Vème REUNION DES INSTITUTS DE RECHERCHES SUR LES VIANDES

PARIS - du 7 au 12 Septembre 1959 -

Nº 8

Data relating the question of correlation between the diameter of the muscle fibres and the quality of meat

By Dr. F. Lőrincz and Dr. G. Biró

Hungarian Meat Research Institute Budapest

Introduction

It is perhaps unnecessary to stress the practical and scientific importance of the question - raised in the title -. The attention of the stock-breeder, technologist and researchworker of meat industry is directed to this question by the demand of the consumer, namely, that the appetizing and savoury meat or meatproduct should be also - and perhaps in the first place - tender. The scientific research has cleared up to now many biochemical, histological and physical details, which explaine the toughness or tenderness of meat, and thus helps the production to avail the desirable m e at quality.

In histological relation the part of connective tissue elements (collagen and elastical fibres, fatty tissue) has been thought more important, than the structure of the muscle fibres. The research workers handle this question only since 1930. To prove the truth of this conclusion - without going into details - we mention only the recapitulative works of some prominent authors dealing with this question (1, 2, 3, 4, 5).

Between the dimensions of the muscle fibres and the quality of meat (texture, tenderness) there are definite correlations so as between the different groups of muscles (meat-parts) and the same muscles of animals of different quality (age, nutrition, etc.). It can be stated, that in the same animal, for instance, the fibres of the tender loin or the deep dorsal muscles, as the M. psoas, - ilio-psoas, -longissimus dorsi, are finer, their crossdiameter is smaller, than the muscle fibres of the neck or the arm, as the M. serratus, M. biceps brachii, M. supraspinatus, etc. The fibre dimensions of the same muscles in animals of the same quality belonging to the same race and sex, differs according to the age of the animal. The fibres of younger animals are finer, than these of the older ones.

Accepting, however, these correlations we must refer to the inconsistencies and uncertainties, which were completely collected by Neseni and Müller (2). These difficulties and inconsistencies can not be cleared without determining the exact method of examination and using always the same procedure.

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Only with muscle samples, which are taken strictly in the same way and are examined with the same method, can be comparable and thus reassuring results achieved. Neseni and his coworker took very much pains in clearing up the questions of sampling and method of examination. In their work, however, they only say, that "fresh muscles" has been examined. Other authors determined the muscle cell dimensions on samples stored for 12 - 15 days on a temperature of + 0.6 - 1.7° C (3) or on transversal or longitudinal sections of muscle parts, which were refrigerated or embedded in paraffin.

This question was also discussed on the IV. Conference of the European Meat Research Workers (Cambridge, 15 - 19th September 1958). In consequence of this discussion - on which we were also participant - we decided to propose, completing our former observations and examinations, a new, internationally acceptable process of sampling and procedure, which would ensure a better comparability and the solving of the discussed questions.

Materials and methods

Our material for the examinations were taken from the following muscles of 16 horned cattle : M. iliopsoas, M. semitendinosus, M. supraspinatus and M. biceps brachii. The samples - 0.5 x 0.5 cm cubes - were taken from the middle of the muscles at various interwalls after the slaughter. After the slaughter and halving, the carcasses were stored on -1 ... + 1° C, and some on + 6 ... + 8° C in cooling room.

a) 5 animals of them were 30 month old Hungarian spotted x Kostromean heifers. They were kept and fed in the same way and slaughtered with an average weight of 480 kg.

b) 6 further animals were 30 month old pure Hungarian spotted heifers. They were raised between themselves under similar conditions, but different in comparison with those of the groups a) and c). Their average live weight was 500 kg.

c) The last 5 animals were 15 month old Hungarian spotted x Kostromean bulls. They were of the same breed as those of the group a). Their live weight at slaughter was 450 kg.

The sampling from the above mentioned muscles of the halved carcasses stored -1 ... + 1° C, resp. + 6 ... + 8° C was accomplished.:

1 hour
24 hours
48 hours
72 hours

after the slaughter. The excised muscle cubes were put immediately into 10 % formaldehyde and examined after fixing them for 4 days.

Methods of examination

We isolated from the muscle cubes very carefully smaller or greater, easily separable bundles of muscles (if possible primary fascicules) taking care

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not to expose the fibres to mechanical pressure or breaking. They were washed with tap water and either held in 20 % nitric acid (after Neseni and Müller, 2), or examined immediately. The bundles of muscles were desintagrated into muscle cells by the aid of metal or glass splitting needles under binocular dissection microskop of 32 x magnification thus, that the cells of the fascicule should remain held together on one and of the bundle by the connective tissue (Fig. 1). Thus could be ensured that the cross measurements of the cells were made in the same height, and on the other hand no one, if possible, should be overlooked at the measurements.

