Effect of prolonged heat treatments at low temperature on shear force and cooking loss in cows and young bulls

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Abstract— **Long term heat treatment at low temperature (LTLT) is known to decrease toughness of meat. However, the contribution from the connective tissue to the toughness of LTLT treated meat is not clear. The aim of the present study was to investigate the effect of LTLT treatments on shear force and cooking loss in *semitendinosus* from cows (4-6 years) and young bulls (12-14 months), representing 2 categories of beef with varying thermal strength of connective tissue. Vacuum packed muscle samples were heat treated at 53°C, 55°C, 58°C and 63°C in water baths for 2½, 7½ and 19½ h. Cooking loss and Warner-Bratzler shear force were measured after heat treatment and subsequent cooling. Shear force of *semitendinosus* from young bulls heated at 53°C for 2½ h was significantly higher compared with all other heat treatments. A decrease of app. 40 N was observed when increasing the heating temperature from 53°C to 55°C, or when increasing heating time from 2½ to 7½ h at 53°C. In *semitendinosus* from cows shear force decreased significantly with increasing temperature, and with increasing heating time from 2½ to 19½ h at 55°C and 63°C. Cooking loss increased with increasing heating temperature in both beef categories. The results show that prolonged heating at low temperatures reduce toughness in beef *semitendinosus*, and that a reduction in toughness require higher temperatures and longer heating times in *semitendinosus* from cows compared with young bulls.**

Keywords— **LTLT, semitendinosus, toughness.**

I. INTRODUCTION

Long term thermal treatments at low temperature (LTLT) increase tenderness of meat [1-5]. Thus, heating bovine muscles at temperatures from 50°C to 60°C markedly decreased shear force [5-6]. The reasons for the decrease in shear force between 50 and 60°C have not been thoroughly investigated. Weakening of collagen has been suggested to be responsible for the tenderization of meat during LTLT treatment of bovine [5, 7, 8, 9] and porcine muscles [10]. Animal age at slaughter is known to affect the thermal strength of connective tissue and it can therefore be hypothesized that the LTLT effect on shear force will differ depending on animal age.

The aim of the present study was to investigate the effect of LTLT treatments on shear force and cooking loss in *semitendinosus* from cows (4-6 years) and young bulls (12-14 months), representing 2 categories of beef with varying thermal strength of connective tissue.

II. MATERIALS & METHODS

A. Raw material

Semitendinosus (ST) were excised 3 days *post mortem* from young bulls 10-12 months old and from 4-6 years old dairy cows, and were further stored for 7 days at 5°C. After storage samples were cut in sizes of app. 5x7x10 cm, vacuum packed and frozen at -20°C.

Samples were thawed for 24 h at 4°C prior to heat treatment. Heat treatments were performed in water baths (ICC "Roner", Frinox Aps, Hillerød, Denmark) set at 53°C, 55°C, 58°C and 63°C. Heat treatments were performed using 3 different heating times; 2.5h (time to reach the temperature of the water bath in the center of the sample), 7.5h (holding time = 5 h) and 19.5h (holding time = 17h). Heating was arrested by keeping the samples in ice water for 10 min. Samples were weighed and cooking loss was calculated as the weight lost during LTLT treatments. Heat treated samples were stored overnight at 4°C prior to analysis.

B. Warner-Bratzler Shear Force

Six blocks of 1x1x6 cm were cut from the meat stored overnight at 4°C and the shear force was measured 3 times on each block on an Instron equipped with a triangular Warner-Bratzler test cell. The mean maximum force required to shear through the sample from six repetitions of each heat treatment was determined.

C. Statistical analysis

Analysis of variance was performed using SAS version 9.2. The model included temperature and time as fixed effects, while animal was included as random effect.

III. RESULTS

The main effects of temperature and time on shear force were significant in ST from both young bulls ($P < 0.001$) and cows ($P < 0.05$). Figure 1 shows Warner-Bratzler shear force values from young bulls, and Figure 2 shows Warner-Bratzler shear force values from cows.

From Figure 1 it appears that shear force of LTLT treated ST from young bulls decreased app. 35 N when increasing temperature from 53°C to 55°C, or when increasing heating time from 2½ h to 7½ h at 53°C. Increasing heating temperature or time further did not affect shear force significantly.

Shear force of LTLT treated ST from cows decreased with increasing heating time from 2½ h to 19½ h at 55°C, while at 53°C, 58°C and 63°C no changes in shear force was observed (Figure 2). Increasing heating temperature from 53°C to 63°C at 19½ h decreased shear force with app. 75 N. Heating ST from cows for 19½ h at 63°C resulted in a shear force value of 40 N, whereas in young bulls the shear force value was 36 N already after 7½ h at 53°C.

The main effect of heating time on cooking loss in ST from young bulls was significant ($P < 0.001$), while in cows no significant main effects on cooking loss were observed. Table 1 shows changes in cooking loss as a result of LTLT treatment of ST from young bulls and cows.

