PE4.77 Effect of microwave heating on beef roast quality from Friesian heifers and cows 273.00

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***Abstract*—*Semimembranosus* (SM) and *Semitendinosus* (ST) muscles from 8 yearling heifers and 8 mature cows were used to evaluate the effect of power of heating and final meat temperature using a domestic microwave (MW) oven on beef quality. Four treatments using combinations of power (250 vs. 900W) and temperature (60 vs. 80°C) were applied in a 2x2 factorial design. There was no power effect on colour and tenderness of ST from heifers or cows. Cooking to an internal temperature of 80°C resulted in lower redness and yellowness of ST compared with 60°C. Heating SM muscle to 80°C showed higher shear force and lightness at 250W for cows compared with 60°C. Microwave cooking of SM muscle at 900W resulted in lower redness compared with 250W in SM from cows. High and low MW power can be used satisfactorily for cooking ST and SM muscles from heifers and cows. Colour differences in SM and ST muscles due to animal age are still significant after MW cooking. Heterogeneous MW cooking results in a cooked meat color gradient which is difficult to measure with accuracy.**

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***Index Terms*— beef, colour, tenderness, microwave.**

I. INTRODUCTION

MICROWAVE cooking became popular because of its rapid speed of food preparation and amount of energy saved in homes, food processing, and food service operations. Meat undergoes changes in its physical properties (i.e. colour, texture) and it is subjected to chemical reactions (i.e. protein denaturation, Maillard reaction) during cooking which influence its final quality and acceptability [*1*]. Meat temperature on the surface is important for its odour, flavour and colour. The temperature gradient influences the rate and extent of the changes of protein structures in meat, whereas the method of heat transfer influences its odour, flavour and colour [*2*]. Korschgen et al. [*3*] indicated that either high- or low- powered MW equipment can be used satisfactorily for cooking longissimus muscle from beef. The aim of this work was to evaluate the effect of power of heating and final internal temperature using microwave cooking on quality of *Semimembranosus* and *Semitendinosus* muscles from Friesian yearling heifers and mature cows.

II. MATERIALS AND METHODS

A. Materials

Beef samples were obtained from *Semimembranosus* (SM) and *Semitendinosus* (ST) muscles from 8 Friesian yearling heifers and 8 Friesian mature cows. The ST and SM muscles were cut into 4 samples each of 10x4x3cm and 15x5x3cm, respectively. Meat samples were vacuum packaged, frozen and stored at -20ºC until analysis. Before cooking, samples were thawed submerged in H_2O in a container with crushed ice overnight in a cooler (2±2°C). Thawed samples were placed in H_2O at 18°C during 45 min. for ST (10x4x3 cm) and 60 min. for SM (15x5x3 cm) to reach meat temperature of 18°C before starting microwave cooking.

B. Microwave cooking

Six or eight optical probes (FOT.L/1.5m; FISO Technologies Inc., Canada. Accuracy ± 0) were alternatively inserted in ST (10x4x3 cm) and SM samples (15x5x3 cm), respectively. Each sample was placed in a tray at the centre of a turntable domestic microwave oven with a frequency of 2.45 GHz. The microwave oven was provided with an electronic interface Microwave Workstation^{TM} from FISO Technologies Inc.

Four treatments using combinations of power (250 vs. 900W) and temperature (60 vs. 80°C) were applied (2x2 factorial design): 250W60, 250W80, 900W60, 900W80. Microwave was stopped when the central deep probe (SM: B-D and C-D, ST: B-D, Figure 1) reached the target temperature (60 or 80°C). After cooking the meat sample was placed on ice and cooled down until internal temperature reached 33°C.

C. Instrumental tenderness

After cooking and cooling, ST and SM samples were cut into 2x1x1 cm parallelepiped samples (6 for ST and 16 for SM, Figure 1) for instrumental texture analysis.

Warner-Bratzler shear force (WBSF) was measured using a texture analyzer Alliance RT/5 (MTS Systems Corp., Eden Prairie, MN, USA) equipped with a Warner-Bratzler blade with crosshead speed set at 2 mm/s.

D. Instrumental colour

Lightness, redness and yellowness (L*, a*, b*) were measured using a Spectrophotometer (Minolta, CM-2002) before and after cooking on one end of the sample (10x4x3 cm for ST, 15x5x3 cm for SM) at 6 points. Chroma and Hue angle were calculated for each measurement.