In course of our examinations we omitted the treatment with nitric acid, because the so treated muscle material became very brittle, it has lost nearly all its elasticity although it was easier to part it into individual cells. The work became thus very difficult and in spite of the greatest caution cells broke out from the bundle of muscles. Thus we couldn't achieve one of our aims namely the measuring, if possible, every cell of the examined bundle. After fixation only with formaldehyde the cells remain elastical enough, so that all cells of the bundle can be preserved for the measurements. The cells were measured with Zeiss-Lumipan (magnification 300 x). In place of the ocular lens there was inserted a micrometer-ocular. The average data of one muscle was calculated always on the basis of 100 fibre measurements, as this number ensures a good approache to the normal distribution curve of the cell dimensions (see fig. 2).

It must be mentioned, that we made many examinations to decide how the dimensions of the muscle cells differ in samples taken from different parts of the muscle. We found the most constant distribution in those samples taken from the depth of the muscles. We tried also various kinds of dying methods, but we omitted this procedure as unnecessary, because for a worker with adequate experience it does not increase the exactness of measurements.

The results

In dependance of the condition of the animal before the slaughter and depending on the storing conditions after it, the rigor mortis sets in differently in time and character. The rigor greatly influences the muscle cell dimensions, it causes longitudinal shortening and transversal thickening. We observed different degrees of these states already one hour after the slaughter at the examined animals. In Fig. 3 and 4. are shown two extrem examples.

Both Figures show that within an interval of 24 hours after the slaughter it is impossible to make correct (exact) measurements. Without going into the details of our interesting observations during the 24 hours of storage, we have to state that the disturbing factor of the rigor mortis may by excluded best by a 48 hours storing and the sampling after the mentioned interval ensures the most exact measurements of cell dimensions. In course of our examinations we observed that, presumably as a result of the autolitic processes of the meat the muscle cells swell on, thus the cell dimensions increase greatly and regularly. This is shown in Table 1.

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As to the question of correlation between the tenderness of single muscles (meat-parts) and the cell dimensions of the various muscles of the same animal and the same muscles of various animals, we came to the following conclusions.

From the intervall diagram of the examined material, that is of the maximum and minimum values of cell dimensions measured in the four muscles of the above mentioned 16 animals (see paragraphs a), b) and c) may be seen, that the cells of the M. iliopsoas are the finest and the fibres of the M. semitendineus are the thickest. The transversal cell dimensions of the remaining two muscles are between that of the aforementioned two muscles (fig. 5). This corresponds to the data of other authors (Neseni, Hiner and coworkers).

Fig. 6 shows the distribution curves of the cell dimensions of the muscles M. iliopsoas and M. semitendineus. The distribution curves of the M. semitendineus are more flat and show a greater dispersion than those of the M. iliopsoas.

The t-test showed also always the significant difference between the two kinds of muscles.

Beside the muscle fibre measurement we also made physicochemical analyses (on water -, fat - and protein content, ratio between connective tissue - and muscle protein, water soluble protein, extract material, cooking and baking loss). In table II are shown some chemical data of these analyses to be published elsewhere. From these may be seen, that the connective tissue content is the smallest, the fibres of the M. iliopsoas being in the same time the finest. But our data are not enough to evaluate the correlation between the connective tissue content and the fibre dimensions.

The two extrem analitical data in this table show, that from the point of view of fibre dimensions and connective tissue content the M. iliopsoas and M. semitendineus are the farthest from each other. In respect of cooking and baking loss and tenderness the better, more savoury and tender meat is the M. iliopsoas without doubt. The data dealing with this question will be published elsewhere (6).

The question is at hand, wether there isn't some correlation between the degree of the rigor mortis its loosening and the connective tissue content (see fig. 3 and 4.). It seems, that the constriction of the M. iliopsoas is more regular during the rigor and the spasmodic state ceases more quickly in this muscle, which contains relatively few connective tissue. But our data in relation of this question must be completed.

