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The effect of growth rate and age at slaughter on dressing percentage and colour, pH_{48} and microstructure of *longissimus dorsi* muscle in Black-and-White (BW) bulls *vs* commercial crossbreds of BW with beef breeds

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The study was performed on 55 young purebred Black-and-White (BW) bulls and 73 bulls being commercial crossbreds of BW with beef cattle. Daily live weight gain from 990 to 927 g was found related to a higher dressing percentage, ranging from 58.3% in crossbreds to 55.9% in pure BW bulls. Meat from crossbreds showed, with no reference to slaughter age and genotype, a pH_{48} higher (5.79) than that found in purebred BW bulls. More intensive growth rate, regardless of age of the bulls, led to the lighter meat colour (Hunter-L; 29.6-27.5) and saturation with red (Hunter-a; 18.7-15.3). A much greater diameter of *longissimus dorsi* (LD) muscle fibres was observed in meat from older animals (35.6-56.5 µm) as well as from those showing higher live weight gain, where the difference in the fibre size reached 16.7 µm. A higher growth rate also resulted in a higher content of FTO and FTG fibres.

KEY WORDS: bulls / commercial crosses / fattening / growth rate / meat quality

Due to increasing demands of consumers, beef production must follow the appropriate technology. This must be based on commercial crossing, which increases beef production taking into account the growth potential of animals [Młynek *et al*. 2000, Steen 1995]. Muscle microstructure is considered to be the crucial factor determining culinary qualities of beef as affected by commercial crossing [Boocard *et al*. 1979] and growth intensity [Renand *et al*. 2001, Keane and Allen 1998, Eepin 1998, Vestergaard *et al*. 2000a]. The typical nature and size of muscle fibre [Ozawa *et al*. 2000, Geesink *et al*. 1995, Monin, 1991] both affect the final quality of raw material of meat. This was the reason for conducting the present study, the aim of which was to show the relations in slaughter indicators and *longissimus dorsi* muscle microstructure resulting from variable growth rate in fattening bulls of different genotypes and at different ages.

Material and methods

Used was the control group of 55 Black-and-White (BW) bulls and 73 commercial crossbred bulls (CC), the latter sired by Charolaise (34.2%), Simmental (17.8%), Limousine (16.4%), Blond d' Aquitaine (16.4%) and Piedmontese (15.1%) sires. The effect of growth rate (group I – daily live weight gain up to 900 g and group II – daily gain over 900 g) was analysed in two age groups. The first age group included bulls slaughtered at the age of 18 months (group A) and the second – those slaughtered at the age of 22 months (group B). Animals from the first group were fattened with farm feeds (hay-based ration), offered *ad libitum* in autumn and winter and green forage in the summer with an addition of crushed cereals (1.0 kg daily). Animals from the second group were additionally offered corn silage in autumn and winter (about 15 kg daily) and crushed cereals up to 3 kg.

Within 30-60 min *post mortem* the *longissimus dorsi* (LD) muscle tissue sections were sampled for histological examination and immediately frozen in liquid nitrogen. The histological analysis was carried out using the method described by Kłosowski and Kłosowska [1988]. Histochemical reactions differentiating the muscle fibres into STO ("red"), FTO ("intermediate") and FTG ("white") were performed according to Ziegan [1979]. The fibre diameter and percentage of fibre types was estimated on the basis of 10 randomly selected muscle bundles measured using the OLYMPUS Cell – Soft Imaging System programme. The colour of LD was estimated using the MINOLTA CR-310 apparatus (HUNTER LAB system) and concerned 200 g steak samples, taken after 48 h carcass cooling at 4°C. At the same time, weighing and estimation of dressing percentage and pH_{48} of LD were performed.

The results were verified with analysis of variation, concerning two genetic groups, two growth rate groups and two age groups. The significance of differences was estimated using the Duncan method.

