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Meat quality characteristics of high dairy genetic-merit Holstein, standard dairy genetic-merit Friesian and Charolais x Holstein-Friesian steers

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Abstract

The increased use of Holstein genetic material in the Irish dairy herd has consequences for beef production. In all, 42 spring-born steers [14 Holsteins (HO), 14 Friesian (FR) and 14 Charolais × Holstein-Friesian (CH)] were reared to slaughter at between 26 and 37 mo of age. Carcass weight was higher and the lipid concentration of **m. longissimus thoracis et lumborum** ***was lower (P < 0.05) for CH than the dairy breeds. Overall acceptability tended to be lower (P = 0.055) while tenderness, texture and chewiness were lower (P < 0.05) for CH compared with the dairy breeds. The proportion of C16:1 in the total lipid tended to be lower (P = 0.055) for CH than the dairy breeds. Replacing male offspring of traditional "Irish" Friesian bulls with offspring from a genetically superior (from a dairy perspective) strain of Holstein bull had no commercially important impact on beef nutritional or eating quality.***

Keywords

Beef • genotype • meat quality • muscle composition

Introduction

Calves born to dairy cows represent approximately 59% of male cattle born annually in Ireland (AIM, 2017). Of these, approximately 52% are the progeny of Holstein-Friesian sires (AIM, 2017). The choice of a particular Holstein-Friesian sire or strain of Holstein-Friesian reflects the priorities of dairy farmers. The national dairy breeding objective in Ireland in the 1990s [i.e., Relative Breeding Index (RBI)] included milk component traits as well as volume (Roche *et al*., 2018), and the importation of North American and European Holstein-Friesian genetic material changed the genetic composition of the Irish dairy herd, from predominantly British Friesian to North American and European Holstein-Friesian (Buckley *et al*., 2000). The production, carcass and body composition implications of the use of these high dairy genetic-merit Holstein beef calves compared with standard dairy genetic-merit Friesian and Charolais × Holstein-Friesian steers reared on a grass-based production system have been reported (McGee *et al*., 2005, 2007, 2008). However, there is little published information on the meat composition and quality traits of dairy herd progeny varying in dairy genetic merit compared with beef × dairy progeny. It is acknowledged that dairy breeding objectives in Ireland have evolved rapidly. Thus, in 2001, the Economic Breeding Index (EBI) was introduced as a replacement for the RBI. In addition to the existing 100% "milk traits" in the RBI further "profitability traits", like calving interval, survival, etc., were included over time such that, now, milk traits only comprise about one-third of the relative emphasis in the index (Roche *et al*., 2018). Nevertheless, the comparative difference in meat quality traits between the "earlier" dairy strains which differed in RBI is still of interest today since if there are differences in the sensory quality or nutritional value of beef due to the use of more extreme dairy breeds, this could compromise the ability of beef producers to service existing markets, where consumers are accustomed to beef with particular attributes of appearance, taste and texture. Alternatively, the ability to develop new markets might be enhanced if beef with different characteristics could be produced using different genotypes.

The objectives of this study were, therefore, to compare the composition and eating quality of beef from high genetic-merit Holstein and standard genetic-merit Friesian steers reared on a grass-based production system. Charolais × Holstein-Friesian steers were included in the design to provide a perspective on the magnitude of any differences between the dairy strains and a late-maturing breed when crossed with dairy cows in Ireland and to allow comparison with previous research (More O'Farrell *et al*., 1989).

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Materials and methods

Animals and management

Three groups of animals, balanced across sire breed, were used in this study. These consisted of (i) steers (n = 18) from the heavy slaughter group described by McGee *et al*. (2005) (Group 1), contemporaries of those animals as described by McGee *et al*. (2008) reared to a light (ii) (Group 2, n = 12) or heavy (iii) (Group 3, n = 12) slaughter weight. In brief, a total of 42 spring-born male calves [14 Holsteins (HO), 14 Friesians (FR) and 14 Charolais × Holstein-Friesians (CH)] were assembled in March and reared from calf-hood to slaughter. The HO group was the male progeny of 16 sires from high genetic-merit (0.92 Holstein, predominantly selected based on milk yield) dairy heifers imported from France and the Netherlands as part of a programme to evaluate various dairy cattle strains at Teagasc, Moorepark, Fermoy, Co. Cork, Ireland. The "Irish" FR animals were sourced from farms with the assistance of the South-Eastern Cattle Breeding Society (Dovea AI). These calves were the progeny of 12 bulls with less than 0.13 Holstein genes and cows of similar genotype. The CH calves were purchased in small numbers at commercial livestock marts to be representative of the commercial population of CH calves generally.

