that a relationship between muscle histochemical profile and meat quality exists. On the other hand, many original studies (Cassens and Cooper, 1971; Cauthier, 1970) indicated that muscle fiber diameter and muscle fiber histochemical type are related. However, the latter seems to depend on several parameters such as sex, age, exercise (Cassens and Cooper, 1971; Brooke and Engel, 1969a; Brooke, 1970; Rantsios, 1972; Lacourt, 1973). It appears therefore that to study the relationship between muscle fiber diameter and fiber histochemical type in beef animals is of some value for interpreting the role of muscle histochemical profile in meat quality.

## Material and Methods

The study was carried out in 18 Friesean steers with an average age of 20.14±0.71 months. Samples of Longissimus dorsi and Trapezius muscles were taken one hour after slaughter, and immediately were snap frozen in melting isopentane. The samples were preserved in -70°C until 10μm thick sections were prepared. The activity of ATPase (Dubowitz and Brook, 1973) and that of Succinic Dehydrogenase (SDH)(Seligman and Rutenburg, 1951) was demonstrated in serial sections.

Protographs of standardised magnification were taken from each section. Muscle fibers were grouped, independently for each of the two enzymes studied, as follows: According to SDH activity in type I (strong reaction), intermediate, and type II (weak reaction). According to ATPase activity in type I (weak reaction), intermediate, and type II (strong reaction). In each photograph the narrowest aspect of the cross section diameter, in 200 fibers, was measured.

For each group of measurements, concerning muscle fiber histochemical type, within each muscle and enzyme treatment, the mean value, standard deviation and standard error were calculated. These values were used in each case for the determination of group mean value, standard deviation, and standard error, reflecting the situation in all animals. Also, out of the aforementioned values histograms were constructed, after classification in classes of 5μm.

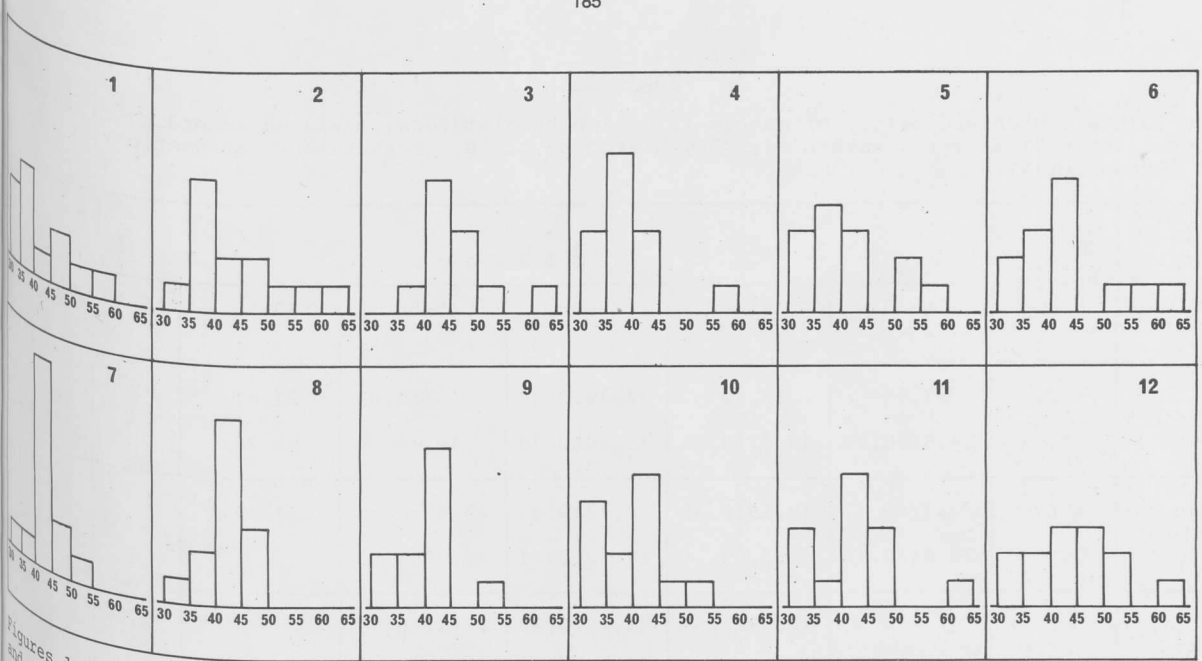
## Results

In Table I the mean values and the standard errors of the muscle fiber measurements are shown according to enzyme reaction and histochemical muscle fiber type in μm. In figures 1-12 value distribution histograms are shown. In addition, in Tables II and III, the mean values and standard errors within each 5μm class of the histograms are presented.

Table I

Mean values ± standard errors of the mean of muscle fiber diameter measurements, according to histochemical type demonstrated with ATPase and SDH activity.

| Muscle | ATPase | | | Succinic dehydrogenase | | |
|---|---|---|---|---|---|---|
| | Histochemical muscle fiber type | | | Histochemical muscle fiber type | | |
| | I | E | II | I | E | II |
| Longissimus dorsi | 41,31 ±2,35 | 42,54 ±2,29 | 47,64 ±2,09 | 42,54 ±5,07 | 42,60 ±1,07 | 46,74 ±1,52 |
| Trapezius | 40,41 ±1,71 | 42,73 ±2,11 | 45,06 ±2,37 | 38,92 ±1,83 | 40,96 ±2,45 | 43,20 ±2,50 |




Figures 1-12. Histograms of muscle fiber diameter length according to muscle, enzyme activity, and muscle fiber histochemical type. 1. L.D.,SDH,fiber type: I. 2. L.D.,SDH,fiber type: intermediate. 3. L.D.,SDH,fiber type: II. 4. T.,SDH,fiber type: I. 5. T.,SDH,fiber type: intermediate. 6. T.,SDH,fiber type: II. 7. L.D.,ATPase,fiber type: I. 8. L.D.,ATPase, T.,ATPase,fiber type: intermediate. 9. T.,ATPase,fiber type: II. 10. T.,ATPase,fiber type: I. 11. 12. T.,ATPase,fiber type: intermediate.