Results and discussion

Table 1 shows that the growth rate in both age groups of bulls was crucial for their dressing percentage. Bulls with the higher daily live weight gain, *i.e*. ranging from 927 to 990 g, showed the highest dressing percentage, varying from 55.9% for BW bulls slaughtered at the age of 22 months to 58.3 % for crossbreds slaughtered at the age of 18 months. Keane and Allena [1998] showed that carcasses of bulls fattened more intensively were by 19.5 kg heavier than those of less intensively fattened

Table 1. Means and their standard errors (±) for fattening performance, slaughter indicators, colour, pH_{48} and histological traits of *longissimus dorsi* muscle as related to age and daily body weight gain of bulls

Trait	Group A (age up to 18 months)				Group B (age over 18 months)			
	daily body weight gain <900 g		daily body weight gain ≥900 g		daily body weight gain <900 g		daily body weight gain ≥900 g	
	CC (n=22)	BW (n=17)	CC (n=14)	BW (n=11)	CC (n=16)	BW (n=11)	CC (n=21)	BW (n=16)
Age of animals (days)	549.6 ± 20.5^{a}	558.2 ± 22.8^{a}	563.8 ± 29.1^{b}	551.1 ± 26.8^{a}	660.2 ± 19.4^{c}	672.2 ± 35.5^{d}	659.9 ± 48.9^{c}	674.5 ± 13.3^{d}
Slaughter weight (kg)	442.8 ± 39.3^{b}	430.2 ± 58.6^{b}	522.6 ± 19.0^{b}	505.8 ± 17.5^{d}	521.3 ± 43.6^{a}	531.5 ± 58.6^{a}	608.4 ± 42.8^{c}	607.3 ± 10.9^{c}
Daily body weight gain (g)	805.0 ± 60^{B}	768.0 ± 80^{D}	928.0 ± 30^{A}	918.0 ± 70^{A}	789.0 ± 50^{B}	791.0 ± 50^{B}	922.0 ± 60^{A}	903.0 ± 50^{c}
Dressing percentage	56.5 ± 1.6^{b}	55.6 ± 1.1^{b}	58.3 ± 2.6^{A}	57.6 ± 2.6^{b}	53.9 ± 2.6^{a}	51.2 ± 3.7^{a}	57.7 ± 4.3^{b}	55.9 ± 3.7^{b}
pH_{48}	5.61 ± 1.65^{a}	5.41 ± 2.65^{b}	5.71 ± 2.52^{a}	5.64 ± 1.25^{b}	5.53 ± 2.62^{b}	5.42 ± 2.95^{b}	5.79 ± 2.69^{a}	5.66 ± 1.26^{a}
Colour (Hunter Lab)								
L	26.4 ± 3.9^{b}	27.1 ± 3.8^{a}	29.6 ± 3.4^{B}	28.6 ± 3.5^{Ba}	25.1 ± 4.2^{Ab}	25.2 ± 5.4^{Ab}	27.5 ± 4.1^{a}	28.3 ± 6.7^{Ba}
a	15.9 ± 3.4^{a}	17.9 ± 3.3^{Ab}	16.7 ± 3.1^{a}	18.7 ± 2.9^{Ab}	13.8 ± 3.0^{Bc}	15.2 ± 0.9^{a}	15.3 ± 2.1^{a}	14.3 ± 2.3^{Bc}
b	8.6 ± 1.9^{b}	8.7 ± 1.8^{b}	9.3 ± 1.3^{a}	9.0 ± 1.9^{ab}	10.8 ± 2.5^{dc}	11.2 ± 2.4^{c}	11.0 ± 2.0^{cd}	11.3 ± 2.5^{c}
Muscle fibre diameter (μm)	22.6 ± 2.6^{A}	27.7 ± 5.3^{B}	31.0 ± 6.1^{B}	31.8 ± 6.4^{B}	35.6 ± 13.6^{C}	39.8 ± 15.2^{D}	52.3 ± 13.7^{E}	56.5 ± 9.4^{F}
Fibre type (%)								
“white” type	72.4 ± 5.2^{b}	70.5 ± 1.6^{Ab}	75.7 ± 4.1^{Ba}	74.1 ± 3.8^{Ba}	68.6 ± 4.3^{Ab}	69.5 ± 3.5^{Ab}	68.0 ± 3.6^{Ab}	69.7 ± 3.8^{Ab}
“red” type	27.6 ± 5.2^{b}	29.5 ± 1.6^{Ab}	24.2 ± 4.1^{Ba}	25.9 ± 3.8^{Ba}	31.4 ± 4.3^{c}	30.5 ± 3.6^{Ab}	32.0 ± 3.7^{c}	30.3 ± 3.8^{Ab}

