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Studies on the Thermal Denaturation of Pork Loin Muscle

Cheon-Jei Kim[1], Min-Seok Song[2], Eui-Soo Lee[2], Chang-Hyun Lee[3], Chan-Ho Lee[2], Jin-Kook Cho[1] and Do-Young Choi

[1]Animal Resources Research Center, KonKuk University, Seoul, Korea, [2]Department of Animal Products Science, KonKuk University, Seoul, Korea, [3]Department of Bioproductive Science, Utsunomiya University, Japan

Keywards: DSC, Pork loin muscle, heating rate, holding time, previous heating

Background: Heating is the most common method of preparing meat(Kijowski *et al.*, 1988). To prepare more acceptable cooked meat by efficient and economical process, the thermal properties of meat during cooking must be known(Baghe-Khandan *et al.*, 1981). Differential scanning calorimetry(DSC) is useful for studing the thermal properties of meat proteins and it has used to investigate the denaturation of meat proteins by many authors(Parsons *et al.*, 1986).

Objectives: We have examined the characteristics on the thermal denaturation of pork loin muscle(M. longissimus dorsi) in previous heating, holding time and heating rate.

Material and methods: Pork loin muscle was used as sample to be storage for 24 hours after slaughter. The sample pH range was obtained 5.5 to 5.6 after storage at 2±2℃ for 24 hours. To evaluate the thermal denaturation of pork loin muscle, we determined the thermal curves using DSC(Perkin-Elmer, USA) with various condition as follows: previous heating, holding time and heating rate.

Results and Discussion: Thermogram of pork loin muscle was obtained over a range of 45~85℃ with three clear major peaks(Fig. 1). Thermal transition temperature(T_{max1}, T_{max2} and T_{max3}) were 55.84℃, 65.56℃ and 79.38℃. It was corresponding to myosin, sacoplasmic protein and actin respectively. As previous heating temperature was raised, major peaks were progressively disappeared and were lost completely at 80℃. A progressive reduction in the enthalpy occurred as the holding time increased. T_{max3} was thermally stable because T_{max3} was less affected relatively than other peaks by holding time and temperature(Table 1, Fig. 2). Especially, as the heating temperature and holding time increased between 50 and 70℃, total enthalpy was decreased obviously, because pork loin muscle proteins were more severely denatured(Fig. 3).

Peaks were progressively shifted to right side as heating rate increased(Fig. 4). T_o(transition onset temperature)was 50.39℃ at 5℃/min(heating rate) and it was increased to 57.45℃ at 40℃/min($p<0.05$). Total enthalpy was 3.52J/g at 5℃/min and total enthalpy was increased to 3.60J/g, 4.14J/g, 4.54J/g and 4.61J/g by degrees at heating rate 10, 20, 30 and 40℃/min respectively(Table 2). It showed that pork loin muscle heated in fast heating rate needed more energy than muscle heated in slower heating rate to achieve equal protein denaturation.

References:

Baghe-Khandan, M. S. and Okos, M. R. 1981. J. Food Sci., 46 : 1302-1305

Findlay, C. J., Stanley, D. W. and Gullett, E. A. 1986. Meat Sci., 16 : 57-70

Kijowski, J. M. and Mast, M. G. 1988. J. Food Sci., 53 : 363-366

Parsons, S. E. and Patterson, R. L. S. 1986. J. Food Tech., 21 : 123-131

Table 1. Temperatures of thermal transitions and denaturation enthalpies of pork loin muscle heated in different previous heating temperatures, cooled and reheated to 108℃ in DSC

