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Effect of muscle stretching on meat quality of *biceps femoris* from beef

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ABSTRACT

The objective of this study was to examine the effect of muscle stretching on meat quality and ultrastructure of *biceps femoris* (BF) from beef. After slaughter, the right side of the carcasses were suspended from the Achilles tendon (AS; n = 10), while the left sides were re-hanged from the pelvic bone (PS; n = 10). Meat quality was evaluated by water holding capacity (WHC), cooking loss (CL), color, shear force (SF) and sarcomere length (SL). As a result, PS had no impact on WHC, CL and color parameters. PS significantly decreased SF values by 7.5% only at 2 days postmortem. At pelvic suspended sides, SL was increased by 0.13 μm, 0.14 μm and 0.12 μm at 2, 7 and 10 days postmortem, respectively ($P<0.001$). Electron microscopy showed that the ultrastructure of BF have longer sarcomeres and smaller fiber diameter after PS. In conclusion, PS is a useful method for improving tenderness by stretching muscles.

1. Introduction

Variations in meat tenderness are a general concern to the meat industry worldwide (Derbyshire et al., 2007). Numerous techniques are currently used to improve this aspect, during postmortem. One of these applications is pelvic suspension (PS) which involves hanging carcasses from the *obturator foramen* shortly after slaughter and before the commencement of rigor (Eikelenboom, Barnier, Hoving-Bolink, Smulders, & Culioli, 1998). Different names for this method have been suggested including hip suspension, aitch-bone hanging and tenderstretch (Rees, Trout, & Warner, 2003).

Pelvic suspension produces a decrease of myofibrils shortening compared with normal hanging from the Achilles tendon (Bertram & Aaslyng, 2007). In PS, the hind leg hangs vertically from the carcass reversing the effects on the muscles involved and the vertebral column is straightened (Ahnstrom, Enfalt, Hansson, & Lundstrom, 2006). However, researches have shown that PS influences muscles in the carcass differently (Desmond & Kenny, 2005). It helps to stretch many of the major loin and round muscles and has been shown to improve tenderness by up to 32% (Wang, Claus, & Marriott, 1995). Fisher, Pouros, Wood, Young-Boong, and Sheard (2000) demonstrated that *M. rectus femoris*, a major muscle in the leg, actually shortens after PS. Moller, Kirkegaard, and Vestergaard (1987) detected that longer sarcomere lengths have been found in *M. semimembranosus* and *M. biceps femoris* (BF). PS has been implemented in meat industry systems of UK, Australia, Sweden and Norway (Sorheim et al., 2001).

This hanging method has attracted for improving tenderness in beef (Hostetler, Landmann, Link, & Fitzhugh, 1970; Herring, Cassens, & Briskey, 1965), lamb (Bouton & Harris, 1972) and pork (Fisher et al., 2000; Dransfield, Ledwith, & Taylor, 1991). The tenderness of meat is determined by the properties of myofibrils and the intramuscular connective tissue and is improved with time of post-mortem aging (Nishimura, Liu, Hattori, & Takahashi, 1998). Therefore, the objective of the present study was to investigate the effects of PS on meat quality and structural changes of BF.

2. Materials and methods

The research protocol of the current study was approved by the Ethic Committee of the Istanbul University Veterinary Faculty (approval number: 2008/151).

2.1. Animals and experimental design

10 beef of the same breed (Holstein × Friesian) with mean live weight of 420 kg at slaughter were procured from Istanbul University Veterinary Faculty farm. The animals were transported to the slaughterhouse from a nearby farm within 15 min, 1 day prior to slaughter. After a rest of 22–24 h, the beef were slaughtered by Halal method. Following exsanguinations and evisceration, carcasses were halved by splitting through the vertebral column within approximately 40 min postmortem. The right sides of the carcasses were suspended from the Achilles tendon (AS; n = 10), while the left sides were re-hanged from the pelvic bone (PS; n = 10). Then, the carcasses

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Table 1
Effect of suspension methods on water holding capacity, cooking loss and color parameters (mean ± SE) of *biceps femoris* in beef carcasses.

	Suspension group			Day		Significance		
	AS	PS	Day II	Day VII	Day X	Group	Time	Group × time
WHC (%)	13.51 ± 0.31	13.25 ± 0.31	15.09^{a} ± 0.34	12.95^{b} ± 0.39	12.10^{b} ± 0.29	NS	***	NS
CL (%)	35.97 ± 0.59	35.36 ± 0.59	36.97^{a} ± 0.14	35.78^{ab} ± 0.74	34.25^{b} ± 0.86	NS	*	NS
L*	32.25 ± 0.27	32.36 ± 0.27	31.73^{a} ± 0.17	31.47^{a} ± 0.24	33.72^{b} ± 0.43	NS	***	NS
a*	16.29 ± 0.23	16.34 ± 0.23	16.68^{a} ± 0.30	17,25^{a} ± 0.30	15.02^{b} ± 0.39	NS	***	NS
b*	14.54 ± 0.37	14.75 ± 0.37	12.01^{c} ± 0.22	15.01^{b} ± 0.49	16.91^{a} ± 0.35	NS	***	NS

