Tenderness measurements in four muscles of Belgian Blue normal and double-muscled bulls

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Introduction and objectives

In Belgium, beef cattle production is predominantly based on the Belgian Blue breed, characterised nowadays by a very high incidence of double-muscling. There remains some controversy regarding the effect of double-muscling on beef tenderness. In earlier work, it was found that beef of double-muscled animals was more tender (Bailey et al., 1982; Boccard, 1982; Bouton et al., 1982), which is in agreement with the general opinion of the meat industry in Belgium. However, in several other studies mean shear force values of samples of the *M. longissimus thoracis* cooked at 75°C were higher for double-muscled bulls compared with normal bulls of the Belgian Blue breed (Uytterhaegen et al., 1994; Fiems et al., 1995).

It is not clear to what extent differences in the methodology used to assess tenderness contribute to these conflicting results. Determination of shear force is often used as an objective measurement of tenderness. Different laboratories used different methods in the past, which makes comparison of results across studies difficult and which increases variability (Wheeler et al., 1994, 1997). There have now been efforts to standardise the procedure (Boccard et al., 1981; Chrystall et al., 1994).

The aim of the present study was to examine the effect of meat preparation preceding shear force determination on beef tenderness in double-muscled and normal cattle. Therefore, tenderness of four different muscles varying in collagen content was measured in double-muscled and normal Belgian Blue bulls by taste panel evaluations and by shear force determinations on raw and cooked meat samples. Shear force on raw meat is mainly reflecting background or collagen toughness, whereas shear force on cooked meat may be considered a measure of myofibrillar toughness.

Materials and methods

Six bulls of normal conformation (N) and five double-muscled bulls (DM) of the Belgian Blue breed were slaughtered in the abattoir of the University of Ghent. At 1 day post mortem, samples were taken of four different muscles (*Longissimus thoracis* (LT), *Semitendinosus* (ST), *Supraspinatus* (SS), en *Triceps brachii* (TB)), vacuum packed and further stored at 3°C until 8 days post mortem. Samples were subsequently frozen at -18 °C until analysis.

For shear force measurements on raw meat, cylindrical cores (∅ 1.27 cm) were taken in partly thawed state parallel to the muscle fibre direction. For measurements on cooked meat, steaks of 2.5 cm thickness were thawed overnight and cooked in open polyethylene bags hanging in a water bath at 75°C for 1 hour. Samples were subsequently cooled for 30 minutes in tap water before taking core samples. Cylindrical core were sheared with a Warner Bratzler shear, mounted on an Instron Food Tester 1140. The average maximum force of 15-30 measurements per sample is considered the shear force of the sample (N).

For taste panel evaluation, 8-12 trained panel members were given three times two meat samples per session. Tenderness was scored on an 8-point scale (1=extremely tender, 8=extremely tough). Taste panel samples (3 x 3 x 1 cm) were grilled during 2 minutes and served warm.

Collagen content (mg/g of fresh meat) was determined by colorimetric analysis of hydroxyproline according to the ISO/DIS 3496.2 procedure and multiplication of hydroxyproline content by factor 8.

Results and discussion

Mean age of the DM and N animals was comparable (respectively 26.8 and 23.0 months), as well as mean live weight (respectively 689 and 633 kg). As expected, the mean dressing percentage was significantly higher for the DM animals compared with the N animals (68.9 versus 63.7 %). According to the SEUROP classification scheme, higher grades were found for the DM compared with the N animals (average S- versus Uo), whereas the fat grade was lower (average 2- versus 2+).

Across muscles, mean collagen content and shear force of raw meat was significantly lower for the DM compared with the N animals, whereas mean shear force of cooked meat samples was not significantly different (Table 1). Lower collagen content in double-muscled animals was repeatedly reported (Boccard, 1982; Uytterhaegen et al., 1994), agreeing with the lower shear force values on raw meat samples in this study. Heating induces denaturation of collagen and conversion to gelatine, thus lowering background toughness, whereas myofibrils are toughening upon heating as a result of coagulation of the myofibrillar proteins (Harris & Shorthose, 1988). One may expect that shear force values in raw meat are mainly determined by native collagen. The finding that mean shear force values after heating were higher compared with the raw state further demonstrates that myofibrillar toughness increases as a result of heating.

Mean collagen content of LT, SS, ST and TB was respectively 4.11, 6.11, 7.47 en 5.43 mg/g for DM animals, and 6.01, 9.85, 10.37 en 8.62 mg/g for normal animals. Across muscles, meat of DM animals was evaluated more tender by the taste panel than meat of normal animals (Table 1). This suggests that, when samples differing widely in collagen content are given to a taste panel, the panel members are primarily judging collagen or background toughness rather than myofibrillar toughness. This is also demonstrated by significant positive correlation coefficients between taste panel scores on one hand, and collagen content and shear force values on raw meat on the other hand. In addition, the correlation between taste panel scores and shear force values on the cooked meat was not significant (Table 2). The latter finding does not correspond with earlier findings at our laboratory showing significant correlation coefficients between shear force values on cooked meat and taste panel scores (Demeyer et al., 1983; Steen et al., 1995). There is no clear explanation for this discrepancy.

