Variation in the eating quality of beef as a result of post slaughter handling.

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Background
Variation in the eating quality of beef is one of the primary concerns of the meat industry worldwide. Evaluation of the success of measures to improve the consistency of beef quality requires knowledge of the existing variation. There is little information on the actual level of variation in the eating quality of fresh Irish beef. Thus, data generated in this project would provide a target on which to focus efforts to improve consistency of beef for the domestic and export markets.

Objective
The objective was to ascertain the variability in the eating quality of beef. The study aimed to quantify the level of variability that exists in the quality of M. *longissimus dorsi* (LD) and M. *semimembranosus* (Sm).

Methods
Steers (n=89) and heifers (n=77) were sampled from two meat plants in Ireland. Animals were slaughtered and conventionally hung for 24 or 48 hours post-mortem; at which time the LD and Sm muscles were excised. Muscles were individually vacuum-packed and stored at 4°C until sampling commenced. All carcasses were classified according to the official EU scheme (EC 1208/1981), and the R4H, R4L, O4H and O4L classifications were chosen based on the percentage distribution of beef slaughtered in the previous year (1999 Central Statistics Office, Ireland). At 14 days post mortem freshly cut samples (2.5cm thick) were taken for analysis. Warner bratzler shear force (WBSF) was measured using the Instron model 5543 (Shackelford *et al.*, 1991). Sensory analysis was carried out on each sample by eight trained in-house panellists (AMSA, 1995). Colour was analysed by a HunterLab (Ultrascan XE) system (Hunt *et al.*, 1993). Moisture and fat content were determined using a CEM analysis system (Bostian *et al.*, 1985), and intramuscular protein percentage by the LECO total nitrogen determinator (Sweeney and Rexroad's, 1987). Data were analysed using the Bartlett's test (SAS, 1985).

Results and Discussion
The extent of variation for classifications and/or sexes in WBSF of the LD ($p<0.001$) was greater than the Sm ($p<0.05$). This is possibly due to structural or compositional differences in the muscle. Heifer WBSF was more variable than that of steers for all classification scores within both muscles. Heifers R4L were the most variable (531.9) for the LD muscles compared to all other classifications and/or sexes. (See table 1 and 2). Tenderness measured by WBSF was more variable for the LD (CV=35.8) and Sm (CV=18.7) when compared with sensory tenderness (CV=18.5 and 16.6 respectively). Contrary to WBSF values, variability in sensory tenderness rating was not significantly different between classifications and/or sexes for both LD and Sm steaks. In general heifer sensory tenderness was more variable than steers, which is in agreement with WBSF results. Variation within the Sm was not as obvious as that found in the LD for both WBSF and sensory tenderness. George *et al.* (1999) also reported the LD to be a variable muscle regarding tenderness. It is possible that this reduction in variation was due to the physical location of the topside muscle deep within the carcass or the layer of muscle covering the topside (Gracilis muscle).
The colour of beef steaks is thought to be a good indicator of the quality and palatability of beef perceived by the consumer (Wulf and Wise, 1999). Lightness (L) of the LD and Sm was significantly variable between classifications and/or sexes ($p<0.01$), with the Sm showing more colour variation than the LD. In this trial the Sm was found to have a two-tone colour (with muscle surface being both pale and dark); this could be a result of the dept of the Sm within the carcass, and perhaps the cause of this wide colour variation. Heifer O4L was the most variable (LD=44.6, Sm=55.7) and heifer R4L the least variable (LD=6.6, Sm=8.8), which shows a wide variation within sex. Hunter 'a' values varied significantly between classifications and/or sexes for the LD ($p<0.001$) and the Sm ($p<0.01$). Heifer O4H (LD=42.5, Sm=58.8) and heifer O4L (LD=44.6, Sm=55.7) had the greatest variances. Only a small variance was seen with redness of heifer R4L for both LD (1.5) and Sm (7.0). Yellowness was also significantly variable between classifications and/or sexes for both muscles ($p<0.001$), with variances similar to those seen for redness. Within the 'O' grade heifers were more variable, yet the 'R' grade steers showed more variation for HunterLab. (See table 1 and 2).
Moisture and protein of the LD did not vary significantly between the classifications and/or sexes. The Sm was significantly variable ($P<0.001$) for both attributes, and it would appear this was due to the variances of heifers O4H (moisture=3.8 and protein=1.6) and O4L (moisture=3.0 and protein=1.0). Moisture content was the least variable compared to all the other attributes for LD (CV=1.5) and Sm (CV=8.1). Marbling was significantly variable between classifications and/or sexes for both the LD ($p<0.01$) and Sm ($p<0.05$), however the LD marbling percentages varied more than the Sm. It would appear this was mainly due to the heifers O4H (2.7 and 1.3 respectively) and O4L (2.6 and 1.3 respectively). Marbling displayed the greatest variation for the LD (CV=55.5) and Sm (CV=99.4) compared to all other attributes. (See table 1 and 2). This variation in marbling could contribute to the variation in WBSF (Wheeler *et al.*, 1994) and colour 'L' values, as high marbling is thought to improve tenderness and cause darker meat (Fiems *et al.* 2000). It is clear that variation exists in tenderness and colour, which are two of the most important palatability characteristics of beef. This problem, coupled with the variation found in compositional attributes, could cause a major defect in current beef production.

