BEEF CHARACTERISTICS OF THREE MUSCLES FROM COW AND YOUNG BULL

Barge M.T., Destefanis G., Barge P. and Brugiapaglia A.
Dipartimento di Scienze Zootecniche, Università di Torino, Via L. da Vinci 44, 10095 Grugliasco, Italia

Background

The social evolution has brought the consumer to prefer products of a high and uniform quality. This is also true for beef, whose characteristics are anyway conditioned by intrinsic and extrinsic factors which increase its variability. In the retail sale, beef is still a quite undifferentiated product and this does not agree with the needs of modern consumers. It is therefore of great importance to know in a more detailed manner the characteristics of meat in relation to the affecting factors so as to provide correct information to the consumer.

Objectives

To study beef characteristics in relation to the animal category and muscle type.

Materials and methods

A portion of *longissimus* (the lowest thoracic vertebrae), the *semitendinosus* and the *supraspinatus* were taken at commercial slaughterhouses from half-carcasses of cattle of various breeds and crosses (14 cows aged between 39 and 143 months and 10 young bulls between 12 and 19 months). The samples were analysed for chemical composition, water-holding capacity (drip losses during 48h; cooking losses in water bath until an internal temperature of 70°C was reached), Warner Bratzler shear force (maximum value in kg and work done in kg cm) on cylindrical cores 2.54 cm in diameter obtained from steaks used to determine cooking losses; measured by an Instron 1011 equipped with a Warner-Bratzler shear device.
The data were subjected to the variance analysis (ANOVA of SAS), considering as sources of variation the category, the muscle and their interaction.

Results and discussion

For each examined parameter, table 1 shows the R^2 value of the model and the factors which have a significant effect, as well as the least square means of the subgroups and of the groups.
Water content appears to be influenced by both the muscle type - higher in SS than in ST, which in turn contains more water than LD - and the category, the meat of cows being less humid than that of young bulls. Also in the experiment by Destefanis *et al*. (2003), carried out on Piemontese young bulls, LT contained less water than ST and SS. Also in Piemontese and Belgian Blue and White hypertrophied young bulls (Destefanis *et al*., 1996) the water content was the highest in SS (77.40%), followed by ST (75.96%) and by LT (75,27%). The present data confirm that the decreasing order for water content in beef is the following: SS, ST, LD. In the study of Gerhardy (1995), the meat of young bulls in average showed a higher humidity than that of cows, the difference being significant in ST, but not in LD.
Category does not influence the protein content, which appears very similar for all three muscles, in accordance with the results of the study by Fiems *et al*. (2003), in which the mean for cows (22.2%) was very close to that of young bulls (22.1%). On the other hand, muscle type influenced the protein content, the LD and ST being richer in proteins than SS (less than 20%). The low protein content in SS and the similar values for LD and ST are consistent with the data reported in the bibliographic survey on muscle type by Barge et al. (2001) and with the results of Barge *et al*. (1993) and Destefanis *et al*. (1996).
Unlike the previous parameters of composition, lipid content was influenced by both factors (P=0.0001), which also interacted each other. Both in cows and in young bulls, LD appeared to be the fattest and ST the leanest. In young bulls, however, LD contained almost twice as much lipids than ST, whereas in cows almost three times. In young bulls, Destefanis *et al*. (2003) reported that SS was the fattest of the three muscles and ST the leanest, while Barge *et al.* (1993) reported that ST was significantly different from SS, with LT in between. Both studies indicated ST as the muscle with the lowest lipid content. On the contrary, Destefanis *et al.* (1996) observed no significant difference between the muscles, the low fat content of hypertrophied young bulls being comprised between 0.39 in LD and 0.46 in SS, with ST in the middle.

