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A note on muscle composition and colour of Holstein-Friesian, Piedmontese × Holstein-Friesian and Romagnola × Holstein-Friesian steers

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Holstein-Friesian (HF), Piedmontese × Holstein-Friesian (PM) and Romagnola × Holstein-Friesian (RO) steers were compared for muscle composition and colour. A total of 120 steers in a 3 breed types (HF, PM and RO) × 2 feeding levels (low and high) × 2 finishing periods (short, S and extended, E) factorial experiment were used. Three samples of *m. longissimus* were taken for chemical analysis, measurement of drip loss and Hunterlab colour measurements. Muscle moisture and protein concentrations were lower, and lipid concentration was higher for HF than for PM and RO, which were similar. There were no effects of feeding level on chemical composition, but after blooming all colour values except hue were lower for the higher feeding level. The E finishing period reduced moisture, protein, drip-loss, *L* (lightness), *a* (redness) and chroma values. It is concluded that PM and RO had similar muscle composition but HF had a higher lipid concentration. Feeding level had few effects on muscle composition, but extended finishing increased all measures of fatness and reduced colour values.

Keywords: beef breeds; dairy crosses; muscle colour; muscle composition

Introduction

The Piedmontese and Romagnola Italian cattle breeds have been imported into Ireland and have been evaluated for beef production (Keane and Allen, 2002). In addition to general productivity, muscle composition and colour are commercially important traits especially for carcasses destined for export to the Italian market (Dunne *et al.,* 2004a). The objective of this

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study was to compare Holstein-Friesian (HF), Piedmontese × Holstein-Friesian (PM) and Romagnola × Holstein-Friesian (RO) steers for *m. longissimus* chemical composition and colour.

Materials and Methods

The production system in which the animals were reared has been described previously (Keane and Allen, 2002). Briefly, over two consecutive years, spring-born calves, from sires representative of the breeds being evaluated, and out of Holstein-Friesian dairy cows, were purchased shortly after birth from co-operating dairy farms and moved to Grange Beef Research Centre where they were reared according to the norms for a two year-old dairy beef system (Keane and Drennan, 1991).

At the start of the second (finishing) winter each year, the animals (20 per breed type) were blocked on weight within breed type, taking account of sire, and assigned from within blocks to a 3 breed types (HF, PM and RO) × 2 feeding levels × 2 finishing periods factorial experiment. The two feeding levels were 3 kg/day (low, L) and 6 kg/day (high, H) supplementary concentrates offered with grass silage *ad libitum*. The two finishing periods were 124 days (short, S) and 207 days (extended, E). Accommodation was in a slatted shed.

After slaughter in a commercial abattoir, cold carcass weight (0.98 × hot weight) and weight of perirenal plus retroperitoneal fat were recorded. Carcasses were graded for conformation and fatness according to the European Union Beef Carcass Classification Scheme (Commission of the European Communities, 1982). After a 24 h chilling period (4 °C), 3 steaks, each about 2.5 cm thick, were cut from the *m. longissimus* cranial from the 10th rib. One was frozen for later chemical analysis for moisture, protein, lipid and ash, one was used to measure drip loss, and the third was used for colour measurements immediately after cutting (0 h) and after a blooming period (2 h). For chemical analysis, protein concentration was measured on the LECO total N analyser, and moisture and lipid concentrations were measured using the CEM moisture/solids analyser and the CEM fat extractor, respectively (Maher *et al.,* 2004). Ash was determined by placing a sample in a porcelain dish, charring on a hot plate, heating in a furnace for 16 h and cooling in a desiccator (Association of Official Analytical Chemists, 1990). Drip loss was measured as the weight loss of a 100 g freshly cut muscle sample hung for 96 h in a chill at 2 °C. Muscle colour was measured using the Hunterlab Ultrascan XE spectrophotometer (Hunterlab Associates Laboratory Inc., Reston, VA, USA). The colour coordinates *L* (lightness), *a* (redness) and *b* (yellowness) were measured through oxygen-permeable film at three locations on each steak and averaged. The measurements were made in the Hunterlab colour space using the D65 illuminant. Chroma and hue were calculated from *a* and *b* colour values (Dunne *et al*., 2004b).