Conclusion

The LD was found to be the more variable muscle for tenderness, colour and IMF content. There was no constant classification and/or sex effect when attributes were looked at all together as 'meat quality', however in general the 'O' grades where more variable than the 'R' grades and heifers more variable than steers. The variation quantified in this study has provided baseline information. Further work will investigate the influences of optimum practices at various stages along the beef production and processing chain in achieving the minimum possible variation.

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Table 1. Variance (mean) and coefficient of variance (CV%) of quality attributes of the M. *longissimus dorsi* (LD) and M. *semimembranosus* (Sm) for the carcass classifications O4H, O4L, R4H, R4L for steers (S) and heifers (H) at 14 days post mortem.

	Class.	Sex(n)	WB[1]	Td[2]	L[3]	a[4]	b[5]	MC[6] %	P[7] %	F[8] %
LD	*O4H*	*S (20)*	68.5(41.7)	0.6(5.8)	14.1(28.0)	20.0(25.6)	1.5(12.8)	1.3(73.6)	0.5(22.2)	1.2(2.8)
		H (23)	403.9(56.9)	1.0(4.8)	39.4(28.5)	42.5(23.2)	5.2(10.8)	1.6(73.6)	0.4(22.5)	2.7(2.6)
	O4L	*S (23)*	232.3(46.4)	0.6(5.7)	25.3(28.1)	29.4(25.2)	3.6(12.3)	1.1(74.1)	0.2(22.5)	1.7(2.1)
		H (21)	335.9(48.9)	1.4(5.0)	44.6(30.1)	38.2(22.1)	5.2(10.8)	2.0(74.3)	0.4(22.7)	2.6(2.0)
	R4H	*S (25)*	177.9(42.6)	1.0(5.7)	29.1(31.9)	30.1(21.1)	4.8(10.7)	1.1(73.7)	0.2(22.5)	1.5(2.8)
		H (19)	410.0(51.8)	0.9(5.1)	16.9(24.7)	19.3(26.7)	2.5(12.3)	0.5(74.2)	0.5(22.7)	0.6(1.9)
	R4L	*S (21)*	173.5(45.5)	0.5(5.3)	27.3(30.8)	33.4(21.5)	5.3(10.8)	0.8(74.5)	0.4(22.8)	0.6(1.7)
		H (14)	531.9(52.8)	1.2(5.3)	6.6[9](28.7)	1.5[9](24.0)	0.6[9](13.3)	1.1(73.7)	0.5(22.8)	0.8(2.4)
		CV(%)	35.8	18.5	18.7	23.3	18.2	1.5	2.8	55.5
		Sig (p)	***	ns	**	***	***	ns	ns	**
Sm	*O4H*	*S (20)*	30.8(48.6)	0.6(4.9)	21.5(26.0)	16.6(26.7)	1.2(12.5)	0.5(75.0)	0.3(22.0)	0.8(1.4)
		H (23)	118.4(58.8)	0.9(4.9)	52.2(28.0)	58.8(24.6)	4.5(11.0)	3.8(75.2)	1.6(22.0)	1.3(1.3)
	O4L	*S (23)*	73.0(52.2)	1.0(5.3)	18.8(27.2)	24.7(25.6)	4.5(12.2)	0.4(75.1)	0.2(22.1)	0.6(1.1)
		H (21)	95.5(57.0)	0.7(4.9)	55.7(29.0)	52.3(23.1)	5.0(10.8)	3.0(74.4)	1.0(22.0)	1.3[10](1.4)
	R4H	*S (23)*	77.5(53.5)	0.8(5.0)	29.3(30.1)	32.6(22.7)	5.0(11.3)	0.9(75.1)	0.4(22.2)	0.3(1.0)
		H (19)	164.3(58.1)	0.4(4.9)	23.2(25.7)	26.0(25.8)	1.1(12.0)	0.8(74.9)	0.3(22.4)	0.7(1.1)
	R4L	*S (19)*	82.6(51.8)	0.3(4.8)	25.3(28.2)	36.8(24.0)	2.9(11.4)	1.5(74.9)	0.7(22.4)	0.9(1.0)
		H (14)	107.9(49.9)	0.6(4.8)	8.8(30.0)	7.0(23.4)	0.4(13.1)	0.3(74.9)	0.8(22.3)	0.4(1.0)
		CV(%)	18.7	16.6	20.1	23.7	16.4	8.1	8.7	99.4
		Sig (p)	*	ns	**	**	***	***	***	*

[1]Warner Bratzler shear force. [2]Sensory tenderness: 1 (extremely tough), 8 (extremely tender). [3]Hunter Lightness: 0 (Black), 100 (White), [4]Hunter redness: Negative values (green), positive values (red), [5] Hunter yellowness: Negative values (blue), positive values (yellow). [6]Moisture content. [7]Protein. [8]Intramuscular fat. [9](n=18). [10](n=20).
P-value to test significance of variance (*=0.05, **=0.01, ***=0.001, ns=non-significant).