For all three muscles and more clearly for LD, the lipid content was higher in cows than in young bulls (2.93 *vs.* 1.35% respectively). A higher fat content in cows than in young bulls (2.3 *vs.* 1.1%) has recently been reported by Fiems *et al*. (2003), whereas our data only partially agree with the results of Gerhardy (1995), which showed a difference between cows and young bulls significant for ST, but not for LD, indicating the relevance of the former muscle for meat analyses. In both muscles, cows contained less than twice as much fat as in young bulls. It should be noted that general mean of all our 72 meat samples is 2.1%, indicating that, even if belonging to commercial carcasses, beef is not as rich in fat as sometimes mass media tend to show. Berg *et al.* (1985) stated "The concept that meat is high in fat and cholesterol is widespread. The effect of this perception has created an atmosphere of negative attitudes which … continue to be reinforced by the usage of outdated data on the nutrient composition of meats".

As far as the haeminic iron is concerned, the adopted model accounts for 58% of the variance and its content is influenced both by category and the muscle type (P=0.0001). Regarding the latter factor, the decreasing order of iron content is: SS, LD, ST. Also Destefanis *et al.* (2003) found SS richer in iron than LT and ST. Concerning the category, cow meat appears remarkably richer, the iron content being one and a half times greater than in young bulls. This is true for all three muscles, but it is particularly relevant in SS. The observation on the difference between the categories seems related to the fact that the quantity of pigment also depend on the age of the animals. In Renerre (1982) the increase in iron with age varied considerably according to the muscle examined and, in the opinion of the Author, these differences were due to the different metabolic type of the muscle fibres.

When studying the haeminic iron content in two muscles of cows and young bulls, Dumont and Bousset (1990) indicated average value of 20.05 µg/g for *longissimus thoracis* and 20.50 for *pectoralis ascendens* of cows and 11.8 and 13.5 for the same muscles in young bulls. In particular, the values of LT ranged between 9.20 µg/g and 15.9 for young bulls and between 15.80 and 26.10 in cows. We observed a similar slight overlapping of categories in SS, ranging from 9 µg/g to 16 in young bulls and from 14 to 28 in cows.

Drip losses - The factors significantly influenced this parameter, for which the general mean indicated a loss of 2% in 48 hours. The losses appeared to be greater for young bulls in all three muscles and especially in ST. Similar results were found by other Authors. In Barnier (1995), drip losses of muscular portion were greater in Friesian young bulls than in cows of the same breed, both in *longissimus* and in *semimembranosus*. Also Fiems *et al.* (2003) found drip losses inferior in cows that in young bulls.

As far as the muscle type is concerned, ST showed greater losses than the other two muscles. The results perfectly agree with other experiments. In Honikel and Potthast (1991) the muscle significantly affected the percentage of drip loss: the highest was in ST, the lowest in SS, in between lied LD. In Destefanis *et al.* (1994) drip losses were greater in ST than in LT, which in turn were greater than in SS. Hypertrophied young bulls showed a significant interaction between muscle and breed (Destefanis *et al.*, 1996). Anyway, drip losses tended to be greater in ST (4.44%) compared to LT (2.64%) and SS (2.51%).

Cooking losses - This is the parameter for which the highest R^2 was obtained, indicating that the adopted model accounts for over two thirds of variability. The considered factors of the model influenced and interacted in a significant way. Also for this parameter, cows showed a lower loss than young bulls, particularly in SS. In ST cows loose less fluid, but the difference was not significant. In LD the situation tends to be reverted, with slightly higher values for cows, even if not statistically different. Gerhardy (1995) found not significant differences between six cattle categories for cooking losses at 75°C both for LD and for ST. However, the data indicated a tendency to slightly greater losses in young bulls than in cows (33.41 *vs.* 32.67% in LD); on the contrary, statistically significant differences between categories appeared for cooking losses at 55°C only in LD. Also in the study of Fiems *et al*. (2003) young bulls showed statistically higher cooking losses than cows (25.1 *vs.* 23.6%).

As for muscles, the order for losses in both categories was ST, SS, LD. In young bulls, however, ST and SS were very close and did not differ much from each other. Similar results were obtained by Destefanis *et al.* (1996), with LT showing significantly smaller losses than SS and ST (similar to each other).

