MEAT QUALITY AND MYOFIBRILLAR PROTEIN FRAGMENTATION IN BULLS TREATED WITH THE β-AGONIST CIMATEROL

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INTRODUCTION

Previous work on β-agonists in beef cattle has shown that growth rate and feed efficiency can be positively affected. Furthermore, carcass composition shifts towards more lean meat and less fat (Boucqué et al., 1987 ; Quirke et al., 1988). Although meat quality has not been extensively investigated, β-agonists may reduce tenderness (Hamby et al., 1986). Therefore meat quality parameters, and myofibrillar protein fragmentation (Buts et al., 1987) as an index of meat conditioning, were studied. The work reported here is an extension of earlier work (Fiems et al., 1989a).

MATERIALS AND METHODS

The investigation was conducted with 32 double muscled Belgian White-Blue (Experiment 1) and 31 Charolais bulls (Experiment 2). In both experiments 16 animals have received 60 µg cimaterol daily per kg liveweight in the diet for about 136 and 92 days, respectively. In experiment 3, 46 Belgian White-Blue bulls with normal conformation were involved to investigate the effect of 4 ppm cimaterol in the diet when administered during on average 246, 127 or 71 days. A 6-day withdrawal period has been applied for treated animals.

After slaughtering ultimate pH (pH_u), colour, loose water value (LWV) and chemical composition were determined on longissimus muscle (LD) samples (8th rib) from the right carcass side, as described by Grau and Hamm (1956) and Boccard et al. (1981). Tenderness of cooked meat and drip and cooking losses were determined on LD-samples from the left carcass side, which have been cooled at 2° C for 11 days and stored at - 20° C for a maximum of 5 months. Myofibrillar protein fragmentation was estimated using sodium dodecyl sulphate polyacrylamide gel electrophoresis (Claeys et al., 1989). Sarcomere length was measured as described by Vandendriessche et al. (1984).

RESULTS AND DISCUSSION

Moisture content was not different between control (CON) and cimaterol-treated (CIM) animals.

Cimaterol affected chemical composition of the longissiumus muscle by a shift towards more protein and less fat. Collagen content was not affected (see Table 1).

The reduction of the fat content is in accordance with the leaner carcasses observed in experiments of Boucqué et al. (1987) and Quirke et al. (1988).

Ultimate pH was not different and averaged 5.6 in experiments 1 and 2 and 5.7 in experiment 3 (see Table 2). These results are in agreement with those of Thornton et al. (1987) in sheep. However, Beermann et al. (1985) and also Warriss et al. (1989) found a higher ultimate pH in sheep treated with beta-agonists.

Meat colour (lightness) was not affected by cimaterol in our experiments, although it was darker in experiments of Warriss et al (1989). Some waterholding capacity parameters were slightly affected : loose water values (LWV) were not different among groups. Drip losses and cooking losses were decreased by cimaterol in experiment 2 ($P < 0.10$) and also after 127 days in experiment 3

TABLE 1. Effect of cimaterol on meat composition (%)

	Expt. 1		Expt. 2	
	CON	CIM	CON	CIM
No of bulls	16	16	16	15
Moisture	75.1[a]	74.9[a]	73.7[a]	74.2[a]
Protein	23.1[a]	24.2[b]	22.7[a]	23.5[b]
Fat	1.3[a]	0.8[b]	3.4[a]	2.4[b]
Collagen[c]	0.8[a]	0.6[a]	0.7[a]	0.7[a]

	Expt. 3			
CIM (days)	0	71	127	246
No of bulls	12	10	12	12
Moisture	74.3[a]	74.8[a]	74.2[a]	74.9[a]
Protein	23.3[a]	23.6[ab]	23.8[ab]	24.0[b]
Fat	2.7[a]	1.5[b]	2.3[a]	1.5[b]
Collagen	0.7[a]	0.7[a]	0.7[a]	0.8[a]

a,b : values with the same superscripts within experiments are not significantly different ($P > 0.05$)
c : only 8 analyses per group

($P < 0.05$). According to Warriss et al. (1989) drip loss was substantially reduced in β-agonist-treated sheep, but this probably is a reflection of the higher pH_u values. Opposite results in our experiments and in experiments of Beermann et al. (1985) and Warriss et al. (1989) may be more related to an interaction between slaughtering circumstances and the cimaterol treatment, than to the cimaterol treatment alone.

Cimaterol feeding significantly increased Warner-Bratzler shear force values in the three experiments. Meat of double muscled animals is usually more tender than in normal conformation animals. Consequent on the cimaterol administration, meat tenderness of treated double muscled bulls (Experiment 1) became slightly lower than in normal untreated bulls (Experiment 3). Reduced tenderness can not be explained by cold shortening, as sarcomere length was similar for control and cimaterol-treated animals (see Table 3), nor by collagen content (hydroxyproline x 7.14, Dransfield et al., 1983) (see Table 1). Although collagen content was not affected, collagen solubility needs

TABLE 2. Effect of cimaterol on ultimate pH, colour and water-holding capacity of the longissimus muscle