CC – commercial crossbreds with Black-and-White.
BW – purebred Black-and-White.
[aA...]Means within the same row bearing a common superscript are not significantly different: small letters – P≤0.05; capitals – P≤0.01.

bulls. They had not proved differences between valuable cuts weights, but significant appeared mean difference in the amount of meat in those cuts. Similar tendencies of increasing dressing percentage together with increased growth intensity have been reported by Młynek *et al*. [2000]. In their study, the dressing percentage varied from 53.51% for bulls with a body weight of 493.3 kg (BW) and 59.7% (BW × beef cattle) and analogically to 55.5 and 61.4% for bulls with 608.6 and 605.2 kg live weight. Pogorzelska *et al*. [1991] reported a dressing percentage of 60.5% in intensively, and 57.6% in extensively fattened bulls.

The muscles of bulls whose mean daily body weight gain reached 922 g, showed higher pH_{48}, ranging from 5.64 to 5.79. Meat with lower pH_{48}, ranging from 5.41 to 5.61, came from bulls with mean daily gain of 805 g. It should be stressed that increased growth rate resulted in a higher content of FTO + FTG fibres. The content of fibres with high oxidative enzyme concentration and a lower content of those with low glycolytic enzyme concentration is thought to decrease the lactic acid concentration and slow down the meat acidification process [Kłosowski i Kłosowska 1993]. This can lead to DFD defect [Kłosowska *et al*. 1992]. Different tendencies were observed by Vestergaard *et al*. [2000a, 2000b] concerning the pH_{48} of LD, ranging from 5.44 in bulls growing intensively to 5.54 in bulls with a slower rate of growth.

In the case of meat colour (Tab. 1), the more advantageous effect of intensive growth was observed in crossbreds. In the group of up to 18 months of age the improvement of the trait reached 3.2 units, and 2.4 units in meat from older animals. In the case of BW breed the corresponding differences were 1.5 to 3.1 units. It is important to note that only in crossbreds slaughtered at the age of 22 months, did the increased growth intensity result in less red colour saturation of meat (Hunter-a), *i.e*. from 15.2 to 14.3 units. In the other groups, increased growth intensity was accompanied with a higher saturation of red colour of meat, reaching 1.6 for BW bulls. Keane and Allen [1998] showed that the red colour of Hunter-L was 36.5 in LD of animals fattened intensively. Meat from bulls reared less intensively reached Hunter-L of 28.2-35.8 units. The cited authors also gained higher red colour saturation of meat from animals slaughtered at the age of 556 and 684 days – Hunter-a 17.9 and 15.0 units, respectively. The result of the present study matches those of Vestergaard *et al*. [2000a] who reported Hunter-L = 41.4 and Hunter-a = 19.5 in bulls growing intensively and slaughtered at body weight of 360 kg. In bulls with a live weight of about 460 kg the respective results were 39.2 and 20.5 units. Bulls growing less intensively and slaughtered at body weight 360 kg showed lighter meat (L = 36.1; a = 16.7) when compared to those slaughtered at 460 kg [Vestergaard *et al*. 2000a].