Cooking loss in ST from young bulls increased 5-10% when increasing time from 2½ h to 19½ h at all temperatures. In ST from cows the cooking loss at 58°C and 63°C after 19½ h were 6-11% lower compared to ST from young bulls.

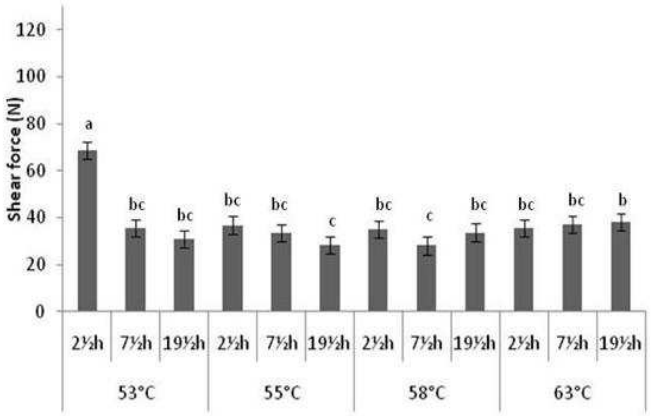

Figure 1. LS means of Warner-Bratzler Shear Force (N) values in low temperature long time treated bovine *semitendinosus* from young bulls heated at 53°C, 55°C, 58°C and 63°C for 2½ h, 7½ h and 19½ h. Letters a-c refer to significance ($P<0.05$) between treatments (n=6).

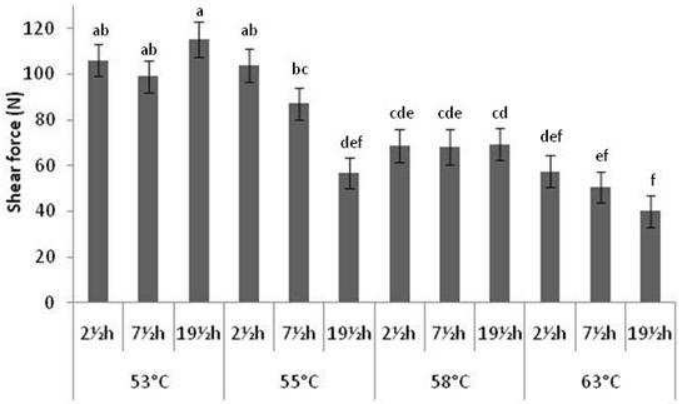

Figure 2. LS means of Warner-Bratzler Shear Force (N) values in low temperature long time treated bovine *semitendinosus* from cows heated at 53°C, 55°C, 58°C and 63°C for 2½ h, 7½ h and 19½ h. Letters a-f refer to significance ($P<0.05$) between treatments (n=6).

Table 1. LS means of cooking loss (%) in low temperature long time treated bovine *semitendinosus* from young bulls and cows heated at 53°C, 55°C, 58°C and 63°C for 2½ h, 7½ h and 19½ h. Letters a-d refer to significance ($P < 0.05$) between treatments within each beef category.

	53°C			55°C			58°C			63°C		
	2½h	7½h	19½h	2½h	7½h	19½h	2½h	7½h	19½h	2½h	7½h	19½h
Youngbulls	21.3^{d}	28.0^{bc}	31.3^{ab}	24.2^{cd}	25.9^{bcd}	29.7^{bc}	22.4^{d}	31.4^{ab}	31.0^{ab}	25.4^{cd}	29.4^{bc}	35.7^{a}
Cows	23.4^{ab}	26.6^{ab}	27.1^{ab}	27.1^{ab}	29.6^{a}	28.7^{a}	19.7^{b}	23.3^{ab}	24.7^{ab}	24.0^{ab}	27.9^{a}	24.7^{ab}

IV. DISCUSSION

The results show that prolonged heating at low temperatures between 53°C and 63°C reduce toughness in beef ST, and that a reduction in toughness requires higher temperatures and longer heating times in ST from cows compared to young bulls. These differences in shear force between the 2 categories of beef may be explained by differences in thermal stability of collagen as it is known that the thermal stability of collagen changes as a result of increasing age at slaughter.

Cooking loss in ST from young bulls increased with increasing time from 2½ h to 19½ h at 53°C, 58°C and 63°C, which is in accordance with previous studies in LTLT treated porcine ST [10].

Further studies are required in order to investigate whether the toughness changes are caused by increased collagen solubilisation.

V. CONCLUSIONS

Prolonged heating up to 19½ h at low temperatures between 53°C and 63°C reduce toughness in beef *semitendinosus*. Reduction in toughness of *semitendinosus* from cows requires higher temperatures and longer heating times than in young bulls. Overall, this study shows that LTLT treatment of bovine *semitendinosus* make tough meat more tender.

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