The data were analysed as a 3 (breed types) × 2 (feeding levels) × 2 (finishing periods) factorial using the general least squares linear model procedures of the Statistical Analysis Systems Institute (SAS, 1989/92). The model had terms for year, block, breed type, feeding level, finishing period and relevant interactions. Differences between breeds were evaluated using the PDIFF statement in SAS (1989/92).

Results

Carcass weight was similar for HF and PM but was significantly heavier for RO (Table 1). Carcass fat class was significantly lower

Table 1. Slaughter traits, muscle chemical composition and muscle colour values of Holstein-Friesian (HF), Piedmontese × Holstein-Friesian (PM) and Romagnola × Holstein-Friesian (RO) steers finished on low (L) or high (H) feeding levels and slaughtered after short (S) or extended (E) finishing periods

	Breed (B)			Feed level (F)		Finishing period (P)		s.e.d.[1]	Significance			
	HF	PM	RO	L	H	S	E		B	F	P	I[2]
Slaughter traits												
Carcass weight (kg)	324[a]	326[a]	341[b]	321	339	311	350	5.44	**	***	***	
Fat class[3]	3.95[a]	3.40[b]	3.83[a]	3.74	3.72	3.42	4.04	0.108	***		***	
Perirenal + retroperitoneal fat (kg)	15.0[a]	12.8[b]	15.1[a]	14.6	14.0	11.7	16.9	0.53	***		***	
Muscle chemical composition (g/kg)												
Moisture	706[a]	718[b]	718[b]	716	713	722	706	3.38	***		***	
Protein	218[a]	223[b]	221[ab]	221	222	224	217	1.63	**		***	
Lipid	63[a]	44[b]	49[b]	49	54	40	63	4.55	***		***	
Ash	11	11	11	11	11	11	11	0.20				
Muscle drip loss (g/kg)	15.4[a]	23.1[b]	23.0[b]	19.8	21.2	24.5	16.5	1.85	***		***	
Hunterlab colour values (0 h)												
L	31.3	31.3	31.8	32.0	30.9	33.4	29.5	0.702		*	***	FxP*[4]
a	13.3[a]	14.7[b]	14.6[b]	14.1	14.4	14.8	13.6	0.492	**		***	
b	8.2	8.3	8.5	8.1	8.5	8.2	8.5	0.281				
Chroma	15.7[a]	16.9[b]	16.9[b]	16.3	16.7	17.0	16.1	0.486	*		*	
Hue	32.0[a]	29.2[b]	30.2[b]	30.2	30.7	28.7	32.2	0.789	**		***	BxP*[5]
Hunterlab colour values (2 h)												
L	30.8	30.5	31.2	31.3	30.3	33.6	28.0	0.711		P<0.08	***	FxP***[6]
a	16.0	16.8	17.3	17.2	16.2	17.0	16.4	0.591		*		
b	9.3	9.5	9.8	10.0	9.1	9.6	9.5	0.360		**		
Chroma	18.6	19.3	19.9	19.9	18.6	19.5	19.0	0.638		*		
Hue	30.4	29.5	29.7	30.2	29.6	29.5	30.2	0.838				

[1] For n = 40 (breed type).
[2] Interactions.
[3] EU Beef Carcass Classification Scheme: scale 1 (leanest) to 5 (fattest).
[4] Values for LS, LE, HS and HE were 33.2, 30.8, 33.5 and 28.2, respectively.
[5] Values for HFS, HFE, PMS, PME, ROS and ROE were 28.9, 35.0, 28.5, 29.9, 28.8 and 31.7, respectively.
[6] Values for LS, LE, HS, and HE were 33.1, 29.6, 34.1 and 26.5, respectively.
[ab] Within a row, values without a common superscript differ significantly.

for PM than for HF and RO, which did not differ. Perirenal plus retroperitoneal fat weight did not differ between HF and RO but was significantly lower for PM.

