COLOUR AND SHEAR VALUE OF BEEF *SEMITENDINOSUS* MUSCLE COOKED BY CONVECTION AND MICROWAVE OVENS*

Anna Badiani, Sandra Stipa, Franco Bitossi, Manfredo Manfredini
Dipartimento di Sanità Pubblica Veterinaria e Patologia Animale – Via Tolara di Sopra 50 – 40064 Ozzano Emilia (BO) – Italy
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Background and Objectives – Microwave meat cooking has not always been acceptable to consumers. The lack, or paucity, of surface browning and crispness, as well as less favourable flavour notes, were taken as indexes of lower eating quality of meat cooked in microwave ovens compared with oven-roasted meat (**1, 2, 3, 6, 11**). However, shear value in beef has often been found to be the same for microwave cooking when compared to cooking to the same final internal temperature by other methods (**2, 3, 4, 6, 8, 10**). More conflicting results have been obtained for colour difference values measured on the interior surfaces (**10, 11**). Several studies (**5, 8, 12, 13**) have identified some end-to-end and cross-sectional variation in the physical structure of beef *Semitendinosus* (ST) muscle. As part of a wider study aimed at assessing cooking-induced changes in physico-chemical and nutritional properties of beef, an experiment was conducted to determine: 1) the effect of cooking method (microwaving *vs* oven roasting) on instrumental colour and Warner-Bratzler shear values in ST; 2) the effect of location within ST on colour readings and shear values.

Methods – Paired ST were obtained from ten beef carcasses as illustrated by Manfredini *et al.* (**9**). A roast about 1 kg weight was obtained as the centre section from each ST. Paired ST roasts from the left and right sides of each carcass were assigned in turn to a convection oven or a microwave oven and cooked as described by Manfredini *et al.* (**9**). Colour measurements were made with a Minolta Chromameter Reflectance II CR200/08 (diffuse illumination/0° viewing angle – specular component included), matched with the standard white tile provided by the manufacturer. L*, a* and b* values were recorded for Standard Source D65; Chroma and hue-angle (Hue) were calculated (**7**). Both the freshly cut proximal (PE) and distal (DE) ends of each raw roast were measured at 5 distinct locations: 1) caudal and lateral; 2) caudal and medial; 3) cranial and medial; 4) cranial and lateral; 5) central. Cooked roasts were cooled to room temperature and trimmed of surface browning. Three 2.54 cm-thick slices were cut perpendicular to the muscle fibre direction (proximal, PS; central, CS; distal, DS, slices) and were allowed to "bloom" for 5 min. Colour readings were made on the proximal surface of each slice at 5 locations, as described previously. A 2.54 cm diameter core was removed from each slice at 3 distinct locations: A) caudal and medial; B) cranial and medial; C) central and lateral. The cores were taken parallel to the fibre orientation and sheared once perpendicular to the grain using a Warner-Bratzler (WB) shear attachment on an Instron Universal Testing machine Model 1011. A cross-head speed of 50 mm/min and a 20 kg load range were used. Data were analysed using a two-way "between group (BG)-within subjects (WS)" analysis of variance. The design was as follows: 2 cooking methods to be applied (BG) x 5 locations (WS) x 2 ends (WS) for raw colour; 2 cooking methods (BG) x 5 locations (WS) x 3 slices (WS) for cooked colour; 2 cooking methods (BG) x 3 locations (WS) x 3 slices (WS) for WB shear value. Duncan's multiple range test was used to separate means at the 5% probability level.

Results and Discussion – Cooking method (applied or to be applied) was not a significant source of variation ($P>0.05$) for both shear values and chromatic coordinates and therefore data were pooled over this factor. For shear values (Table 1), as to the position of the slices in the roast, a statistically significant difference among slices emerged at location C, the central slice (CS) being more tender. As to the location within slices, only for the central slice a significant difference was observed, the more tender location being C. Shear values were affected by a certain amount of variability, which in any case was lower for the central slice and the B location. On the whole, colour of raw meat was more intense (higher a* and Chroma, lower Hue) at the distal end than at the proximal one (Table 2). Location 3 showed the highest redness (a*) and yellowness (b*), and therefore the highest Chroma, coupled with a low lightness value (L*). This could be ascribed to the higher proportion and larger cross-sectional area of type I fibres in this region of the muscle (**5, 13**). Moreover only at location 3 all the differences between proximal and distal end were statistically significant. Cooking induced a considerable increase in L*, b* and Hue values, whereas a* and Chroma decreased (Table 3). No significant variations occurred in b* values of cooked ST, neither between, nor within slices. Whenever between-slices variation was statistically significant, the distal slice was darker and redder. Location 1 (and 2, to a lesser extent) had higher L* and Hue values, lower a* and Chroma values than location 3 (and 5, to a lesser extent). Therefore, locations 1 and 2 were clearly more done than locations 3 and 5.

Conclusions – Microwave and oven roasting did not produce statistically significant differences in shear values and interior colour readings of beef *Semitendinosus* muscle. Caudal locations appeared to be more thoroughly cooked and slightly tougher than cranial and central ones.

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Table 1 - Warner-Bratzler shear values (kg) of cooked *Semitendinosus* muscle (see text for explanation)[a]

WB shear[b]	Location		
	A	B	C
PS	9.78 ± 0.47	10.71 ± 0.41	*x* 10.40 ± 0.40
CS	10.72 ± 0.37 a	10.30 ± 0.23 a	*y* 9.06 ± 0.27 b
DS	10.50 ± 0.38	9.86 ± 0.33	*xy* 9.66 ± 0.37

[a]Values are mean ± standard error of the mean. PS = proximal slice; CS = central slice; DS = distal slice.