After a mean rearing period of 8 wk (McGee *et al*., 2005), calves were turned out to pasture. They were subsequently castrated (at 9 mo of age), housed for a 156-d winter (October 25) and turned out to pasture for a second grazing season of 203 d. At the end of the second grazing season animals in Group 1 were housed and finished on grass silage plus a daily allowance of 6 kg of supplementary concentrates until slaughter at 26 mo of age. At the end of the second grazing season animals in Group 2 and Group 3 were housed for a second winter period of 108 d after which they were used in a separate endocrinology study until the end of August. They were then put to pasture until the beginning of November, after which they were housed and offered the finishing ration described above. Group 2 animals were slaughtered at 33 mo of age and Group 3 animals at 37 mo of age.

Carcass dissection

Animals were slaughtered in a commercial meat plant (Group 1) and at the Teagasc Food Research Centre, Ashtown, Co., Dublin (Group 2 and Group 3) at a mean live weight of approximately 650 kg (Group 1), 629 kg (Group 2) and 724 kg (Group 3). After a 24-h period (Group 1) and 72-h (Group 2 and Group 3) chilling period (4°C), the pistola hind quarter (i.e., the hind quarter to the fifth rib without the area on the abdominal side of *m. iliocostalis lumborum*) of the right side of each carcass was placed in a chill room (4°C). For Group 1, the hinds were transported to Ashtown in a refrigerated truck.

Meat quality

At 72 h post-mortem, the ultimate pH of *m. longissimus thoracis et lumborum* (LTL) at the 10th/11th rib interface was measured using an Orion pH meter (Model 420A, Orion Research Inc., Boston, MA, USA) with a glass electrode (Model EC-2010-06, Reflex Sensors Ltd., Westport, Co. Mayo, Ireland). Steaks, each 2.5 cm thick, were cut from the right LTL starting between the 10th and 11th ribs and cutting towards the anterior. The samples used for shear force measurement and taste panel assessment, both as described by French *et al*. (2000), were vacuum packaged immediately, aged for 10 d at 4°C and then frozen. Those used for fatty acid (O'Sullivan *et al*., 2002) and proximate analysis (French *et al*., 2000) were frozen.

Statistical analyses

Data were subjected to analysis of variance using a model which had terms for group and genotype. Shear force and sensory data were also analysed using intramuscular fat concentration as a covariate. The relationship between shear force and tenderness was examined using linear regression.

Results

Mean carcass weight, carcass conformation and fat scores, LTL pH and chemical composition are shown in Table 1. Carcasses from CH were heavier ($P < 0.05$) than those from HO and FR, which did not differ. Carcass conformation score was higher ($P < 0.05$) for CH than HO with FR intermediate. Carcass fat score was higher ($P < 0.05$) for FR than HO with CH intermediate. There was no effect ($P > 0.05$) of genotype on LTL pH or concentrations of moisture, protein and ash. The LTL from CH had a lower ($P < 0.05$) concentration of lipid than LTL from the dairy breeds, which did not differ. The proportion of C12:0 in the total lipid was lower ($P < 0.05$) for CH than for HO which, in turn, was lower ($P < 0.05$) than for FR. The proportion of C16:0 in the total lipid was lower ($P < 0.05$) for HO than for FR but similar to CH, which did not differ from FR. There was no statistically significant effect of genotype on the proportions of the other individual fatty acids measured or on the ratios of total fatty acids.

The sensory and shear force data for the LTL muscle are summarised in Table 2. There was no statistically significant difference between HO and FR for any of the sensory attributes measured or for shear force. While shear force did not differ between CH and the dairy breeds, trained panellists rated LTL from CH lower ($P < 0.05$) for tenderness, texture, chewiness and overall acceptability ($P = 0.06$) compared with both the dairy breeds. When adjusted for differences in intramuscular fat concentration, the differences in tenderness and texture remained, but LTL from each genotype was rated similarly for

Table 1. Characteristics of the carcass and *m. longissimus thoracis et lumborum* muscle of Holstein (HO), Friesian (FR) and Charolais × Holstein-Friesian (CH) steers

