EFFECT OF THE DOUBLE-MUSCLING GENOTYPE ON CARCASS AND MEAT QUALITY IN BELGIAN BLUE SLAUGHTER BULLS

S. De Smet, E. Claeys, A. Balcaen, D. van den Brink, M. Seynaeve and D. Demeyer

Department of Animal Production, Faculty of Agricultural and Applied Biological Sciences, Ghent University, Proefhoevestraat 10, 9090 Melle, Belgium

Background

The Belgian Blue beef breed is known for its extreme muscularity and leanness, partly due to the high frequency of double-muscling. There are several studies describing large differences in carcass and meat quality characteristics between normal and double-muscled phenotypes (Boccard, 1982; Uytterhaegen et al., 1994; Fiems et al., 1995; Clinquart et al., 1998). Recently, it was shown that the double-muscling phenotype is caused by mutations in the myostatin gene (Grobet et al., 1998), enabling also to characterise cattle with respect to the genotype for double-muscling and to examine differences between the three genotypes more accurately.

Objectives

To compare carcass and meat quality characteristics between the genotypes for double-muscling in the Belgian Blue breed with the emphasis on tenderness measurements.

Material and methods

Seventy six young bulls of the Belgian Blue breed, widely differing in body conformation, were slaughtered in the abattoir of Ghent University. Animals originated from different farms and were fattened on high-concentrate diets. Genotyping for the mutation nt821 (del11) in the myostatin gene responsible for the double-muscling phenotype in the Belgian Blue breed was done following Grobet et al. (1998) (double-muscled, mh/mh; heterozygous, mh/+; normal, +/+). Carcass classification was performed according to the SEUROP scheme for conformation and fat cover. Temperature and pH were measured at several times *post mortem* in the *M. longissimus thoracis* (LT). At 1 day *post mortem*, 5 different muscles were removed from the left carcass side: *M. longissimus thoracis* (8th-10th thoracic rib), *M. rectus femoris, M. semitendinosus*, *M. triceps brachii* and *M. gluteobiceps*. Each muscle sample was divided in 7 sub-samples in a standardised way. Sub-samples were vacuum packed, stored at 2-3 °C for 4, 11 or 25 days and frozen at –18 °C until analysis. Warner-Bratzler shear force was measured with a Lloyd TA 500 Texture Analyser on cooked (water bath heating at 75 °C for 1 hour) and grilled (until an internal temperature of 80°C) steaks. A 12 member sensory panel evaluated samples (3×3×1 cm, grilled for 2 minutes) of each muscle (after ageing for 11 days) for tenderness and juiciness on a 8-point scale (1 = extremely tender or juicy to 8 = extremely tough or dry). Drip losses, cooking losses, collagen content (ISO/DIS 3496.2), intramuscular fat content (ISO 1444-1973), sarcomere length and CIELAB colour values (L*, a*, b*) were also determined.

Results and discussion (Table 1)

Effect of double-muscling genotype on carcass quality

The genotype for double-muscling has a large effect on carcass conformation, allowing almost complete phenotypic discrimination between mh/mh animals and mh/+ or +/+ animals. All mh/mh animals except 2 were classified in the S or E conformation class, whereas all mh/+ and +/+ animals except 1 belonged to the U or R conformation class. Phenotypic discrimination between mh/+ and +/+ animals is more difficult. All animals belonged to fat class 2 or 3, meaning that these were lean carcasses. Mean live weight at slaughter, age at slaughter and whole live growth rate were comparable for the three genotypes. Dressing yield (%) increased and fat cover decreased significantly as the number of mh alleles increased. Carcass compositional data (not shown) also indicate that heterozygous animals are either intermediate or closer to the +/+ animals.