E. Statistical analysis

Data were analyzed as a factorial design with power (250 v. 900W), final internal temperature (60 vs. 80°C), animal age (yearling heifers and mature cows) and two- and three-way interactions in the model using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Sample raw weight was included as covariate in the model.

III. RESULTS AND DISCUSSION

MAXIMUM TEMPERATURE (Tmax)

A gradient of temperature was produced within each roast during MW cooking resulting in areas with different degree of doneness [4].

Semitendinosus muscle

Table 1 shows the effect of power, temperature and animal age on maximum temperature for ST muscle. There was an interaction ($P<0.05$) between power and temperature. At both powers Tmax was higher for 80ºC compared with 60ºC, but the difference in Tmax between 60ºC and 80ºC is greater at the lower power. At 60ºC Tmax was higher for 900 compared with 250W. However, at 80ºC Tmax was about the same for 250 and 900W. Maximum temperature during heating and cooling was higher for ST from cows than heifers.

Semimembranosus muscle

Table 2 shows the effect of power, temperature and animal age on maximum temperature for SM muscle. There were significant interactions ($P<0.05$) between power and age and power and temperature. The maximum temperature during treatment was higher at 900 than 250W for cows. However, there was no difference due to power in Tmax of SM from heifers. At 900W Tmax was higher for SM from cows compared with heifers, with no difference in Tmax between animal ages at 250W. At both powers Tmax is higher for 80 compared with 60ºC. Tmax was higher for 900 compared with 250W when samples were cooked to 60 ºC.

INSTRUMENTAL TEXTURE (WBSF)

Semitendinosus muscle

There were no interactions ($P>0.05$) among temperature, power and animal age or main effects on Warner-Bratzler shear force for the ST muscle (Table 3). Shear-force values for ST were similar between heifers and cows (5.1 vs. 5.4 kg, respectively) despite of the age difference between the two groups of animals (heifers: yearling animals, mature cows: 5.5 years old on average).

Semimembranosus muscle

There were no interactions ($P>0.05$) between power, temperature and animal age for WBSF (Table 4). Shear force was higher for SM cooked to 80 compared with 60ºC ($P<0.0049$) with no effect of power or age on tenderness. This is in accordance with the increase of shear force and sensory hardness with cooking temperature measured on the SM muscle for long heating treatment [*5, 6*].

Shear force was also determined on additional SM samples cooked in water bath at 65C during 30 min. (data not shown). Shear force values from samples cooked in water bath were 4.9 vs. 5.4 kg for heifers and cows, respectively. The difference in shear force between SM from heifers and cows was 0.5 kg for water bath cooking compared with 0.1 kg for MW cooking (5.7 v.s 5.8 kg for heifers and cows, respectively). MW heating could behave differently for yearling and mature animals in samples that differed significantly in tenderness. Shear force values were higher for MW cooking compared with water bath cooking.

INSTRUMENTAL COLOUR (L*, a*, b*)

Non-uniform microwave heating resulted in heterogeneous cooked colour within each roast [*4*]. This gradient makes it difficult to measure colour with accuracy.

Semitendinosus muscle

There were no interactions ($P>0.05$) among power, temperature and animal age for any of the ST colour parameters including lightness, redness and yellowness. There were no effects of power or temperature on colour lightness (Table 5). *Semitendinosus* cooked samples from cows (L*: 53.5) were darker than ST from heifers (L*: 60.9). Colour values before cooking (data not shown) also showed lightness differences between cows and heifers (35.7 vs. 39.7, respectively). There was no effect ($P>0.05$) of power on colour redness or yellowness. *Semitendinosus* muscle from cows was redder and less yellow than heifers, and samples cooked to 60 were redder and more yellow than those cooked to a final temperature

of 80ºC (Tables 6 and 7). Colour values before cooking were 12.1 vs. 13.7 for a* and 6.0 vs. 4.1 for b* from heifers and cows, respectively. Results indicate that colour differences due to animal age are still evident after MW cooking.