	Genotype			SED[1]	Significance
	HO	FR	CH		
Carcass weight (kg)	354.5[a]	340.6[a]	381.9[b]	9.77	***
Conformation score[2]	1.2[a]	2.1[b]	3.0[c]	0.19	***
Fat score[3]	3.8[a]	4.3[b]	4.0[a,b]	0.19	*
pH	5.63	5.67	5.59	0.039	
Chemical composition (g/kg)					
Moisture	701	693	707	6.4	
Protein	217	220	226	4.5	
Lipid	78[a]	77[a]	58[b]	7.6	*
Ash	10	10	10	0.2	
Fatty acid composition (g/kg fatty acids)					
C12:0	0.6[a]	0.7[b]	0.5[c]	0.05	*
C14:0	31.9	33.8	29.3	2.02	
C16:0	294.9[a]	311.0[b]	305.7[a,b]	7.48	0.055
C16:1	47.0	45.0	37.3	4.04	
C18:0	171.0	173.5	180.2	15.39	
C18:1	414.0	398.0	404.0	12.90	
C18:2	31.9	30.4	35.0	3.38	
C18.3	8.0	7.5	7.7	0.54	
SFA[4]	498.4	519.1	515.8	13.52	
MUFA[5]	461.7	443.0	441.5	14.55	
PUFA[6]	39.9	37.9	42.8	3.73	
PUFA:SFA	0.08	0.07	0.08	0.007	
C18:2:C18:3	4.03	4.03	4.61	0.344	

[1]Standard error of the difference.
[2]EU Beef Carcass Classification Scheme – Scale 1 (poorest) to 5 (best).
[3]EU Beef Carcass Classification Scheme – Scale 1 (leanest) to 5 (fattest).
[4]Total saturated fatty acids.
[5]Total mono-unsaturated fatty acids.
[6]Total poly-unsaturated fatty acids.

chewiness and overall acceptability. Shear force was negatively correlated with sensory tenderness (r = -0.44, P < 0.001).

Discussion

Among the criteria that determine market acceptability of beef are carcass weight/classification, gender and age of the animal at slaughter, and ultimately the sensory experience of the consumer. There has also been an increasing interest in the nutritional value of meat and in particular on its fatty acid composition, which reflects advice from health advisory agencies (e.g., World Health Organisation, 2003). Since decisions made by dairy farmers influence the type of dairy origin animals available to beef farmers, it is important to examine how changes in the type of animal might impact on their market suitability. McGee *et al*. (2005, 2007, 2008) reported the production and carcass characteristics of high genetic-merit Holstein-sired male cattle compared with standard "Irish" Friesian or Charolais-sired male cattle. This paper reports some aspects of meat quality from a sub-set of those animals.

The differences in carcass weight and carcass conformation and fat scores of the three genotypes are given for reference here and have been discussed in detail by McGee *et al*. (2005, 2008). The lower intramuscular fat concentration of the CH compared with the dairy breeds in this study is in accord with other studies comparing beef crosses with pure Friesian or Holstein-Friesian cattle (Keane and More O'Ferrall, 1992, Keane, 1994, Dunne *et al*., 2004). The similarity between the two dairy genotypes in both lipid and moisture content concurs with Dunne *et al*. (2004) who found no difference

Table 2. Sensory characteristics and shear force of the *m. longissimus thoracis et lumborum* muscle from Holstein (HO), Friesian (FR) and Charolais × Holstein-Friesian (CH) steers

	Genotype			SED[1]	Significance
	HO	FR	CH		
Shear force (kg)	5.50	6.09	6.06	0.313	
Sensory assessment					
Tenderness[2]	5.52[a]	5.49[a]	4.39[b]	0.315	***
Texture[3]	3.87[a]	3.84[a]	3.40[b]	0.125	***
Juiciness/moistness[2]	5.50[a]	4.88[a,b]	4.58[b]	0.305	*
Flavour[3]	4.02	3.82	3.58	0.193	
Chewiness[3]	3.84[a]	3.93[a]	3.47[b]	0.168	*
Overall acceptability[3]	3.78[a]	3.69[a]	3.38[b]	0.169	0.055
Sensory assessment[4]					
Tenderness[2]	5.56[a]	5.41[a]	4.44[b]	0.343	*
Texture[3]	3.88[a]	3.82[a]	3.39[b]	0.136	*
Juiciness/moistness[2]	5.49[a]	4.92[a,b]	4.59[b]	0.332	0.057
Flavour[3]	3.99	3.79	3.63	0.209	
Chewiness[3]	3.87	3.94	3.43	0.181	
Overall acceptability[3]	3.78	3.65	3.38	0.183	

[1]Standard error of the difference.
[2]Scale 1–8.
[3]Scale 1–6; a lower score denotes a more negative rating.
[4]Adjusted for differences in intramuscular fat concentration.

in moisture or intramuscular lipid content of the *longissimus dorsi* between the male progeny of two strains of high genetic-merit Friesian cows ("Irish" and "New Zealand").