End-point Temperature(℃)	Holding Time(min)	Temperature of Transition(T_{Max}, ℃)			Heat Energy of Transition(J/g)			
		T_{Max1}[1)]	T_{Max2}[2)]	T_{Max3}[3)]	ΔH_1[4)]	ΔH_2[5)]	ΔH_3[6)]	ΔH_{Total}[7)]
Raw		55.84±0.44	65.56±0.08	79.38±0.12^{a,b}	1.38±0.15^{a}	1.73±0.15^{a}	0.85±0.01^{a,b,c}	3.96±0.03$^{a,b)}$
40	1 min	55.93±0.75	65.76±0.67	79.26±0.25^{b}	1.28±0.06^{a,b}	1.69±0.11^{a}	0.92±0.05^{a}	3.90±0.03^{a}
	5 min	56.68±0.28	66.25±1.08	79.38±0.13^{a,b}	1.18±0.06^{b,c}	1.67±0.04^{a}	0.81±0.04^{b,c}	3.66±0.09^{b}
	10 min	56.72±0.32	65.53±0.17	79.15±0.07^{b}	1.06±0.15^{c}	1.71±0.05^{a}	0.84±0.06^{a,b,c}	3.61±0.14^{b}
50	1 min	–	66.11±0.44	79.27±0.18^{b}	0.32±0.04^{d}	1.73±0.02^{a}	0.87±0.05^{a,b}	2.93±0.08^{c}
	5 min	–	65.98±0.54	79.26±0.17^{b}	0.08±0.02^{e}	1.42±0.08^{b}	0.88±0.10^{a,b}	2.38±0.04^{d}
	10 min	–	66.30±0.41	79.53±0.32^{a,b}	0.05±0.00^{e}	1.35±0.07^{b}	0.84±0.11^{a,b,c}	2.20±0.04^{e}
60	1 min	–	–	79.31±0.09^{b}	–	0.45±0.03^{c}	0.84±0.06^{a,b,c}	1.29±0.06^{f}
	5 min	–	–	79.44±0.06^{a,b}	–	0.31±0.04^{d}	0.81±0.02^{b,c}	1.11±0.02^{g}
	10 min	–	–	79.49±0.41^{a,b}	–	0.23±0.01^{d}	0.75±0.00^{c}	0.98±0.01^{h}
70	1 min	–	–	79.56±0.15^{a,b}	–	–	0.50±0.01^{d}	0.50±0.01^{i}
	5 min	–	–	79.79±0.36^{a}	–	–	0.15±0.02^{e}	0.15±0.02^{j}
	10 min	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–

[a-j] Within same column, means with different superscripts are significantly different($P < 0.05$)
[1)-3)] Thermal transition temperature [4)-7)] Heat transition energies.
[8)] Means of three replicate determinations * Heating rate = 10℃/min

Table 2. Thermal properties of pork loin muscle heated at different rates

Heating Rate (℃/min)	Temperature of Transition(T_{Max}, ℃)				Heat Energy		
	T_o[1)]	T_{Max1}[2)]	T_{Max2}[3)]	T_{Max3}[4)]	$\Delta H_1 + \Delta H_2$[5)]	ΔH_3[6)]	ΔH_{Total}[7)]
5	50.39±0.44^{a}	54.71±0.27^{a}	62.32±0.19^{a}	77.83±0.24^{a}	2.66±0.05^{a}	0.86±0.05^{a}	3.52±0.02$^{a,b)}$
10	52.23±0.98^{b}	56.88±0.63^{b}	66.94±0.58^{b}	79.93±0.04^{b}	2.87±0.17^{a,b}	0.73±0.10^{a}	3.60±0.17^{a}
20	54.25±0.21^{c}	61.20±1.46^{c}	69.24±0.45^{c}	83.18±0.25^{c}	3.22±0.34^{b}	0.92±0.03^{a}	4.14±0.35^{a,b}
30	55.84±0.42^{d}	64.00±0.83^{d}	–	86.48±1.56^{d}	3.25±0.17^{b}	1.29±0.22^{b}	4.54±0.23^{b}
40	57.45±0.92^{e}	68.36±1.20^{e}	–	87.87±0.98^{e}	3.19±0.38^{b}	1.42±0.23^{b}	4.61±0.61^{b}

[a-e] Within same column, means with different superscripts are significantly different($P < 0.05$)
[1)] Onset temperature of transition [2)-4)] Thermal transition temperature
[5)-7)] Heat transition energies. [8)] Means of three replicate determinations

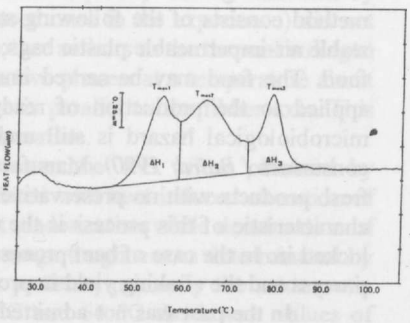

Fig. 1. DSC thermogram for pork loin muscle.

