Grading beef carcases on the meat haem iron content

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SUMMARY: A method of grading beef carcases on the meat haem iron content (Fe) is proposed. The average Fe of the carcase is calculated from the haem iron content (fe_i) from some specific samples of selected muscles (*semimembranosus, gracilis, vastus lateralis*) found as highly representative of Fe (the combination of the three muscles explaining, by multiple linear regression, 98.1 per cent of the Fe variation). To estimate fe_i it is proposed, as an alternative to the Hornsey's method to determine the haem iron content from microsamples of meat (3 samples of 2 g each) by measuring, as suggested by HUDZIK (1990), the optical density of their water extracts at 410 nm which was found to be very highly correlated (r = + 0.999) with the values of Fe given by the Hornsey's method.

Applications of the grading carcasses method for haem iron content are discussed by considering both the certification of nutritional value of meat and the assessment of maturity index of the carcase.

INTRODUCTION: The importance of meat, as a food item, comes both from the level of its consumption and from its peculiar nutritional attributes. Meat is a very dense food, rich in proteins of high biological value and well provided in important metabolic components like vitamins of the B group or minerals, namely Zinc and Iron.

In red meats, like beef, the amount of iron is higher than in other types of meat (pork and poultry) and, as it exists as haem iron, its interest is reinforced by its high bio availability.

The haem iron of beef varies according the anatomical (and biochemical) types of muscles and the origin of the animals (BOUSSET and DUMONT 1990, DUMONT and BOUSSET 1990). The variation found between beef carcasses is explained by the effect of age (RENERRE, 1982). The haem iron content of meat has been found a good criterion of the ageing and can play the role of a maturity index, which discriminates individuals better than the maturity indices only based on the skeleton evolution (DUMONT and BOUSSET, 1990).

For these two main reasons, to which one can add the intensity of meat colour which is strictly dependent on the amount of myoglobin (main form of haem iron in muscles), it thus seems interesting to grade beef carcasses on the haem iron content of their muscles. The present work reports the results of one study conducted in this subject and suggests the procedure to use to grade carcasses on this criterion.

MATERIALS and METHODS

The animals used in this study (N=10) have been chosen to represent a very large sample of the different types of cattle found in the French market of beef, as age, carcass weight and carcass conformation are concerned. The average carcass weight was 316.2 ± 66.9 Kg, the age (estimated from teeth evolution according BRAZAL *et al.* (1971) was 51.2 ± 23.7 months and the conformation score (according DUMONT *et al.* (1975) was 9.1 ± 3.3 (in a scale from 1 to 16). The sample of animals comprised six females (cows and heifer), three steers and one young bull.

24 h *post mortem* carcasses were dissected and the muscles were then stored at 0°C up to their sampling, made 3 or 4 days *post mortem*. In each muscle location one slice 5 cm depth was taken and completely trimmed of external fat and epimysium. The sample was minced and carefully mixed and the haem iron was determined according to HORNSEY (1956) and expressed as p.p.m. of iron element.

39 muscle locations were considered. For most of them the samples were taken in the middle part of the muscle : *vastus lateralis, tensor fasciae latae, gluteus medius, triceps brachii caput laterale, triceps brachii caput longum, rectus femoris, supraspinatus, adductor, infraspinatus, transversus abdominis, rectus abdominis, semispinalis capitis, serratus ventralis pars cervicis, latissimus dorsi, pectineus, gracilis, gastrocnemius caput mediale, subscapularis, iliacus, obliquus internus abdominis, splenius, vastus internus, gastrocnemius caput*

laterale ; for the others, the sample was taken at specific places : *semitendinosus* (middle, 1/3d cranial part and 1/3d caudal part), *psoas major* (4th lumbar vertebra), *longissimus dorsi* (3d lumbar vertebra and 10/11th thoracic vertebra), *pectoralis profundus* (middle, 1/3d cranial part), *semimembranosus* (middle, 1/3d cranial part, 1/3d caudal part) and *gluteobiceps* (middle, 1/3d caudal part and 1/3d cranial part), *cutaneus trunci* (at the level of the navel).