(L.D. = Longissimus dorsi; T = Trapezius)

Table II

Mean values ± standard errors of muscle fiber length diameter, measured according to muscle fiber histochemical type, within each 5µm histogram class. Measurements in sections stained for Succinic dehydrogenase activity.

| Muscle fiber histo-chemical type | Muscle | Classes | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 30-35 | 35-40 | 40-45 | 45-50 | 50-55 | 55-60 | 60-65 |
| Type I | L.D. | 32,66±0,84 | 37,71±0,86 | 42,42 | 47,61±0,45 | 53,91 | 55,33 | |
| | T. | 32,40±0,62 | 37,42±0,72 | 43,07±1,29 | | | 55,01 | |
| Inter-mediate type | L.D. | 33,68 | 37,40±0,56 | 41,08±0,47 | 47,93±0,55 | 51,23 | 55,72 | 60,76 |
| | T. | 32,32±1,23 | 36,99±0,69 | 41,42±0,31 | | 53,00±0,28 | 57,29 | |
| Type II | L.D. | | 38,33 | 43,58±0,38 | 46,85±0,75 | 54,78 | | 64,38 |
| | T. | 33,92±0,94 | 37,96±0,83 | 41,92±0,29 | | 51,47 | 55,40 | 63,43 |

(L.D. = Longissimus dorsi; T. = Trapezius)

Table III

Mean values ± standard errors of muscle fiber length diameters, measured according to muscle fiber histochemical type, within each 5μm histogram class. Measurements in sections stained for ATPase activity.

| Muscle fiber histo-chemical type | Muscle | Classes | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 30-35 | 35-40 | 40-45 | 45-50 | 50-55 | 55-60 | 60-65 |
| Type I | L.D. | 31,95 | 39,35 | 42,38±0,69 | 46,32±0,82 | 54,07 | | |
| | T. | 33,58±0,43 | 37,07±0,35 | 42,10±0,79 | 49,11 | 53,20 | | |
| Inter-mediate type | L.D. | 34,00 | 39,16±0,35 | 42,72±0,43 | 47,48±0,74 | 52,73±0,65 | | 61,94 |
| | T. | 33,84±0,76 | 38,09 | 42,62±0,71 | 46,96±0,83 | | | |
| Type II | L.D. | | 37,58±1,65 | 43,78±0,89 | 47,22±0,57 | | 55,80 | 64,69 |
| | T. | 33,09±1,07 | 38,72±1,71 | 43,63±0,23 | 47,61±0,87 | 51,86±1,18 | | |

(L.D. = Longissimus dorsi; T. = Trapezius)

Discussion

Reproducibility of muscle fiber diameter length measurements is a precondition for any comparable results between different workers. If a perfect cross section of any individual fiber in a histologic section could be achieved, there would not have been a problem. However, as it is described by Brook and Engels (1969a), and Brook (1970), this cannot always be the case. Therefore, the narrowest aspect of the cross section diameter of each fiber was adopted as its diameter. This is not altered regardless of the ankle of the section of the fiber.

On the other hand, the reciprocity between oxidative and glycolytic enzyme activity in muscle fibers, suggested in earlier works (Dubowitz and Pearse, 1960) does not seem to be perfectly applied in beef animals (Klosowska et al, 1979; Rantsios, 1981). It appears, therefore, reasonable to suggest that for a full demonstration of the histochemical profile of a muscle, at least ATPase and Succinic dehydrogenase (or other oxidative enzyme) activity must be studied.

There is no significant difference between any pair of mean values presented in Table I. Also, the measurements in different sections stained for the demonstration of the two enzymes examined are highly correlated ($r = 0,8925$, $p < 0,01$). In addition the values are fairly evenly distributed, as it can be deduced from the histograms in figures 1-12, the correlation coefficient value ($r = 0,3035$, $p < 0,05$) between figures 1-6 and 7-12 for the number of cases allocated in each histogram class, and the mean values within classes, which are presented in Tables II and III. As a result, allowing some reservations, due to the development of cold-shortening in all the samples, one is forced to accept the uniformity of muscle fiber size regardless of histochemical type. Comparable evidence is presented by others.

Average diameter in horse (2 year old ponies) Semitendinosus muscle was 7 to 10μm less for intermediate and type I muscle fiber than muscle fibers type II. However, the differences were not significant (Aberle et al, 1976). In young humans there is no difference between muscle fiber diameter of the two histochemical types I and II. Nor between sexes. On the contrary, in adults the size is larger for type II in men and type I in women. However, although type I is standard, type II changes according to exercise (Brook and Engel, 1969a, 1969b).

Consequently, it could be suggested that our observations are the result of the young age of the beef animals and the limited opportunity for exercise they have. Alternatively, it could be claimed that if in cold-shortening only the type I fibers (red) are involved, an increase in their diameter due to shortening could bring them about at the diameter size of the other histochemical type muscle fibers, so that no differences could be observed. These last points require further elucidation.

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