CHARACTERISTICS OF VARIOUS BEEF MUSCLES IN COMPARISON TO THOSE OF *LONGISSIMUS*

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Background

Meat analyses are generally performed on the *longissimus* muscle, even though the beef carcass consists of many muscles, with different physiological functions. As a reflection of the proportion of the fibre types, muscles show differences for several characteristics (Monin & Ouali, 1991). The knowledge of the characteristics of beef muscles in relation to the widely used *longissimus* would be useful from various points of view, but for the moment it is far from satisfactory. On this topic, we examined in a previous work (Barge *et al.*, 2001) the relationship between the water, protein, fat and collagen content of many beef muscles and the composition of the *longissimus*.

Objectives

The aim of this work is to study some characteristics of beef muscles -such as colour, haeme iron content, collagen solubility, sarcomere length, water-holding capacity (drip losses and cooking losses)- expressing them in relation to the characteristics of the *longissimus*.

Methods

A data set was prepared using data from our researches or published by other Authors, in which the meat analyses were performed on one or more muscles in addition to the *longissimus*. We included animals of any beef category, provided that they were reared and slaughtered in conventional manner. Therefore, if during a trial some drug (f.e. clenbuterol) was used or the carcasses were electrically stimulated or blast chilled, we only took data related to the control group. For each experimental group available, we reported: the number of animals; the category and other group characteristics (f.e. breed, feeding strategy); the mean value of the *longissimus* for each parameter and finally, we calculated the index of each muscle, as mean value * 100 / mean value of the *longissimus* (LD). Generally the meat sample of the *longissimus* used for the analysis is removed between the 8th thoracic and 1st lumbar vertebra.

We found data regarding the following muscles: AF=*adductor femoris*; BB=*biceps brachii*; BF=*biceps femoris*; DI=*diaphragma*; ECR=*extensor carpi radialis*; GA=*gastrocnemius*; GB=*gluteobiceps*; GL=*gluteus medius*; IS=*infraspinatus*; LatD=*latissimus dorsi*; LL=*longissimus lumborum*; OEA=*obliquus externus abdominis*; PA=*pectoralis ascendens*; PM=*psoas major*; PP=*pectoralis profundus*; QF=*quadriceps femoris*; RA=*rectus abdominis*; RF=*rectus femoris*; SC=*semispinalis capitis*; SM=*semimembranosus*; SN=*splenius*; SS=*supraspinatus*; ST=*semitendinosus*; SV=*serratus ventralis*; TA=*transversus abdominis*; TB=*triceps brachii*; TFL=*tensor fasciae latae*; TR=*trapezius*; VL=*vastus lateralis*.

Results and discussion

In the following tables, for each parameter we report the abbreviation of the muscles, the median value of the index and, within square brackets, the number of experimental groups used to calculate the index. The groups included a different number of animals, from a few units to several tens (as in Kotula & Loosby, 1982), the median values ranging from 8 (colour parameters) to 12 (drip losses).

The animals involved belonged to various breeds or crosses and to different categories, with young bulls generally being well represented, whereas veal and cows were more rare.

<u>Colour</u>: data were obtained from 46 experimental groups (of 15 Authors) totalling some 600 animals. Most Authors express the colour parameters in the Hunter system; otherwise, we converted them as indicated by Mac Dougall (1994). The average values of the LD resulted: L=36.25; a_L=17.94; b_L=9.47. If we keep in mind that colour is usually considered the most important sensory characteristic in the appearance of meat, it is surprising that we have been able to calculate indexes for a rather limited number of muscles. Nevertheless, the presence of indexes above, near and below 100 for each parameter is indicative of the colour variability among the muscles. Generally speaking, the SS appears very close to the colour of the LD. On the contrary, the TB shows the smallest indexes for the three parameters. The ST has the highest index for lightness (median=117.8; range 108÷121) and for yellowness (median=127.7; range 106÷153). As for redness, we found rather high index in the AF and GL even if, due to the very reduced number of groups involved, this remark should be proved by further data.