According to Smulders et al. (1991) not only temperature but also duration of heating is important. The internal temperature of the meat pieces given to the taste panel raised to 80-90 °C during preparation (2 minutes grill), but the short duration probably had little impact on the collagen. The effect of heating on the collagen component is probably much higher when meat samples are heated for 1 hour at 75°C. This may also explain why taste panel evaluations in this study corresponded better with collagen content and collagen toughness (shear force on raw meat) than with myofibrillar toughness (shear force on cooked meat).
When muscles are examined separately (data not given), results correspond well with overall findings presented here. Shear force on raw meat was significantly lower in all four muscles for the DM compared with the N animals, whereas shear force on cooked meat was lower but the difference was not significant. For the LT muscle the latter finding does not correspond with earlier findings at our laboratory (Uytterhaegen et al., 1994). However, it should be mentioned that differences in conformation between DM and N cattle were lower in the present study. Mean shear force on cooked meat of the LT muscle in the present study compared with the study of Uytterhaegen et al. (1994) corresponded well for DM animals (respectively 52.3 and 59.8 N), but for N animals shear force on cooked meat was clearly higher in the present study (respectively 57.7 and 38.3 N).

Conclusions

Collagen content and shear force values on raw meat were lower and taste panel evaluations for tenderness were better for double-muscled animals compared with normal animals of the Belgian Blue breed. On the other hand, there was no significant effect of double-muscling on shear force of cooked meat in the present study.

References

Bailey A., Enser M.B. & Dransfield E. (1982). In: Muscle Hypertrophy of genetic origin and its use to improve beef production. Eds. J.W.B. King & F. Ménissier, Martinus Nijhoff Publishers, The Hague, 178-204.

Boccard R., Buchter L., Casteels M., Cosentino E., Dransfield E., Hood D.E., Joseph R.L., MacDougall D.B., Rhodes D.N., Schön I., Tinbergen B.J. & Touraille C. (1981). Livestock Production Science, 8, 385-397.

Boccard R. (1982). In: Muscle Hypertrophy of genetic origin and its use to improve beef production. Eds. J.W.B. King & F. Ménissier, Martinus Nijhoff Publishers, The Hague, 148-163.

Bouton P.E., Harris P.V., Shorthose W.R., Ellis R.W & Philips D.(1982). Meat Science, 6, 309-318.

Chrystall B.B., Culioli J., Demeyer D., Honikel K.O., Moller A.J., Purslow P., Schwägele F., Shorthose R. & Uytterhaegen L. (1994). Proceedings 40th ICoMST, The Hague, S-V.06.

Demeyer D., Hindryckx P. & Verbeke R. (1983). Landbouwtijdschrift, 2(36), 279-286.

Fiems L.O., Van Hoof J., Uytterhaegen L., Boucqué C.V. & Demeyer D.I. (1995). In: Expression of tissue proteinases and regulation of protein degradation as related to meat quality, Eds. A. Ouali, D.I. Demeyer & F.J.M. Smulders, Ecceamst, Utrecht, 381-393.

Harris P.V. & Shorthose W.R. (1988). In: Developments in Meat Science-4, Elsevier Applied Science, London, 245-296.

Smulders F.J.M., van Laack R.L.J.M. & Eikelenboom G. (1991) In: The European Meat Industry in the 1990's. Ed. F.J.M. Smulders, Ecceamst, Audet tijdschriften, Nijmegen, 121-164.

Steen D., De Smet S., Claeys E. & Demeyer D. (1995). Measurement of beef tenderness. Proceedings 9th Forum for Applied Biotechnology, 1, 1719-1726.

Uytterhaegen L., Claeys E., Demeyer D., Lippens M., Fiems L.O., Boucqué C.Y., Van de Voorde G. & Bastiaens A. (1994). Meat Science, 38, 225-267.

Wheeler T.L., Koohmaraie M., Cundiff L.V. & Dikeman M.E. (1994). Journal of Animal Science, 72, 2325- 2330.

Wheeler T.L., Shackelford S.D., Johnson L.P., Miller M.F., Miller R.K. & Koohmaraie M. (1997). Journal of Animal Science, 75, 2423-2432.

Table 1 Mean (standard deviation) collagen content, shear force values and taste panel scores for tenderness in Belgian Blue normal and double-muscled bulls

	Normal (n=24)	Double-muscled (n=20)	P
Collagen content (mg/g)	8.71 (1.99)	5.78 (1.58)	.001
Shear force raw (N)	44.2 (12.7)	22.8 (6.7)	.000
Shear force 75° C (N)	50.5 (10.7)	46.3 (9.6)	.178
Taste panel #	4.79 (0.83)	3.80 (0.82)	.000

8-point scale (1= extremely tender, 8= extremely tough)

Table 2 Correlation coefficients between taste panel scores for tenderness, shear force on raw and cooked (1 hour at 75 °C) meat and collagen content in Belgian Blue bulls (n=44, across animal type and muscle)

	Shear force raw	Shear force 75°C	Collagen content
Taste panel score #	0.617 *	0.106	0.650 *
Shear force raw (N)		-0.025	0.845 *
Shear force 75°C (N)			0.029

8-point scale (1= extremely tender, 8= extremely tough)
* significant at $P < 0.01$