For each muscle sample (m_i) the average of the **individual muscle haem iron** content (fe_i) was calculated from three replicates determinations. From the 39 individual fe_i the **average carcase index of haem iron** was calculated as $Fe = (\Sigma fe_i)/39$. In addition each of the 39 **partial carcase index** of haem iron (S_i) was calculated as $S_i = 39. Fe - fe_i$.

The correlation coefficients (r_i) between fe_i and Fe, and between the various S_i were also calculated. The simple regression between fe_i and Fe and Fe and fe_i were calculated in the same time as the multiple regression of Fe on fe_i from muscles *semimembranosus*, *gracilis* and *vastus lateralis*.

The SAS procedure was used for all the statistical treatments.

RESULTS and DISCUSSION:

Between muscles of the same carcase one finds a steady variation of the fe_i values which are regularly disposed between those of the two extreme muscles, m. *cutaneus trunci* (the lowest value of fe_i) and m. *diaphragma p. medialis* (the highest value). The ranking of muscles one can make on fe_i is very similar for the different animals, which differ, each one, for any of the muscles, by the level of fe_i. This situation explains the observed variability of Fe which was, on the average, 18.77 p.p.m. with a range from 14.21 to 22.35.

The relationships between muscles which explain the general variation found in one given carcase are very close. The same situation is found when the relationships between S indices are considered.

Table 1

Prediction of Fe from the haem iron content of some muscles (fe) (in p.p.m.)

Muscle	Regression equation	adjusted R^2	Significance level (+)	Residual standard deviation of estimation
Semimembranosus (1/3d cranial part)	Fe = 0.881 fe + 3.047	0.9589	****	0.606
Gracilis	Fe = 0.740 fe + 3.966	0.9461	****	0.695
Vastus lateralis	Fe = 0.720 fe + 5.213	0.9309	****	0.787
Adductor	Fe = 0.766 fe + 3.298	0.9291	****	0.797
Gluteus medius	Fe = 0.975 fe + 1.567	0.9269	****	0.809
Longissimus thoracis	Fe = 0.836 fe + 5.161	0.9240	****	0.888
Rectus abdominis	Fe = 1.074 fe + 0.089	0.9151	****	0.872
Rectus femoris	Fe = 0.900 fe + 4.000	0.9121	****	0.
Subscapularis	/	0.6279	**	/
Semitendinosus (1/3 caudal part)	/	0.5666	**	/
Diaphragma p. medialis	/	0.3640	*	/

(+) : * 0,05 ; ** 0,01 ; **** 0,0001

The correlations between S values are all highly significant and very high, being comprised between + 0.9996 and + 0.9998.

The correlations between fe_i and Fe (r_i) are all significant and, most of time, highly significant ($P < 0.0001$) and very high : twenty four of the 39 r_i are $\geq +.90$ and, for ten, r_i is $\geq +.95$. Table 1 gives the list of these muscles and also the three muscles which are the least related to Fe. From the fe_i value of the muscles the most highly related to Fe it is thus possible to estimate Fe with a good accuracy.

When considering by multiple regression analysis the association of two or more of these muscles the percentage of explanation of Fe variation is still slightly increased as shown in Table 2.

Table 2

Prediction of Fe from combinations of muscles haem iron content (ppm)

Muscles	Multilinear equation	adjusted R^2
Vastus lateralis (VL) ; Gracilis (G)	$0.326\ VL + 0.426\ G + 4.108$	0.9654
Semimembranosus (S) (1/3 d cranial part)	$0.532\ S + 0.305\ G + 3.191$	0.9655
	$0.273\ VL + 0.113\ G + 0.445\ S + 3.436$	0.9810

Note : all the regressions are highly significant ($P<0.0001$).

On the other hand, it is also possible to estimate fe_i from Fe values with an accuracy which varies with muscles in the same manner as for the regression of Fe on fe_i

Fe is an average index from 39 muscle locations, which, by weight, represent about the two-thirds of the muscle mass of the carcass and which comprise nearly all the heaviest individual muscles it is possible to propose to consumers as individual cuts and for which one typification on composition might be envisaged. It is clear that from the Fe values it is possible to set the limits of the class of haem iron content in which the different muscles could be included.