Effect of double-muscling genotype on meat quality

The early *post mortem* temperature in LT was somewhat higher for the mh/mh animals, whereas pH at 5 hours *post mortem* was slightly lower, reflecting the more glycolytic muscle metabolism (Fiems et al., 1995). This may have resulted in a more pronounced protein denaturation, and consequently also higher drip losses. In contrast, cooking losses were significantly lower for the mh/mh group compared with the two other genotypes, which is not in accordance with Uytterhaegen et al. (1994) but agrees with several other authors (Batjoens et al., 1989; Clinquart et al., 1994; Fiems et al., 1995). For most of these traits, the mh/+ group was either intermediate to both homozygous groups or closer to the +/+ group. As expected from other reports, collagen and intramuscular fat content of mh/mh animals were significantly lower compared with the other genotypes. Values were also significantly lower for mh/+ animals than for +/+ animals. Colour L* values were significantly different between the three genotypes, with the mh/mh animals having the palest colour and the heterozygous animals being again partly intermediate. Batjoens et al. (1991) and Fiems et al. (1995) also found higher L* values and reported a more glycolytic muscle fibre type for double-muscled animals. Sarcomere length was not dependent on the genotype.

Mean shear force values across muscles on cooked samples after different ageing times and on grilled samples were slightly but significantly lower for the mh/mh genotype compared with the mh/+ genotype (Table 1). Differences between the mh/mh and the +/+ and between the mh/+ and the +/+ genotype were mostly not significant. In previous work, we found no difference in shear force values on cooked meat between double-muscled and normal animals (De Smet et al., 1998). On the other hand, several authors found clearly higher shear force values in the LT muscle for double-muscled compared with normal animals, demonstrating higher myofibrillar toughness (Uytterhaegen et al., 1994; Clinquart et al., 1994; Fiems et al., 1995). The reason for these discrepancies is unclear. The effect of ageing until 25 days *post mortem* on shear force values was similar for the three genotypes, in contrast to earlier results suggesting a reduced *post mortem* tenderisation for double-muscled animals due to decreased proteolysis (Uytterhaegen et al., 1994). Mean shear force values and cooking losses were remarkably similar for cooked and grilled samples, in spite of the large difference in heating procedure.

In line with De Smet et al. (1998) on a limited number of animals of similar type, taste panel tenderness scores were significantly different between genotypes, with the highest (toughest) and lowest (most tender) scores for +/+ and mh/mh respectively. This finding is most probably a consequence of differences in collagen content and is further supported by large differences in shear force on raw meat samples (data not shown), in line with Boccard (1982). The correlation coefficient across genotypes and muscles between collagen content and tenderness score was 0.53. Taste panel juiciness scores were significantly higher (dryer meat) for mh/mh compared with the other genotypes, with no significant difference between the mh/+ and +/+ genotypes. Juiciness was related to the intramuscular fat content (r = -0.23).

Effect of muscle

Highly significant differences between muscles were found for sarcomere length, muscle collagen and fat content, colour L* value, shear force and taste panel tenderness and juiciness scores. Although of minor importance, significant genotype x muscle interaction effects were also noticed for these traits. For shear force and L* values no genotype x muscle interaction was found.

Conclusions

Large and significant differences are found depending on the double-muscling genotype for several carcass and meat quality traits. Mh/mh bulls have the highest carcass dressing % and yield more tender but less juicy meat with a lower fat and collagen content and paler colour. Taste panel tenderness differences between genotypes were not confirmed by shear force values on cooked or grilled meat samples. Meat ageing effects also appeared not to differ between genotypes. Significant differences between muscles were also found for most of the meat quality traits studied, but genotype x muscle interactions were mostly of minor significance.

References

Batjoens, P., Van Hoof, J. & Vereecke, D. (1989). Proc. 35th ICoMST, 1082-1087.

Batjoens, P., Fiems, L.O., Van Hoof, J., Van Vooren, T. & Vereecke, D. (1991). Proc. 37th ICoMST, 324-327.

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

Clinquart, A., Hornick, J.L., Van Eenaeme, C. & Istasse, L. (1998). INRA Productions Animales, 11 (4), 285-297.

Clinquart, A., Van Eenaeme, C., Van Vooren, T., Van Hoof, J., Hornick, J.L. & Istasse, L. (1994). Sciences des Aliments, 14, 401-407.

De Smet, S., Claeys, E., Buysse, G., Lenaerts, C. & Demeyer, D. (1998). Proc. 44th ICoMST, 288-289.

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, 381-393. Eds. A. Ouali, D.I. Demeyer & F.J.M. Smulders, Ecceamst.