AS: Achill suspension; PS: pelvic suspension; WHC: water holding capacity; CL: cooking loss.
NS: Not significant ($P>0.05$).
Means with different letters in a same row are significantly different from one another.
*** $P<0.001$.
* $P<0.05$.

were placed in a conventional chiller (air temperature, 2 ± 1 °C; wind velocity, 1 m/s). At 24 h postmortem, BF was removed from each carcass after measuring ultimate pH using a portable pH meter (Hanna HI 8314) and the three portions were obtained. Portions were packaged in Cryovac barrier bags and stored at 0–4 °C for up to 10 days postmortem prior to evaluating the water holding capacity (WHC), cooking loss (CL), color (L^*, a^*, and b^*), shear force (SF) and sarcomere length (SL).

2.2. Water holding capacity and cooking loss

The percentage of free liquid was evaluated as a measure of WHC by the filter press method described by Hertog-Meischke, Smulders, Logtestijn, and Knapen (1997). The outline area of the expressible juice and the meat film were traced and two areas were measured using AUTOCAD. CL was calculated from the weight of the samples taken before and after cooking. After measurements, the same samples were used for determination of texture parameters.

2.3. Color

Meat color of BF was measured using a Color Flex Hunter Lab Color Measurement System (Hunter Associates Laboratory Inc.) at 2, 7 and 10 days postmortem. Color coordinate values as L^* lightness, a^* redness, b^* yellowness values were recorded. Before each measurement, the apparatus was calibrated using a white, black and reference standard respectively. Color values were obtained considering the average of five readings, performed in different locations of the surface (Hunt et al., 1991).

2.4. Shear force

SF of chops from BF was determined by measuring the force required to shear through a cooked sample at 2, 7 and 10 days postmortem. Samples were cooked individually in a 100 °C water bath until an internal temperature of 75 °C was reached. The cooked samples were cooled and the pieces were removed parallel to the muscle fiber. The pieces were sheared by a Warner–Bratzler shear attachment mounted on an Instron with a 50 kg load transducer and crosshead speed of 200 mm/min. An average of five sub-samples was accepted to be an SF value of that sample.

2.5. Sarcomere length

SL was determined using phase the contrast microscopy (Olympus CX41) method as described by Cross, West, and Dutson (1981). The mean SL of each muscle was determined by measuring 25 myofibrils containing four sarcomeres each.

2.6. Transmission electron microscopy

Tissue samples of BF were prefixed in glutaraldehyde-paraformaldehyde (pH 7.4) as described by Karnovsky (1965), and subsequently fixed in 1% osmic acid solution for 2 h. Following the second fixation, tissue samples were maintained in 1% uranyl acetate for 2 h, dehydrated through an ascending series of graded alcohols, propylene oxide and embedded in Araldite M. The semi-thin (1 μm) from blocks was stained with toluidine blue and 300–400 Å thickness was cut. These sections were contrast stained as described by Veneable and Coggeshall (1965) and were examined under a Carl Zeiss EM 9S-2 transmission electron microscope (Zeiss Oberkochen, Germany).

2.7. Statistical analysis

The results of WHC, CL, color, SF and SL parameters from AS and PS were subjected to analysis of variance for repeated measures of ANOVA by using SPSS Inc. (1999). The model used in the statistical analyses included analysis time as a within subject factor and groups as a between subject factor. Contrast test was used to evaluate the significance of the difference.

3. Results and discussion

The effect of suspension methods on WHC and CL are presented in Table 1. PS had lower WHC and CL than AS at 2, 7 and 10 days postmortem. However, no statistically significant difference were found ($P>0.05$), which indicated that suspension methods had no impact on WHC and CL of BF steaks after vacuum packaging. Honikel (1999) suggested that WHC and CL depend on the ultimate pH value. In this study, the ultimate pH values obtained in AS and PS were 5.59 and 5.62, respectively. There were no significant differences between the suspension methods ($P>0.05$). Similar results were reported by

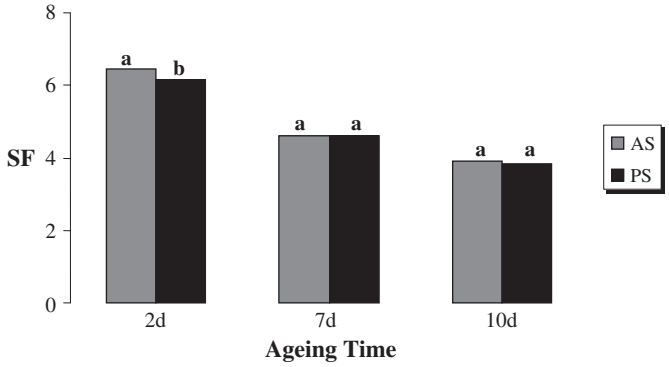

Fig. 1. Effect of suspension methods on shear force values of *biceps femoris* in beef carcasses.