Muscle chemical composition and drip loss did not differ between PM and RO but HF had a lower muscle moisture concentration, lower drip loss, and a higher muscle lipid concentration than the two beef crosses. Muscle colour values, immediately on cutting and after 2 h blooming did not differ between the beef crosses but the *a* and chroma values were lower after cutting for HF. Changes in colour as a result of blooming were small, but the breed difference present at 0 h had disappeared at 2 h. Ash concentration was unaffected by any of the treatments. The high feeding level increased carcass weight by 18 kg ($P<0.001$) but there was no effect on carcass fat class, perirenal plus retroperitoneal fat weight, muscle chemical composition or drip loss. The only effect of feeding level on muscle colour traits at 0 h was a decrease in the *L* value as a result of the higher feeding level, but after 2 h blooming, the values for *L* ($P<0.08$), *a*, *b* and chroma were all significantly lower for the higher feeding level.

Extending the finishing period increased carcass weight by 39 kg ($P<0.001$). This was associated with significant increases in carcass fat class and perirenal plus retroperitoneal fat weight. Muscle moisture and protein concentrations, together with drip loss, were significantly lower, and muscle lipid concentration was significantly higher, for extended finishing. At 0 h, *L*, *a* and chroma colour values were significantly lower, and hue value was significantly higher, for extended finishing. After 2 h blooming, the *L* value was still significantly lower for extended finishing, but none of the other differences were significant though the trends were the same as at 0 h.

There were feeding level × finishing period interactions for *L* at both 0 h and 2 h. This was due in both instances to a greater decrease in the *L* value with extended finishing for the higher feeding level. There was a breed × finishing period interaction for hue at 0 h because of a greater increase in hue value for HF with extended finishing than for the beef crosses.

Discussion

The lower muscle moisture and protein concentrations, and higher lipid concentration of HF parallel the differences in pistola composition published previously (Keane and Allen, 2002). However, the absence of differences between PM and RO in muscle chemical composition is at variance with the differences between these breeds in pistola composition (Keane and Allen, 2002), which showed greater fatness for RO. Differences between Holstein-Friesians and late maturing beef breed crosses in muscle chemical composition have been demonstrated previously (Keane *et al*., 1991, 2001). With late maturing beef breeds, Homer *et al*. (1997) found no difference in muscle moisture concentration between Charolais-cross and Belgian-Blue-cross steers differing in subcutaneous fat proportion, but there was a difference in muscle lipid concentration. While drip loss reflected differences in muscle moisture concentration, being higher for PM and RO than for HF, the difference between HF and the beef breeds in drip loss was relatively greater than the difference in moisture concentration, suggesting the involvement of other factors. As the small differences between HF and the beef crosses in *a* and chroma colour values at 0 h disappeared with blooming, there would be no differences amongst the breeds in the colour of bloomed muscle on commercial display.

While the high feeding level did increase carcass weight, the effect (18 kg) was relatively small and had no effect on muscle chemical composition. However, the *L* colour value was lower both at 0 h and after blooming ($P<0.08$), and the *a*, *b* and chroma colour values were also lower after blooming. These lower values for the higher feeding level appear to be at variance with the findings of Keane and Allen (1998) who reported higher *L*, *a* and *b* values for conventionally reared compared with extensively reared steers, and intensively reared animals had a higher *b* value than those conventionally reared.

The lower muscle moisture concentration and the higher muscle lipid concentration with extended finishing agree with the findings of Keane and Allen (1998). The lower drip loss for extended finishing paralleled the lower moisture concentration, while the lower *L* colour value at both 0 h and 2 h would be expected from the greater age of the animals (Boccard *et al.,* 1979). Other than L value, muscle from the two finishing periods would be indistinguishable in colour following blooming.

It is concluded that HF had lower muscle moisture and protein concentrations and a higher muscle lipid concentration than PM and RO which were similar. After blooming there were no muscle colour differences between the breeds. Feeding level during finishing had no effect on muscle chemical composition but after blooming all colour values except hue were lower for the higher feeding level. Extending the finishing period increased carcass weight and all measures of fatness. It also reduced muscle moisture and protein concentrations, and drip loss, and increased muscle lipid concentration. The *L* colour value both before and after blooming was also lower after extended finishing.

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