Semimembranosus muscle

There was a significant interaction (P>0.05) among power, temperature and age for colour lightness (Table 8). *Semimembranosus* muscle from cows was significantly darker (lower L*) than SM from heifers. There was no power or temperature effect on colour lightness of SM from heifers. Lightness values were lower (P<0.05) for samples cooked to 60 compared with 80ºC at 250W for SM from cows. There was a significant interaction between power and age of the animal for a* (Table 9). Colour redness was higher for SM from cows compared with heifers, and for SM from cows cooked at 250 compared with 900W. There was no temperature effect (P>0.05) on meat redness. There were no interactions (P>0.05) between power, temperature and age for b* (Table 10). Yellowness was lower for SM from cows compared with heifers. There was no temperature or power effect (P>0.05) on SM yellowness. Colour results from SM muscle also indicate that MW cooking does not modify differences in colour due to animal age.

In summary, there was no power effect on colour and tenderness of ST from heifers or cows. ST muscle from cows showed higher redness and lower lightness and yellowness compared with heifers. Cooking to an internal temperature of 80°C may result in lower redness and yellowness of ST compared with 60°C. Microwave cooking of SM muscle at 900W resulted in lower redness in SM from cows. Heating SM muscle to 80°C showed higher shear force and lightness at 250W for cows compared with 60°C. SM from cows showed lower L* and b* and higher a* at 250W when compared with SM from heifers.

IV. Conclusion

Either high (900W) or low (250W) microwave power can be used satisfactorily for cooking ST and SM muscles from heifers and cows. MW cooking to 80°C may result in higher shear force of SM muscle compared to 60°C. Colour differences in SM and ST muscles due to animal age are still significant after MW cooking. Heterogeneous MW cooking results in a cooked meat color gradient which is difficult to measure with accuracy.

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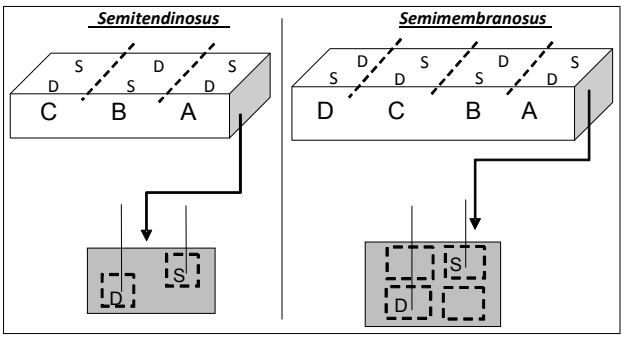

Figure 1. Diagram of probe position in ST and SM muscles. D: probes inserted in deep position, S: probes inserted in superficial position. Each sample was cut after cooking into 3 (ST: A, B, C) or 4 (SM: A, B, C, D) pieces. Each piece was further cut into 2 (ST) or 4 (SM) parallelepiped samples (1x1x2 cm) for shear force analysis.

Table 1. Effect of animal age, power and temperature on Tmax (ºC) for ST muscle.

Power	Temp.	Tmax	SE
250	**60**	71.79[c]	1.90
250	**80**	84.80[a]	1.86
900	**60**	77.68[b]	1.89
900	**80**	83.63[a]	1.85
Age	**Heifers**	76.87[b]	1.32
	Cows	82.08[a]	1.32

Age*Power*Temperature: ns; Age*Temperature: ns; Age*Power: ns; Power*Temperature: P<0.05; Age: P<0.05; Power: ns ; Temperature: P<0.05.

Means within the same column and effect with different letters differ ($P < 0.05$).

Table 2. Effect of animal age, power and temperature on Tmax (ºC) for SM muscle.

Age	Power	Tmax	SE
Heifers	**250**	74.00[b]	1.60
Heifers	**900**	74.17[b]	1.69
Cows	**250**	75.21[b]	1.62
Cows	**900**	83.35[a]	1.64
Power	**Temp.**		
250	**60**	65.37[c]	1.60
250	**80**	83.83[a]	1.62
900	**60**	73.33[b]	1.58
900	**80**	84.18[a]	1.58

Age*Power*Temperature: ns; Age*Temperature: ns; Age*Power: P<0.05; Power*Temperature: P<0.05; Age: P<0.05; Power: P<0.05; Temperature: P<0.05

Means within the same column and effect with different letters differ ($P < 0.05$).

Table 3. Effect of animal age, power and temperature on Warner-Bratzler shear force (WBSF, kg) for ST muscle.

		WBSF	SE
Age	**Heifers**	5.11[a]	0.17
	Cows	5.36[a]	0.17
Temp	**60**	5.11[a]	0.17
	80	5.36[a]	0.17
Power	**250**	5.34[a]	0.17
	900	5.12[a]	0.17

Age*Power*Temperature: ns; Age *Temperature: ns; Age*Power: ns; Power*Temperature: ns; Age: ns; Power: ns; Temperature: ns

Means within the same column and effect with different letters differ ($P < 0.05$).