Another major interest of Fe is that it well characterizes the degree of maturity of the animals and, then, can be used in association with the skeleton traits to grade carcasses on maturity as suggested by BORDES and BOCCARD (1988) and confirmed by DUMONT and BOUSSET (1990).

The knowledge of iron content (as haem iron) of the various beef muscles (i.e. beef cuts) is very important to dieteticians and consumers in making meat cuts choices that will more easily supply the nutrient needs. This concept is specially valid when people must balance nutrient intake with caloric needs. In diets with low energy content (for instance 1500 Kcal or less) it is difficult to obtain the recommended levels of those nutrients, such as iron (or zinc) which are in low concentration in most of the common foods. To obtain recommended allowances from a limited calories diet (which is now a very common dietary guideline) requires careful selection from foods which are nutrient dense. In that case lean meat is one valid option for such an objective, mainly the red lean meat and, at first, the naturally iron fortificated foods which are some of the beef cuts from mature animals.

The relationships between fe_i and Fe suggest that it could be possible to grade beef carcasses from the measurements of haem iron content of some specific and representative muscles (like *gracilis, vastus lateralis* or *semimembranosus*). Such a grading system must fulfil some practical conditions as sampling and chemical determinations are concerned. The grading system could apply only if it was possible (from a simple, limited, fast and accurate sampling of skeletal muscle specimens obtained by carcass biopsy) to make a quick on-line determination of the haem iron content. Once the anatomic type of muscles retained for sampling it seems now possible to use some calibrated biopsy needle to take the limited amount of muscle which is necessary for the chemical analysis.

There are many methods which have been proposed to estimate the haem iron content ; most of them are not convenient, specially because they are rather long and dangerous. We suggest to use, in place of any of the former methods, the method which has been recently proposed by HUDZIK (1990) as an alternative to the Hornsey's method. This new procedure involves a water extraction of muscle soluble proteins in which is found the haem, ferroprotoporphyrin component of muscle myoglobin, certain respiratory enzymes (such as the cytochromes) and hemoglobin from the residual blood content. Each of the haem proteins have a specific maximum of absorption near 410 nm (SORET's bands). HUDZIK found that the absorbance of the water extract at 410 nm of various types of meats was highly correlated with the amount of their haem iron content according HORNSEY.

The method of HUDZIK has been applied in one recent study where we have compared the haem iron content (Y) (as determined by the HORNSEY's method) of ground beef samples (N=8) obtained by mixing, in various proportions, *semimembranosus* muscles from veal and cows and the absorbance at 410 nm (X) of their water extracts. For each sample the determination were made on three replicates for X and Y and the average **x** and **y** considered for regression analysis. The relationship between **x** and **y** was highly significant ($r = +0.999$) and expressed by the following equation : $\mathbf{y} = 10{,}07\ \mathbf{x} + 0.72$.

The different operations involved in the HUDZIK's method can be automatized, as well as the sampling procedure which is, in fact, the initial step of the method. The sampling has to be adapted to the general traits of the carcasses (weight, conformation, dimensions...).

One point to be stressed is the number of samples to be considered at each location. At least three samples of 2 g each could be necessary. But this number could be increased (up to 6 or more) according to the repetability of the obtained results (in relation with the muscle heterogeneity which can be checked). For the chemical determination a special consideration might be put to the fact that as the weight of meat sample could slightly vary, the amount of water must be adapted so that the extraction ratio be constant. The whole system of haem iron determination is currently in progress in our laboratory.

<u>CONCLUSION</u>: Up to now, in various countries, the grading systems of beef carcasses have mainly concerned cutability and (or) meat quality. The nutrient composition of cuts was not considered as such (even if it existed some nutritional differences between grades due to their different amount of fat). It is suggested here to move in the way for a discriminating nutrient grading system of beef carcasses which would help the meat industry identify beef cuts with known levels of nutrients. We suggest to start with the haem iron content for it is obvious that there is now a real need for further differentiate among cuts and animals to accomodate the reduction in energy of the diet and the recommended iron intake.

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