- ΔH_1, ΔH_2 and ΔH_3 mean enthalpies.
- T_{max1}, T_{max2} and T_{max3} mean thermal transition temperature.
- Heating rate = 10℃/min.

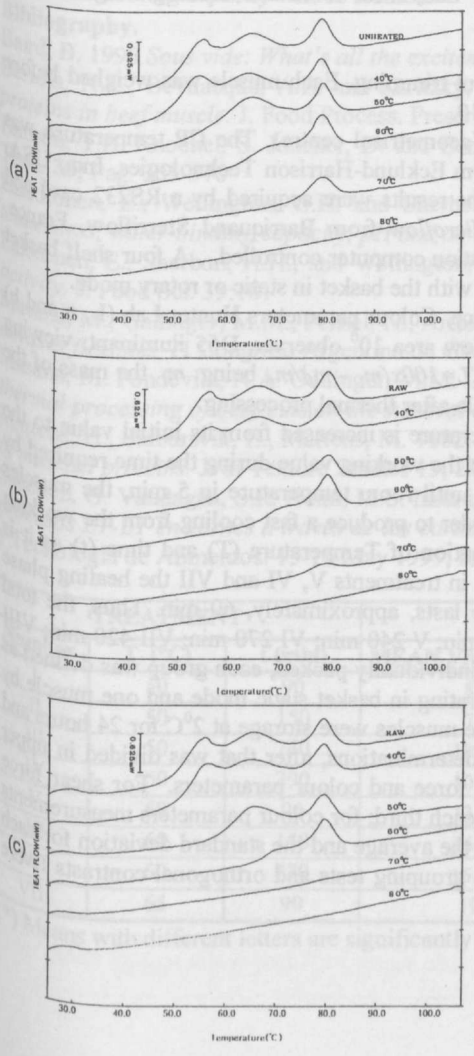

Fig. 2. DSC thermogram for pork loin muscle heated different end point temperatures and different holding times.
* (a) Holding time : 1 min, (b) Holding time : 5 min, (c) Holding time : 10 min (Heating Rate = 10℃/min).

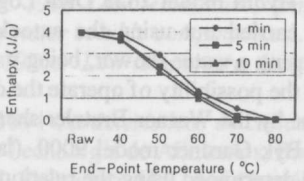

Fig. 4. Changes in total thermal denaturation enthalpies for pork loin muscle heated in different end-point temperatures and different holding times. heating rate = 10℃/min.

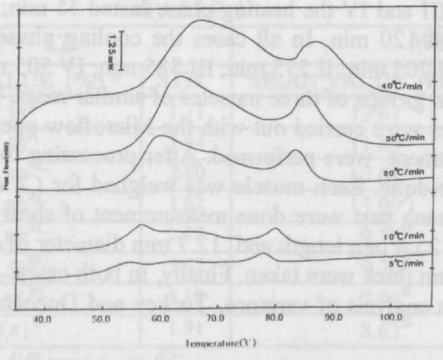

Fig. 3. DSC thermogram of pork loin muscle heated at different heating rates.
* Heating rates = 5, 10, 20, 30 and 40℃/min.

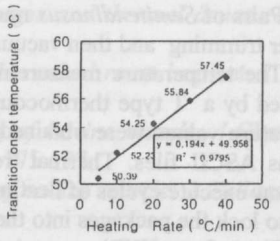

Fig. 5. Effect of heating rate on transition onset temperature(T_o) of pork loin muscle. Values shown are mean of three separate assays.

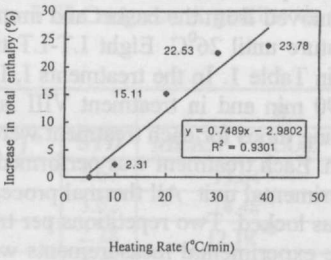

Fig. 6. Effect of heating rate on the rate of increasing in total enthalpy. Values shown are mean of three separate assays.