WB max - The category had a great influence (P=0.0001), showing average values of 15.72 kg in cows *vs.* 10.66 in young bulls. The muscle did not affect the parameter nor did it interact with the other factor. It should be noted that the values of the muscles are near within the category: from 10.22 in LD to 11.28 kg in SS for young bulls, and from 14.83 in SS to 17.13 kg in ST for cows. On the contrary, a lower shear force for LT was found by Destefanis *et al*. (2003). If we consider that the three muscles of the present study belong to cuts of different economic value, due to the assumed tenderness of the product, the proximity of the values of these muscles is quite remarkable.

WBw - The two factors had an influence on this parameter and interacted. The model accounted for a great part of the variability (54%). The meat of cows required a greater work than that of young bulls for all muscles, but the difference varied from 27% in SS to 40% in LD, up to 70% in ST. Gerhardy (1995) had reported significant differences between the categories of cattle for maximum shear force and for shear force done in LD only for the cooking at 55°C (mean values higher in cows than in young bulls and in heifers), whereas significant differences were found in ST (higher value in cows *vs.* young bulls for two out of three cooking methods). As for the muscle type, in young bulls the LSM ranged from 20.82 kg cm in LD to 22.60 in SS, values statistically not different. In cows, instead, the work necessary to shear ST (36.66) was higher than that for the other two muscles (about 29.00 kg cm). In each of the three muscles, WB max and WBw were higher in cows than in young bulls, with a slight difference in SS (+31 and +27%), intermediate in LD (+31 and +40%), greater in ST (+64 and +67%).
Gerhardy (1995) found significant differences between LD and ST for max shear force, for extension and for shear work done, being the values always higher in ST.

Conclusions

The fact that cows had a protein content similar to that of young bulls in all the three muscles examined, indicates that also the meat of cows is a good source of proteins. However, in comparison with young bulls, meat from cows was fatter (about twice and even more in LD) and showed a shear force about 1.5 times higher. In return, it contained one a half times as much iron. Young bulls showed a water-holding capacity less good than cows, loosing more drip and more fluid during cooking (significant difference in SS).
The muscle type significantly influenced many parameters. Among the three muscles used, *longissimus* is the poorest in water but the richest in lipids; it is the muscle with the lowest cooking losses, but most of all tends to low shear force. The *semitendinosus* is the leanest (mean <1.7% even in cows), but contains less iron, shows a poor water-holding capacity and, at least in cows, the highest WB max. The *supraspinatus* contains more water and less protein than the other two muscles, but is richer in iron and tends to loose less drip.
As well as acting on many parameters, at times the muscle interacted with the category, confirming the need to work also on muscles other than *longissimus*, every time that the effect of some factor or of a new technological treatment is being studied. Apart of the interest at research level, a punctual knowledge of the characteristics of beef would allow the consumer to choose the category and the muscle which better suit him, considering that the most valuable products are not necessarily the best with respect to chemical composition or water-holding capacity or shear force.
Instead of pursuing the probably utopian idea of the uniform quality, while keeping on selling beef as an undifferentiated product, perhaps it would be better to study methodically the different characteristics of the muscles, of the categories, etc. and inform the consumer, enabling him to choose according to his objectives.

References

Barge M. T., Brugiapaglia A., Destefanis G. and Mazzocco P. (1993). The influence of muscle type, ethnic group, muscular hypertrophy on the composition of beef meat. 39th I.Co.M.S.T., S5P02.WP.

Barge M. T., Destefanis G., Brugiapaglia A. and Barge P. (2001). Chemical composition of beef muscles in relation to the composition of *longissimus*. Proc. 47th I.Co.M.S.T., I: 178-179.

Barnier V. M. H. (1995). Determinants and predictors of beef tenderness. Ph. D. thesis. The University of Utrecht. The Netherlands.