Grobet L., Poncelet D., Royo L.J., Brouwers B., Pirottin D., Michaux C., Ménissier F., Zanotti M., Dunner S. and Georges M. (1998). Mammalian Genome, 9, 210-213.

Uytterhaegen L., Claeys E., Demeyer D., Lippens M., Fiems L.O., Boucqué C.V., Van de Voorde G., Bastiaens A. (1994). Meat Science, 38, 255-267.

Acknowledgements

This research was supported by the Ministry of Small Enterprises, Traders and Agriculture, Directorate Research and Development. A. Van den Bossche and L. Herman are gratefully acknowledged for the genotyping analyses.

***Table 1.** Mean values (standard deviation) of carcass and meat quality characteristics according to the double-muscling genotype*

	mh/mh (n=32)	mh/+ (n=22)	+/+ (n=22)		mh/mh (n=32)	mh/+ (n=22)	+/+ (n=22)
Carcass measurements				Mean values for meat quality measurements in five muscles			
Age (months)	19.8 (2.6)	19.2 (1.8)	19.0 (2.9)	Drip losses (%) [3]	4.3 (2.2) [a]	3.0 (1.2) [b]	2.5 (1.5) [b]
Live weight (kg)	683 (88.2)	633 (58.0)	651 (64.6)	Cooking losses (%) [3]	30.0 (3.9) [a]	31.5 (5.8) [b]	31.5 (2.8) [b]
Daily gain (g/d) [1]	1056 (113)	1007 (142)	1051 (127)	Fat (%)	0.7 (0.4) [a]	1.4 (0.7) [b]	2.1 (1.3) [c]
Carcass dressing %	70.4 (1.8) [a]	64.4 (1.9) [b]	61.0 (1.2) [c]	Collagen (mg/g)	5.97 (2.12) [a]	8.75 (2.85) [b]	9.98 (3.18) [c]
Conformation [2]	3.2 (1.7) [a]	8.4 (1.7) [b]	10.0 (1.4) [c]	CIE L* value	43.5 (4.3) [a]	38.2 (4.4) [b]	36.8 (4.1) [c]
Fat cover [2]	4.9 (0.9) [a]	6.2 (1.4) [b]	7.1 (1.3) [c]	SL (µm) [4]	2.02 (0.25)	2.06 (0.24)	2.07 (0.27)
Measurements on longissimus muscle				SF 4 days pm (N) [5]	38.2 (9.3) [a]	41.7 (7.1) [b]	40.4 (5.9) [a, b]
pH 5 h pm	5.68 (0.15)	5.84 (0.22) [b]	5.87 (0.20) [b]	SF 11 days pm (N) [5]	33.3 (9.4) [a]	36.2 (6.4) [b]	34.6 (6.2) [a, b]
pH 24 h pm	5.56 (0.08)	5.63 (0.16)	5.59 (0.07)	SF 25 days pm (N) [5]	28.8 (8.1) [a]	32.8 (4.8) [b]	31.7 (4.6) [b]
Temp 2 h pm (°C)	37.3 (1.7) [a]	34.9 (2.6) [b]	34.4 (3.0) [b]	SF grill (N) [3]	32.5 (8.8) [a]	35.5 (5.8) [b]	35.0 (6.6) [b]
Temp 5 h pm (°C)	26.3 (2.0) [a]	23.9 (2.5) [b]	24.5 (2.5) [b]	TP tenderness [6]	3.6 (0.8) [a]	4.6 (0.8) [b]	4.9 (0.8) [c]
				TP juiciness [6]	4.7 (0.6) [a]	4.4 (0.5) [b]	4.3 (0.4) [b]

a, b, c: different superscripts indicate significant differences between genotypes ($P < 0.05$)

[1] Whole life average daily gain; [2] Carcass conformation following SEUROP classification on 18-point scale: class S+ = 1 (very good) ... class P- = 18 (very poor); fat cover on 15-point scale (1-15): class 1- = 1 (very lean) ... class 5+ = 15 (very fat); [3] After ageing time 11 days; [4] SL= sarcomere length; [5] SF= shear force on cooked meat after 4, 11 or 25 days ageing; [6] Lower taste panel values means more tender or more juicy.