	AF [1]	BF [4]	GL [3]	OEA [6]	PP [10]	SM [17]	SS [22]	ST [18]	TB
L	95.4	107.6	95.6	99.9	94.4	101.6	98.1	117.8	93.5 [1]
a_L	117.3	95.7	114.2	95.5	99.5	105.2	101.6	102.8	92.4 [5]
b_L	103.9	117.9	117.2	94.8	91.0	110.6	100.7	127.7	88.9 [1]

<u>Water-holding capacity</u>: we found more data about cooking losses than drip losses. For the latter parameter, we obtained indexes relating to 8 muscles starting from 33 groups (of 12 Authors) for a total of 683 animals. The IS and PP stand out for their low indexes, whereas the SM and ST lose much more drip (about 1.5 times) than the *longissimus*. For the cooking losses, data taken from 88 groups (of 24 Authors) and related to 856 animal, allowed us to calculate indexes for 11 muscles. The IS has a median lower than 100 for this parameter also, whereas all the others muscles show a higher cooking losses than the LD. Some of them, as the BF and SM, have the median slightly above 100 and include 100 in their range. The remainders show median values growing from 110.4 in the PP to more than 140 in the PM and RF, never including indexes below 100.

Examining the numerous data relating to the ST, we observe a tendency (34 groups out of 37) to higher cooking losses than the LD, which seems more manifest at low temperatures of cooking. In fact, the ST indexes relating to six beef categories (derived from data of Gerhardy, 1995) ranged from 116 to 126 when the meat was heated in a water bath to an internal temperature of 75°C, while they ranged from 141 to 179 when cooked in the same way to an internal temperature of 55°C.

	AF [1]	BF [10]	IS	PM	PP [10]	RF [3]	SM	SN [3]	SS [12]	ST	TB
DL	138.1	-	43.2 [4]	93.9 [6]	64.2	-	141.2 [7]	-	94.1	158.4 [11]	87.6 [2]
CL	125.3	103.2	86.9 [12]	141.9 [2]	110.4	143.4	106.9 [29]	121.0	121.0	117.5 [37]	117.1 [4]

Sarcomere length: data were obtained from 34 experimental groups (of 22 Authors) that included 650 animals belonging to various categories, with a predominance of steers and heifers. We only used data from carcasses suspended by the Achilles tendon, keeping in mind that the influence of the suspension method is different for the various muscles (Herring *et al.*, 1965), depending on how they are attached to the skeleton and on the orientation of fibres within the muscle. The sarcomere length was measured always on raw meat, while two Authors performed the analysis also on cooked meat. The average of the LD resulted equal to 1.76 μm. Among the 20 available muscles, only the GL and BF show the median below 100, even though their range included 100. The LL and SM seem to have a sarcomere length quite similar to the LD. Many muscles have sarcomeres longer than the *longissimus*; this is especially noticeable in the PM, with a median equal to 184.4, a minimum index of 165 related to 14 months-old Angus steers (Mc Keith *et al.*, 1985) and a maximum of 243 in 18 months-old steers (Dransfield, 1977).

AF [3]	BB [1]	BF [6]	ECR [1]	GA [1]	GL [4]	IS [8]	LatD [4]	LL [1]	PM [10]
103.3	153.8	94.1	163.6	197.2	92.5	127.8	143.3	98.2	184.4
PP [5]	QF [4]	RA [2]	RF [4]	SC [1]	SM [10]	SS [4]	ST [14]	SV [5]	TB [11]
133.8	111.8	130.4	117.2	155.2	100.8	117.8	107.1	106.0	133.0

Collagen solubility: data for this parameter originate from 61 groups, obtained from 19 Authors with a total of 509 animals, for the most part young bulls. The average collagen solubility of the LD resulted equal to 18.26%. In comparison with collagen content (Barge *et al.*, 2001), the data we found as to its thermal solubility are definitely less numerous. Therefore, the number of muscles available for the solubility resulted almost halved compared to that for collagen content.

Only the SN e TB seem to have a higher collagen solubility compared to the LD (even if both include 100 in the range of their indexes), while the solubility of the PM appears to be rather close to the LD. The medians of the others muscles are - more or less - below 100, with none or, at most, one of their indexes above 100. Also the ST shows a lower collagen solubility than the *longissimus*; however there is one index equal to 100, and 5 above 100, related to young bulls (four groups in Destefanis *et al.*, 1997 and one group in Vestergaard *et al.*, 2000). With exception of PM, which has far lower indexes for the collagen amount (Barge *et al.*, 2001) and a similar collagen solubility, the muscles for which we found both parameters have high indexes for the collagen content and low indexes for its solubility. This is in agreement with the statement of Mc Cormick (1992), that says that muscles with high collagen content possess high crosslink concentrations.