	Expt. 1		Expt. 2	
	CON	CIM	CON	CIM
pH_u	5.6[a]	5.6[a]	5.6[a]	5.6[a]
Colour	39.8[a]	38.5[a]	40.6[a]	41.0[a]
LWV (cm^2)	5.2[a]	5.3[a]	5.3[a]	5.4[a]
Drip loss (%)	7.5[a]	6.2[a]	8.1[a]	6.5[a]
Cooking loss (%)	21.7[a]	20.4[a]	25.1[a]	22.8[a]

	Expt. 3			
CIM (days)	0	71	127	246
pH_u	5.7[a]	5.7[a]	5.8[a]	5.8[a]
Colour	38.8[a]	39.0[a]	37.9[a]	39.6[a]
LWV (cm^2)	4.9[a]	5.0[a]	5.0[a]	5.3[a]
Drip loss (%)	5.0[a]	4.0[a]	4.0[a]	5.0[a]
Cooking loss (%)	24.7[a]	23.3[ab]	21.7[b]	22.7[ab]

a,b : values with the same superscripts within experiments are not significantly different ($P > 0,05$)

further investigation. A reduced tenderness agrees with the results of Hamby et al. (1986) in sheep and Miller et al. (1988) in heifers. According to Beermann et al. (1985) meat tenderness was unaltered in lambs.

Higher shear forces can be related to a reduced fragmentation of myofibrillar proteins (Buts et al., 1987). Amounts of troponin-T, filamin and titin were higher, while the 30 Kdalton component was decreased. This lower myofibrillar protein fragmentation may indicate that the reduced meat tenderness in cimaterol-treated bulls is probably related to a restricted meat conditioning. Such a reduced postmortem proteolysis due to cimaterol is in accordance with the lower muscle protein degradation observed in growing animals (Fiems et al., 1989b). The coincidence of a decreased meat tenderness and a decreased degradation of troponin-T with a lower appearance of the 30

TABLE 3. Effect of cimaterol on tenderness, sarcomere length and myofibrillar protein fragmentation

	Experiment 1		Experiment 2	
	CON	CIM	CON	CIM
Shear force (N)	37.1[a]	52.7[b]	42.1[a]	55.9[b]
Sarcomere length (μm)	1.76[a]	1.74[a]	1.92[a]	1.88[a]
Myofibrillar proteins (μg BSA equivalent/mg myofibrillar protein)				
Troponin-T	0.8[a]	3.6[b]	2.1[a]	6.5[b]
30 Kdalton	14.2[a]	8.8[b]	12.1[a]	6.6[b]
Filamin	0.9[a]	2.0[a]	3.1[a]	3.4[a]
Titin	22.2[a]	26.2[b]	24.4[a]	28.7[b]
	Experiment 3			
Cimaterol (days)	0	71	127	246
Shear force (N)	48.2[a]	62.9[b]	61.2[b]	70.2[b]
Sarcomere length (μm)	1.85[a]	1.86[a]	1.83[a]	1.78[a]
Myofibrillar proteins (μg BSA equivalent/mg myofibrillar protein)				
Troponin-T	2.4[a]	4.4[ab]	10.9[c]	7.5[bc]
30 Kdalton	12.8[a]	7.4[b]	4.0[b]	6.2[b]
Filamin	1.9[a]	3.0[b]	2.7[ab]	2.7[ab]
Titin	24.1[a]	28.5[b]	30.2[b]	30.0[b]

a,b,c : values with the same superscripts within experiments are not significantly different ($P > 0.05$)

Kdalton component is in agreement with the findings of MacBride and Parrish (1977). Penny and Ferguson-Pryce (1979) concluded that the loss of troponin-T with the concomitant production of the 30 Kdalton component can be attributed to the action of endogenous proteolytic enzymes. Consequently, the results of Table 3 may suggest an inhibition of proteolytic activity in cimaterol-treated animals. This hypothesis has been confirmed by Forsberg et al. (1987),Higgins et al. (1988) and Kretchmar et al. (1988). They reported an increased calpastatin activity by 0.68 to 0.99, expressed in terms of units per kg muscle and units per gram extractable protein, respectively, and a decreased activity of cathepsin B by 0.36 to 0.45, expressed as units per gram of wet muscle, due to cimaterol, clenbuterol or L-644,969 in sheep muscle. Reduced proteolytic activity affecting meat tenderness is obviously also reflected in a reduced muscle protein turnover and higher concentrations of large molecular weight proteins, such as filamin and titin (see Table 3).

CONCLUSION

Dietary cimaterol significantly increased protein content and reduced fat content of the longissimus muscle. Ultimate pH, waterholding capacity and meat colour were not affected. However, diverging results from our experiments and the literature may indicate an interaction between pre-slaughter circumstances, such as cimaterol-withdrawal period, fasting period and stress. Meat tenderness decreased significantly in cimaterol-treated bulls, and could not be attributed to cold shortening or collagen content. The reduced tenderness coincided with a lower degradation of troponin-T and a lower appearance of the 30 Kdalton component. This reduced myofibrillar protein fragmentation may be related to a depression of meat conditioning by the inhibition of the proteolytic enzymes, also reflected in a lowered muscle protein turnover.

The results were similar for diffe-

rent types of the Belgian White-Blue breed (normal conformation and double muscled bulls) and also for bulls of the Charolais breed. Effects on meat quality parameters were not affected when the length of the cimaterol administration ranged between about two and eight months.

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