Discussion and conclusions

The main aim of our work was to solve the question of the details of sampling and methods of analysis. We stated, that the samples are best taken 48 hours after slaughter, that is after the loosening of the rigor. If the samples are taken later than 48 hours after slaughter, we have to reckon with the dimension-alterations of the muscle cells. The cells of the primary fascicules izolated carefully from the middle of the muscle samples, which were fixed for four days in 10 % formaldehyde, must be prepared thus, that

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the fibres belonging to each other could be measured without omitting any one of them (Fig. 1). The measurement data of hundred fibres of a single muscle give approximately a normal distribution curve (fig. 2).

Our experimental data correspond to those of other authors, according to which the muscles, resp. meatparts with thinner (finer) muscle cells (M. iliopsoas) are more tender, than those, which have thicker fibres (M. semitendineus, M. supraspinatus, etc.). Our results correspond also to those of Hiner and coworkers (3) in saying, that between the connective tissue content and the tenderness of meat there is a ~~positive~~ correlation too.

The muscle cell dimensions, the quality and quantity of the connective tissue are factors, which with the interrelation of other factors must be looked at as the cause of the tenderness or toughness of meat.

It is essential in our opinion, that the sampling, the preparation of the material, and the procedure of examination should be uniform. The data of various authors would become thus comparable and practically useful.

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Table 1 : The alteration of the crossdiameter of various muscle cells of the same animal after storing it on + 6 ... + 8° C for 48, resp. 72 hours.

Name of the muscle	Time after the slaughter, hours	Crossdiameter of the muscle celles μ
M. iliopsoas	48 72	36.3 47.1
M. semitendineus	48 72	49.8 52.4
M. supraspinatus	48 72	58.9 73.8
M. biceps brachii	48 72	56.2 66.4

Table II : Correlation between the connective tissue, protein content and the fibre dimensions of various muscles.

Name of the muscle	Fibre dimension	Connective tissue protein, %	Muscle protein, %	Connective tissue N, as per cent of total N
M. iliopsoas	40.8 43.1	0.87 0.63	19.70 18.72	4.20 3.25
M. supraspinatus	55.1 52.9	1.49 1.08	18.00 17.67	6.67 5.56
M. semitendineus	56.6 62.8	1.75 1.62	18.81 20.30	8.63 8.30
M. biceps brachii	57.9 58.4	1.92 2.22	18.20 18.90	9.56 10.50

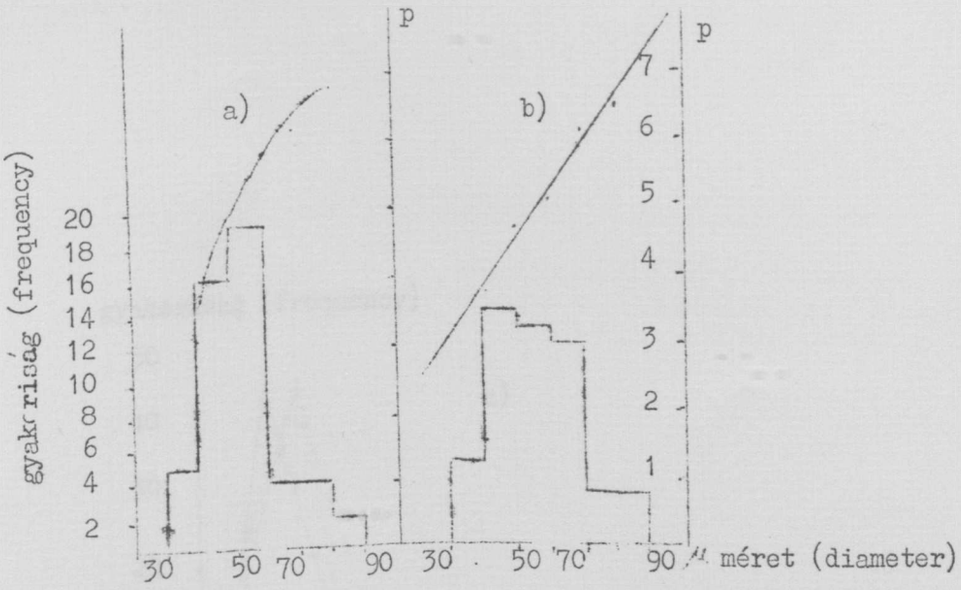

Fig. 2. The distribution curve of a) 5° and b) 100 measurements of the muscle cells.

