MICROSTRUCTURE AND PHYSICO-CHEMICAL PROPERTIES OF BOVINE *M.SEMITENDINOSUS* DURING AGEING AND ROASTING

Krystyna Palka
Animal Products Technology Department, University of Agriculture, Al.29-Listopada 52, 31-425 Kraków, Poland

Key words: bovine *m.semitendinosus*, roasting, microstructure, texture, shear value, cooking losses, collagen solubility

Background

The muscle is an integrated structure, composed of muscular fibres, cytoskeleton, extracellular matrix and water. Changes occurring in the microstructure of meat during post-mortem ageing and processing have a significant influence on its quality traits, especially texture, tenderness and water holding capacity. The comprehensive reports on changes in microstructure and physico-chemical properties of meat in consequence of ageing and heating processes are not available (Palka 2000 a).

Objective

The aim of this study was to determine relationships between structural changes occurring in meat during ageing and roasting, and its texture, shear value, water holding capacity and the solubility of intramuscular collagen.

Materials and methods

The analyses were carried out on *semitendinosus* (ST) muscles removed from the carcasses of 18-month-old bulls 24 h after slaughter. After 5 and 12 days of ageing at a temperature of 4°C, 20 mm slices of muscles were packed into aluminium foil and roasted at a rate of 3°C/min to the internal temperatures: 50, 60, 70, 80, and 90°C in an electric oven heated to 170°C. The microstructural changes in meat were determined with a scanning electron microscope (SEM), after preparing the samples by method reported previously (Palka & Daun 1999). The quantity and solubility of collagen were measured according to the method described by Palka (1999). Texture profile analysis (TPA) and shearing tests of samples were conducted using a texture analyser as described by Palka (2000 b, c). Cooking losses were expressed as differences between the masses of the samples before and after heating.

Results and discussion

After 12 days of post mortem ageing of ST muscle at 4°C, solubility of intramuscular collagen was twofold higher then in 5-day-aged meat and TPA parameters – hardness and chewiness – twofold lower (Tab. 1). Shear force values of raw meat samples aged for 5 and 12 days did not differ significantly (Tab. 1). These results indicate that transversal resistance of muscle is probably more dependent on extracellular matrix where as this is found the extensive changes occurs after 14-28 days post mortem [Nishimura et al. 1996].

Shear force values, measured after roasting, were lower for of 12-day-aged meat as compared to 5-day-aged samples, whereas values of TPA parameters did not differ significantly. Shear force value of roasted meat was positively correlated with the total intramuscular collagen content. The quantity of soluble collagen in meat samples roasted to internal temperature of 80°C increased twice. At higher temperatures the quantity of soluble collagen in meat 5-day-aged decreased, and stayed at the same level in meat aged for 12 days.

Cooking losses increased with internal temperature of meat (Tab. 2). They were on an average 3% lower during roasting of 12-day-aged as compared to 5-day-aged meat. A decrease in fibre diameter was observed in samples roasted to internal temperature of 60°C in meat aged for 5 days, and to 50°C in meat aged for 12 days (Tab. 2). Sarcomere length decreased continuously, starting from 60°C and 50°C in meat roasted after 5 and 12 days of ageing respectively (Tab. 2). Decrease in fibre diameter and sarcomere length of 12-day-aged meat at internal temperature 50°C, might be a consequence of changes in cytoskeletal proteins and weakening of transverse and longitudinal integrity of muscle fibres during ageing. Changes in sarcomere length and cooking losses were inversely proportional.

Conclusions

- The ageing of ST muscle at 4°C for 12 days causes twofold increase in collagen solubility and twofold decrease in value of TPA parameters: hardness and chewiness. Shear force values, measured after roasting, are lower for of 12-day-aged meat as compared to 5-day-aged samples. Relationship between the texture of raw and roasted meat is limited.
- Quantity of soluble collagen in meat roasted to 80°C increases twice. At higher internal temperatures of meat this variable depends on degree of meat ageing.
- Cooking losses are about 3% lower in meat roasted after 12 days of ageing when compared to meat aged for 5 days.
- Decrease in fibre diameter and sarcomere length during roasting is observed at 60°C in 12-day-aged meat and at 50°C in 5-day-aged samples.
- Changes in sarcomere length and cooking losses during roasting are inversely proportional.