[b]Means within a column and trait preceded by different letters differ significantly ($P \leq 0.05$). Means on the same row followed by different letters differ significantly ($P \leq 0.05$).

Table 2 - Chromatic coordinates (CC) of raw *Semitendinosus* muscle (see text for explanation)[a]

CC	End[b]	Location				
		1	2	3	4	5
L*	PE	47.97 ± 0.48 a	47.00 ± 0.34 b	*x*46.45 ± 0.61 b	*x*47.85 ± 0.56 a	46.26 ± 0.35 b
	DE	46.92 ± 0.56 a	45.81 ± 0.42 ab	*y*45.31 ± 0.61 b	*y*46.57 ± 0.56 a	45.27 ± 0.54 b
a*	PE	*y*16.72 ± 0.49 d	*y*18.55 ± 0.47 c	*y*21.00 ± 0.40 a	*y*18.78 ± 0.40 c	*y*20.15 ± 0.39 b
	DE	*x*18.75 ± 0.35 d	*x*20.34 ± 0.40 c	*x*22.65 ± 0.48 a	*x*21.15 ± 0.43 c	*x*21.48 ± 0.31 b
b*	PE	*x* 6.15 ± 0.24 b	6.17 ± 0.22 b	*x* 7.90 ± 0.26 a	7.35 ± 0.27 a	7.57 ± 0.21 a
	DE	*y* 5.32 ± 0.21 c	5.79 ± 0.24 b	*y* 7.01 ± 0.26 a	6.97 ± 0.29 a	7.06 ± 0.25 a
Chroma	PE	*y*17.87 ± 0.44 e	*y*19.56 ± 0.50 d	*y*22.47 ± 0.38 a	*y*20.22 ± 0.35 c	*y*21.54 ± 0.40 b
	DE	*x*19.52 ± 0.32 d	*x*21.16 ± 0.43 c	*x*23.73 ± 0.51 a	*x*22.29 ± 0.46 b	*x* 22.64± 0.33 b
Hue	PE	*x*20.49 ± 1.02 a	*x*18.39 ± 0.41 b	*x*20.68 ± 0.73 a	*x*21.50 ± 0.94 a	*x*20.62 ± 0.51 a
	DE	*y*15.95 ± 0.74 c	*y*15.85 ± 0.49 bc	*y*17.18 ± 0.51 ab	*y*18.21 ± 0.62 a	*y*18.19 ± 0.56 a

[a]Values are mean ± standard error of the mean. PE = proximal end; DE = distal end.
[b]Means within a column and trait preceded by different letters differ significantly ($P \leq 0.05$). Means on the same row followed by different letters differ significantly ($P \leq 0.05$).

Table 3 - Chromatic coordinates (CC) of cooked *Semitendinosus* muscle (see text for explanation)[a]

CC	Slice[b]	Location				
		1	2	3	4	5
L*	PS	62.86 ± 0.36 a	62.19 ± 0.65 a	*x*59.08 ± 0.63 b	*x*62.46 ± 0.56 a	*x*61.68 ± 0.51 a
	CS	63.25 ± 0.55 a	62.25 ± 0.76 ab	*x*57.90 ± 0.62 d	*x*60.75 ± 0.87 bc	*y*59.60 ± 0.35 cd
	DS	61.92 ± 0.74 a	61.34 ± 0.81 a	*y*56.26 ± 0.71 c	*y*58.30 ± 0.76 b	*y*59.78 ± 0.71 b
a*	PS	7.43 ± 0.25 c	7.87 ± 0.27 c	8.90 ± 0.17 a	*y* 7.99 ± 0.15 bc	8.68 ± 0.19 ab
	CS	7.47 ± 0.24 d	7.72 ± 0.30 cd	9.22 ± 0.18 a	*y* 8.33 ± 0.24 bc	8.88 ± 0.19 ab
	DS	8.03 ± 0.42 b	8.06 ± 0.24 b	9.51 ± 0.18 a	*x* 9.43 ± 0.39 a	9.22 ± 0.42 a
b*	PS	11.59 ± 0.24	11.31 ± 0.23	11.84 ± 0.13	11.77 ± 0.17	11.62 ± 0.18
	CS	12.09 ± 0.27	11.88 ± 0.22	12.18 ± 0.18	11.92 ± 0.20	11.67 ± 0.14
	DS	12.17 ± 0.23	12.27 ± 0.26	12.31 ± 0.23	11.70 ± 0.18	11.98 ± 0.18
Chroma	PS	13.82 ± 0.21 b	13.81 ± 0.29 b	14.82 ± 0.18 a	14.24 ± 0.19 ab	14.52 ± 0.21 ab
	CS	14.27 ± 0.22 b	14.23 ± 0.20 b	15.29 ± 0.18 a	14.58 ± 0.20 ab	14.68 ± 0.16 ab
	DS	14.66 ± 0.33	14.73 ± 0.24	15.56 ± 0.26	15.07 ± 0.34	15.19 ± 0.31
Hue	PS	57.30 ± 1.17 a	55.25 ± 0.86 ab	53.10 ± 0.43 b	*x*55.86 ± 0.49 a	53.25 ± 0.64 b
	CS	58.17 ± 1.14 a	57.03 ± 1.22 ab	52.88 ± 0.66 c	*x*55.07 ± 0.93 bc	52.76 ± 0.67 c
	DS	56.82 ± 1.27 a	56.65 ± 1.01 a	52.28 ± 0.46 b	*y*51.42 ± 0.95 b	52.73 ± 1.23 b

[a]Values are mean ± standard error of the mean. PS = proximal slice; CS = central slice; DS = distal slice.
[b]Means within a column and trait preceded by different letters differ significantly ($P \leq 0.05$). Means on the same row followed by different letters differ significantly ($P \leq 0.05$).