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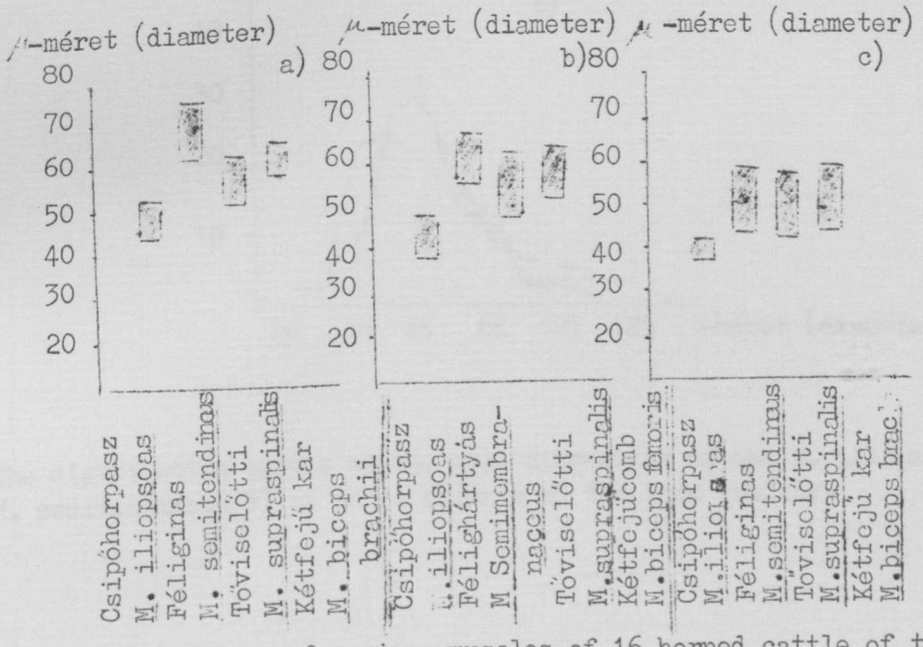

Fig. 5. The fibre dimensions of various muscles of 16 horned cattle of three groups a), b), c).

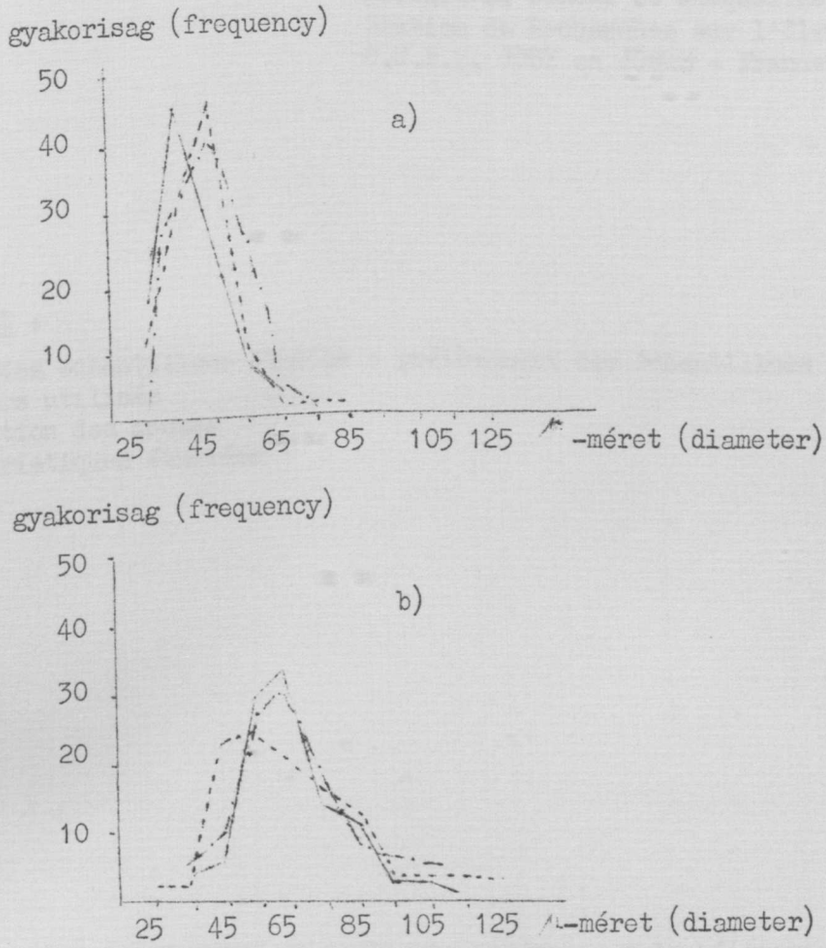

Fig. 6. The distribution curves of the cell dimensions of the M. iliopsoas a) and M. semitendineus b) of three animals of the same quality.