References

1. Nishimura T., Hattori A., Takahashi K. 1996. Relationship between degradation of proteoglycans and weakening of the intramuscular connective tissue during post mortem ageing of beef. Meat Sci., 42, 251-260.
2. Palka K. 1999. Changes in intramuscular connective tissue and collagen solubility of bovine *m.semitendinosus* during retorting. Meat Sci., 53, 189-194.
3. Palka K. 2000 a. Zmiany w mikrostrukturze i teksturze mięśni bydlęcych podczas dojrzewania poubojowego i ogrzewania. Zesz. Nauk. AR w Krakowie, rozprawy, 270, 1-69.
4. Palka K. 2000 b. Roasting-induced changes in intramuscular connective tissue and tenderness of bovine *semitendinosus* muscle. Pol. J. Food Nutr. Sci., 9/50, 3, 39-44.
5. Palka K. 2000 c. Roasting-induced changes in texture and fibre microstructure of bovine *semitendinosus* muscle. Pol. J. Food Nutr. Sci., 9/50, 2, 41-45.
6. Palka K., Daun H. 1999 Changes in texture, cooking losses, and myofibrillar structure of bovine *m.semitendinosus* during heating. Meat Sci., 51, 237-243.

Table 1. Soluble collagen, TPA parameters, and shear force value of bull ST muscle during post mortem ageing at 4 °C. Mean values and standard errors.

Time of ageing [Days]	Soluble collagen1) [% of total collagen]	Texture parameters2)					Shear force value2) [KG/cm^{2}]
		Hardness [N]	Chewiness [N]	Springiness [-]	Resilience [-]	Cohesiveness [-]	
5	13.30^{a} ± 0.80	4.02^{a} ± 0.26	1.86^{a} ± 0.18	0.81^{a} ± 0.02	0.23^{a} ± 0.01	0.52^{a} ± 0.01	3.20^{a} ± 0.17
12	27.43^{b} ± 0.72	2.26^{b} ± 0.14	0.84^{b} ± 0.10	0.72^{b} ± 0.02	0.22^{a} ± 0.01	0.53^{a} ± 0.02	3.40^{a} ± 0.25

1) n = 9 2) n = 36 3) n = 18

Different letters following numbers in the same column indicate significant differences between means ($p < 0.05$)

Table 2. Fibre diameter, sarcomere length, and cooking losses of bull ST muscle raw and roasted to various temperatures after different time of ageing at 4 °C. Mean values and standard errors.

Muscle	Fibre diameter1) [μm]		Sarcomere length2) [μm]		Cooking losses3) [%]	
	Time of ageing [Days]					
	5	12	5	12	5	12
raw	49.7 ± 0.87^{a}	49.2 ± 1.15^{a}	2.3 ± 0.03^{a}	2.3 ± 0.04^{a}	-	-
roasted [°C]						
50	48.3 ± 0.70^{a}	44.4 ± 1.34^{b}	2.3 ± 0.03^{a}	2.2 ± 0.02^{b}	21.3 ± 0.55^{a}	19.6 ± 0.60^{a}
60	40.5 ± 1.06^{b}	40.0 ± 1.03^{c}	2.2 ± 0.03^{b}	2.1 ± 0.02^{c}	31.3 ± 0.67^{b}	27.3 ± 0.65^{b}
70	38.3 ± 0.73^{b}	37.0 ± 0.73^{c}	2.0 ± 0.03^{c}	1.8 ± 0.01^{d}	38.8 ± 0.64^{c}	35.5 ± 0.40^{c}
80	38.1 ± 0.82^{b}	36.9 ± 1.04^{c}	1.8 ± 0.05^{d}	1.3 ± 0.02^{e}	42.7 ± 0.68^{d}	40.7 ± 0.55^{d}
90	39.2 ± 1.06^{b}	39.8 ± 1.90^{c}	1.6 ± 0.06^{e}	1.2 ± 0.02^{f}	45.6 ± 0.59^{e}	42.0 ± 0.49^{d}

1) n = 40 2) n = 20 3) n = 12

Different letters following numbers in the same column indicate significant differences between means ($p < 0.05$)