Berg P. T., Marchello M. J., Erickson D. O. and Slanger W. D. (1985). Selected nutrient content of beef longissimus muscle relative to marbling class, fat status, and cooking method. J. Anim. Sci. 50: 1020-1033

Destefanis G., Barge M. T. and Brugiapaglia A. (1994). pH, colour and water holding capacity in muscles of young bulls differing for ethnic group. 40th I.Co.M.S.T., S-IVA.25.

Destefanis G., Barge M. T. and Brugiapaglia A. (1996). Meat quality in four muscles of hypertrophied Piemontese and Belgian Blue and White young bulls. Proc. 42nd I.Co.M.S.T., H3: 298-299.

Destefanis G., Barge M. T. and Brugiapaglia A. (2003) Effect of housing system on meat quality of Piemontese bulls. EEAP - 54th Annual Meeting, poster CMNS1.24, p. 176.

Dumont B.L. and Bousset J. (1990). Comparaison des indices de caracterisation de la maturité de deux types de carcasses de bovins. Viandes et produits carnés, 11: 240-241.

Fiems L. O., De Campeneere S., Van Caelenbergh W., De Boever J. L. and Vanacker J. M. (2003). Carcass and meat quality in double-muscled Belgian Blue bulls and cows. Meat Sci., 63: 345-352.

Gerhardy H. (1995). Quality of beef from commercial fattening systems in Northern Germany. Meat Sci., 40: 103-120.

Renerre M. (1982). Influence de l'âge et du pois à l'abattage sur la couleur de viandes bovines (races Frisonne et Charolaise). Sci. des aliments, 2: 17-30.

Table 1 – R^2 values, significant effects (P<0,005) and least square means.

parameter	R^2; sign. effects	muscles	Cows	Young bulls	Cows + y.b.
Moisture (%)	0.49 category muscle	LD	74.066	75.583	74.824^c
		ST	76.097	76.529	76.313^b
		SS	76.979	77.432	77.205^a
		LD+ST+SS	75.714^w	76.515^z	**76.114**
Protein (%)	0.32 muscle	LD	20.922	21.203	21.063^a
		ST	21.125	21.088	21.107^a
		SS	19.810	19.960	19.885^b
		LD+ST+SS	20.619	20.750	**20.685**
Lipids (%)	0.45 category muscle interaction	LD	4.827^a	1.924^{bc}	3.376
		ST	1.679^{bd}	0.968^{cd}	1.323
		SS	2.284^b	1.148^{bc}	1.716
		LD+ST+SS	2.930	1.347	**2.138**
Haeminic iron (µg/g)	0.58 category muscle	LD	17.800	12.466	15.133^b
		ST	14.089	9.282	11.685^c
		SS	21.584	13.941	17.762^a
		LD+ST+SS	17.824^w	11.896^z	**14.860**
Drip losses (%) (DL)	0.44 category muscle	LD	1.730	2.321	2.026^b
		ST	1.806	2.937	2.371^a
		SS	1.379	2.121	1.750^b
		LD+ST+SS	1.638^w	2.460^z	**2.049**
Cooking losses (%) (CL)	0.69 category muscle interaction	LD	17.764^c	17.321^c	17.543
		ST	24.996^a	26.947^a	25.971
		SS	21.317^b	25.855^a	23.586
		LD+ST+SS	21.359	23.374	**22.367**
WB max (kg)	0.42 category	LD	15.183	10.223	12.703
		ST	17.134	10.463	13.799
		SS	14.831	11.280	13.056
		LD+ST+SS	15.716^w	10.655^z	**13.186**
WBw (kg cm)	0.54 category muscle interaction	LD	29.14^b	20.82^c	25.67
		ST	36.66^a	21.96^c	30.54
		SS	28.76^b	22.60^c	26.20
		LD+ST+SS	31.52	21.79	**26.66**

Within a beef parameter, significantly different values (P<0.05), are given with different superscripts (w, z for the category; a, b… for the muscle and for muscle x category).