The results presented in Table 1 concerning the LD microstructure proved an increased diameter of muscle fibres, ranging from 4.1 μm in BW to 8.4 μm in BW crossbreds, in groups of bulls slaughtered at 18 months. Bulls slaughtered at 22 months, exceeded those slaughtered at month 18 by 16.7 μm. The share of muscle fibre types proved the effect of intensive growth on fibre transformation only in animals slaughtered at the age of 18 months. The higher growth rate resulted in an increased share of FTO + FTG fibres and decrease in the STO fibres share by 3.5 per cent points (pp) in this group. In older bulls the difference was only 0.4 pp. Similar results have been reported by Vooren *et al*. [1992] and Ashmore and Vigneron [1988]. Therkildsen *et al*. [1998] and Yambayamba and Price [1991] also stress out the significant effect of fattening system on microstructure traits of beef. In heifers reared intensively and slaughtered at the age of 199 days they report FTG + FTO fibre share rate of 72.4% and, contrary to the papers cited earlier, a smaller diameter (38.2 µm) of a single fibre. Even Seideman and Crouse [1986] reported a higher share rate of "white" type fibres (64.5%) and a low share rate of "red" fibres (35.4%) in intensively growing bulls. Similar results were reported by Lewis *et al*. [1977], Gier *et al*. [1988]. Maltin *et al*. [2001] and Młynek *et al*. [2003].

It may be concluded that microstructure traits of muscles are to the greatest extent determined by factors linked to the age and growth intensity of bulls. The frequency of fibres in LD muscle depends on the transformation of FTO and STO fibres into FTG fibres with prevailing glycolytic metabolism, and is related to growth intensity, particularly in younger animals. The results concerning dressing percentage and meat quality prove that production of beef from cattle fattened with farm-produced feed and slaughtered at the age of 22 months, is economically ineffective. This may be concluded from the lowest dressing percentage in this group, which reached only 53.9%, and from the least advantageous colour parametres and pH_{48} level.

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Wpływ intensywności wzrostu i wieku w dniu uboju na wydajność rzeźną, pH_{48} oraz mikrostrukturę i barwę mięśnia najdłuższego grzbietu buhajów rasy czarno-białej (cb) i mieszańców towarowych cb z rasami mięsnymi

S t r e s z c z e n i e

Badania przeprowadzono na 55 buhajach cb (BW) i 73 mieszańcach cb (BW) z rasami mięsnymi (charolaise, simmental, limousine, blond d'aquitaine i piemontese). Badano wpływ intensywności wzrostu i wieku w chwili uboju na wybrane parametry wartości rzeźnej oraz pH_{48} cechy jakościowe i mikrostrukturę mięśnia najdłuższego grzbietu (LD).

Stwierdzono, że większa intensywność wzrostu mieszańców towarowych w młodszym wieku sprzyja osiąganiu przez nie wyższej wydajności rzeźnej (58,3%) oraz rozjaśnieniu barwy mięsa (29,6 Hunter-L). Mięso zwierząt rosnących intensywniej, niezależnie od wieku i zastosowanego krzyżowania towarowego, charakteryzowało się wyższym pH_{48} (5,64-5,79) niż mięso uzyskiwane w wyniku opasania ekstensywnego. Większa intensywność wzrostu zwierząt starszych wiązała się ze zwiększeniem przeciętnej średnicy włókien w LD. Na kształtowanie się tej cechy miało również wpływ zastosowane krzyżowanie towarowe. Średnica włókien mięśnia LD mieszańców była mniejsza niż średnica włókien LD buhajów rasy cb (odpowiednio 52,3 i 56,5 μm^2). W mięśniu LD młodych opasów stwierdzono wyższy udział włókien z przewagą przemian glikolitycznych (FTG i FTO). Na kształtowanie się proporcji typów włókien mięśniowych miały również wpływ, zwłaszcza u zwierząt młodszych, zwiększona intensywność wzrostu i genotyp uzyskany w wyniku zastosowanego krzyżowania towarowego.