Consistent with the present findings, Dunne *et al*. (2004) found no difference between the pH of the *longissimus dorsi* of the steer progeny of two strains of high genetic-merit Friesian cows slaughtered at either a light or heavy weight. Moreover, Sinclair *et al*. (2001) found no difference in the pH of the *m. longissimus lumborum* between purebred Holstein and Charolais steers and Lynch *et al*. (2002) found no significant difference in the pH of the *longissimus dorsi* between Friesian and Charolais heifers. In this study, all groups had similar pre-slaughter handling and were finished indoors, making them unlikely to suffer from pre-slaughter stress-related loss of glycogen. Consequently, all values were within the "normal" pH range (i.e., 5.4–5.8) (Viljoen *et al*., 2002) and there was no evidence of "dark cutting".

The fatty acid profile of LTL lipid of the dairy breeds in this study was broadly similar to that reported by Moreno *et al*. (2008) for the male progeny of the two strains of high genetic-merit Friesian cows described by Dunne *et al*. (2004) above. Moreno *et al*. (2008), however, found no difference in the proportion of C16:0 in LTL lipid in contrast with this study. The rather similar fatty acid profile of LTL across genotypes was not unexpected as the review of De Smet *et al*. (2004) concluded that breed differences in fatty acid composition while often statistically significant, are small, and in particular when compared with the potential effects of the composition of the ration consumed before slaughter. The change in the proportion of C16:0 observed in this study is of little consequence from a human nutrition perspective. Nuernberg *et al*. (2005) reported a lower proportion of C14:0 and C16:1 and a higher proportion of C18:2 poly-unsaturated fatty acid (PUFA) in intramuscular lipids from Simmental compared with Holstein bulls which are consistent with the numerical differences in this study. Mills *et al*. (1992) reported that Holstein steers had higher C16:0 and C18:2 and lower C18:0 concentration in the *longissimus* muscle than Angus × Charolais × Simmental steers.

Tenderness is considered to be a major factor in the assessment of meat quality by consumers (Miller *et al*., 2001). In agreement with the present results, previous studies have found no difference in shear force between Friesian and Charolais-sired steers (More O'Farrell *et al*., 1989), purebred Holstein and Charolais steers (Sinclair *et al*., 2001, Christensen *et al*., 2011), and between Holstein and Gascon (a late-maturing breed) bulls (Bures and Barton, 2018). In contrast, Lively *et al*. (2005) reported a lower shear force for purebred Holstein than Charolais (>0.75 ancestry) steers and Nuernberg *et al*. (2005) reported a lower shear force for Holstein than Simmental bulls. In this study, although not statistically significant, it is noteworthy that HO had a numerically lower (10%) shear force than CH.

The moderate negative associations between the two measures of tenderness observed in this study are similar to many other studies (Caine *et al*., 2003; Keady *et al*., 2017), suggesting that shear force may not always be a reliable indicatory of consumer perception of tenderness. Maher *et al*. (2004) found no difference in sensory tenderness or overall acceptability between the steer progeny of two strains of high genetic-merit Friesian cows in agreement with this study. We are not aware of other studies that compared the eating quality of muscle from different strains of Holstein/Friesian steers. With regard to the comparison of dairy- and beef-sired steers, previous studies have reported no differences between Holstein and Charolais steers (Sinclair *et al*., 2001), Holstein and Simmental bulls (Nuernberg *et al*., 2005), Holstein and Limousin or Blonde d'Aquitaine bulls (Monson *et al*., 2005), in tenderness or overall acceptability. The contrast between these reports and with the tenderness data, in particular, of this study may reflect the relatively higher intramuscular fat concentration and the age of the animals. When adjusted for differences in intramuscular fat concentration, the genotype difference in tenderness remained but overall acceptability was similar, consistent with the literature cited above. This result suggests that other factors such as collagen concentration and crosslinking may have made a greater concentration to tenderness than intramuscular fat in these animals.

In conclusion, under the conditions of this study, replacing male offspring of traditional Friesian sires with offspring from a genetically superior (from a dairy perspective) strain of Holstein sire in a beef production system had no commercially important impact on beef nutritional or eating quality. While the trained sensory panel rated CH-sired beef lower than that of the dairy-sired beef, whether the difference would be detected by untrained consumers given the lack of difference in shear force needs to be confirmed.

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