BF [12]	LL [1]	PM [10]	PP [8]	RA [3]	RF [1]	SM [13]	SN [3]	SS [6]	ST [33]	TB [4]
54.5	82.6	98.5	67.2	94.4	70.1	64.3	112.0	67.9	85.8	103.1

Haeme iron: data were obtained from 35 groups of 14 Authors, with a total of 541 animals. We found data related to a great number of muscles, but 11 out of 24 derived from one study only (Bousset *et al.*, 1987). Among the others muscles, only the TFL and ST have less iron content than the LD, being their indexes near 77. The PM, GL, RA show a median close to 105, even if 100 is included in their range. Indexes increased as we passed from the SM and SN to the TA and TB, and reached a maximum in correspondence with the DI, of which the haeme iron content seems to be almost double in comparison with the LD. The iron content of meat represents a very important parameter from the nutritive point of view. The fact that most muscles have indexes above 100, while the analyses are normally performed on the *longissimus*, suggest that the richness in iron of beef meat is probably underestimated.

AF [1]	DI [15]	GB [1]	GL [11]	IS [1]	LatD [1]	LL [1]	OEA [1]	PA [2]	PM [5]	PP [1]	RA [3]
123.9	193,6	118.4	105.1	129.4	93.8	97.5	98.2	108.3	104.6	108.0	106.7
RF [1]	SC [1]	SM [14]	SN [3]	SS [8]	ST [16]	SV [2]	TA [3]	TB [4]	TFL [8]	TR [1]	VL [1]
100.6	132.5	110.2	111.4	139.4	77.5	136.1	121.8	125.2	76.6	95.2	115.3

In conclusion, the relationship between the characteristics of the *longissimus* and those of the other beef muscles results rather well established for certain muscles, for which several parameters have been studied and derived from a sufficient number of experimental groups. For other muscles, however, only a few characteristics have been taken into account and/or with a small number of data. Generally speaking though, most muscles examined show a higher iron content, lower collagen solubility, higher cooking losses and longer sarcomeres than the *longissimus*.

Pertinent literature

Barge M.T., Destefanis G., Brugiapaglia A., Barge P. (2001) Chemical composition of beef muscles in relation to the composition of *longissimus*. *Proc. 47th ICoMST*, I:178-179. Bousset J., Dumont B.L., Hudzik E., Mera Th. (1987) Composition en matière sèche, fer héminique et azote de la viande de boeuf parée. *Sci Aliments*, n° hors-série VIII:239-244. Destefanis G., Brugiapaglia A., Barge M.T. (1997) Contenuto e solubilità del collagene nella carne di vitelloni di diversi gruppi etnici. *Atti XII Congr. Naz. ASPA*: 139-140. Dransfield E. (1977) Intramuscular composition and texture of beef muscles. *J. Sci. Fd. Agric.* 28:833-842. Gerhardy H. (1995) Quality of beef from commercial fattening systems in northern Germany. *Meat Sci.*, 40:103-120. Herring H.K., Cassens R.G., Briskey E.J. (1965) Further studies on bovine muscles tenderness as influenced by carcass position, sarcomere length, and fiber diameter. *J. Food Sci.*, 30:1049-1054. Kotula A.W., Lusby W.R (1982) Mineral composition of muscles of 1- to 6-year-old steers. *J. Anim. Sci.* 54:544-548. MacDougall D.B. (1994) Colour of meat. In: A.M. Pearson & T.R. Dutson (eds.) *Advances in meat researches - Vol. 9*. Blackie Academic & Professional, London, 79-93. Mc Cormick R.J. (1992) The flexibility of the collagen compartments of muscle. *Proc. 38th ICoMST*, I: 51-60. Mc Keith F.K., De Vol D.E., Miles R.S., Bechtel P.J., Carr T.R. (1985) Chemical and sensory properties of thirteen major beef muscles. *J. Food Sci.*, 50:869-872. Monin G., Ouali A. (1991) Muscle differentiation and meat quality. In: Lawrie R. (ed.) *Development in Meat Science, Vol. 5*., Elsevier Applied Science Publisher, London, 89-157. Vestergaard M., Therkildsen M., Henckel P., Jensen L.R., Andersen H.R., Sejrsen K. (2000) Influence of feeding intensity, grazing and finishing feeding on meat and eating quality of young bulls and the relationship between muscle fibre characteristics, fibre fragmentation and meat tenderness. *Meat Sci.*, 54:187-195.

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