Table 4. Effect of animal age, power and temperature on Wartner-Blatzer shear force (WBSF, kg) for SM muscle.

		WBSF	SE
Age	**Heifers**	5.69[a]	0.22
	Cows	5.78[a]	0.22
Temp	**60**	5.30[b]	0.21
	80	6.17[a]	0.21
Pot	**250**	5.68[a]	0.21
	900	5.79[a]	0.21

Age*Power*Temperature: ns; Age *Temperature: ns; Age*Power: ns; Power*Temperature: ns; Age: ns; Power: ns; Temperature: P < 0.05.

Table 5. Effect of animal age, power and temperature on colour lightness (L*) for ST muscle.

		L*	SE
Age	**Heifers**	60.92[a]	0.64
	Cows	53.49[b]	0.64
Temp	**60**	57.10[a]	0.63
	80	57.31[a]	0.63
Power	**250**	56.78[a]	0.64
	900	57.63[a]	0.64

Age*Power*Temperature: ns; Age *Temperature: ns; Age*Power: ns; Power*Temperature: ns; Age: P<0.05; Power: ns; Temperature: ns.

Table 6. Effect of animal age, power and temperature on colour redness (a*) for ST muscle.

		a*	SE
Age	**Heifers**	6.63[b]	0.24
	Cows	8.25[a]	0.24
Temp	**60**	7.83[a]	0.23
	80	7.06[b]	0.23
Power	**250**	7.50[a]	0.24
	900	7.39[a]	0.24

Age*Power*Temperature: ns; Age*Temperature: ns; Age*Power: ns; Power*Temperature: ns; Age: P<0.05; Power: ns; Temperature: P<0.05.

Table 7. Effect of animal age, power and temperature on colour yellowness (b*) for ST muscle.

		b*	SE
Age	**Heifers**	13.67[a]	0.16
	Cows	13.15[b]	0.16
Temp	**60**	13.71[a]	0.16
	80	13.11[b]	0.16
Power	**250**	13.43[a]	0.16
	900	13.39[a]	0.16

Age*Power*Temperature: ns; Age *Temperature: ns; Age*Power: ns; Power*Temperature: ns; Age: p<0.05; Power: ns; Temperature: P<0.05.

Table 8. Effect of age, power and temperature on colour lightness (L*) for SM muscle.

Age	Power	Temp	L*	SE
Heifers	**250**	**60**	54.47[a]	0.77
Heifers	**250**	**80**	56.36[a]	0.75
Heifers	**900**	**60**	55.36[a]	0.78
Heifers	**900**	**80**	56.19[a]	0.76
Cows	**250**	**60**	41.91[c]	0.75
Cows	**250**	**80**	48.45[b]	0.78
Cows	**900**	**60**	47.08[b]	0.78
Cows	**900**	**80**	47.37[b]	0.75

Age*Power*Temperature: p<0.05; Age *Temperature: ns; Age*Power: ns; Power*Temperature: p<0.05; Age: p<0.05; Power: p<0.05; Temperature: p<0.05

Table 9. Effect of animal age, power and temperature on colour redness (a*) for SM muscle.

Age	Power	a*	SE
Heifers	**250**	7.71[c]	0.36
Heifers	**900**	7.72[c]	0.38
Cows	**250**	10.90[a]	0.37
Cows	**900**	9.45[b]	0.37
Temp	**60**	10.22[a]	0.25
	80	7.66[b]	0.25

Age*Power*Temperature: ns; Age *Temperature: ns; Age*Power: p<0.05; Power*Temperature: ns; Age: p<0.05; Power: ns; Temperature: p<0.05

Table 10. Effect of animal age, power and temperature on colour yellowness (b*) for SM muscle.

		b*	SE
Age	**Heifers**	12.62[a]	0.19
	Cows	10.98[b]	0.19
Temp	**60**	11.98[a]	0.18
	80	11.62[a]	0.18
Power	**250**	11.77[a]	0.18
	900	11.83[a]	0.18

Age*Power*Temperature: ns; Age *Temperature: ns; Age*Power: ns; Power*Temperature: ns; Age: p<0.05; Power: ns; Temperature: ns