

Effects of blade tenderisation and postmortem storage on the quality characteristics of mature camel (*Camelus dromedarius*) meat

A SAMI¹, G SULIMAN², A ALOWAIMER³ and M KOOHMARAIE⁴

King Saud University, PO Box 2460, Riyadh 11451 Saudi Arabia

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ABSTRACT

Two experiments were carried out to determine the effects of blade tenderisation (BT) and postmortem storage (PM) on the tenderness of meat from mature (> 8 years, as determined by dentition) male camels. In experiment 1, 18 *Longissimus dorsi* (LD, from the 9th to the 12th vertebrae) and 18 *Biceps femoris* (BF) muscles of 18 mature male camels were obtained from a local meat market to determine the effect of BT. Twenty-four hours after slaughter, each muscle was divided into 3 steaks, which were passed: 0 (control), 1 pass and 2 passes through a blade tenderiser. After treatment, steaks were cooked and slice shear force (SSF) was determined. The SSF values of LD and BF were significantly reduced by 3.2 kg or 22.4% and 6.3 kg or 21.6%, respectively, when muscles were passed through the blade tenderiser twice compared to control muscles. Experiment 2 was conducted to determine the effect of PM on LD tenderness. Nine LD muscles of mature male camels were purchased from a local meat market and stored at 2° C. Each LD muscle was divided into 3 steaks and stored for 2, 7 or 14 days PM at 2° C. Postmortem storage significantly decreased SSF, increased myofibril fragmentation index and did not affect cooking loss, cooking time and sarcomere length. Postmortem storage for 14 days was more effective in reducing SSF (reduction of 7.9 kg or 56.5%) than BT. Our results indicated that both BT and PM are effective methods to improve the tenderness of mature camel meat.

Key words: Blade tenderisation, Camel, Meat tenderness, Postmortem, Tenderness

Camel meat, a preferred source of meat for Saudi citizens (Abouheif *et al.* 1989), has low fat content and cholesterol as compared with other sources of meat (Elgasim and Alkanhal 1992, Dawood and Alkanhal 1995, Kadim *et al.* 2006, 2008a, b). Dawood and Alkanhal (1995) found that camel meat is relatively high in polyunsaturated fatty acids (PUFA) as compared with beef. It is well known that consumers' satisfaction with beef is determined by the interaction of tenderness, juiciness and flavour. However, tenderness is considered the most important trait for consumer satisfaction (Huffman *et al.* 1996). Thus, variation in meat tenderness is often the primary reason for consumer dissatisfaction and an acceptable level of tenderness is required to meet consumers' expectations (Riley *et al.* 2009). Blade tenderisation improves meat tenderness (Wheeler *et al.* 1990) and it has been widely used by further processors to enhance meat tenderness (George-Evins 1999). Blade

tenderisation also reduces the variation in meat tenderness.

As animals age increases, meat tenderness decreases, owing primarily to an increase in connective-tissue strength (Shimokomaki *et al.* 1972). Camel is a major source of meat in Saudi Arabia, but Saudi citizens believe that mature camels yield meat that is of poor quality (Al-Owaimer 1999). Therefore, the objective of this study was to determine the effect of blade tenderisation and postmortem storage on the tenderness of meat from mature camels.

MATERIALS AND METHODS

Experiment 1: Blade tenderisation (BT): Eighteen *Longissimus dorsi* (LD) and 18 *Biceps femoris* (BF) were collected from the left side of 18 mature male camels (> 8 years as determined by dentition) and stored at 2°C for 24 hrs. Each muscle was divided into 3 steaks for 0 (control), 1 or 2 passes through a blade tenderiser. To eliminate the location effect, locations were rotated among the 3 BT passes. Steaks (2.54 cm thick) from each location were obtained for slice shear force (SSF) determination. All steaks were packed under vacuum and kept frozen at – 20°C.

Cooking method: Frozen steaks were thawed for 24 h at 4°C. Steaks were placed in a commercial oven (dry heat oven)

Present address: ¹Associate Professor (e mail: assami70@yahoo.com), ²Assistant Professor (e mail: gm_suliman@yahoo.com), ³Professor (e mail: owaimer100@yahoo.com), ⁴Professor (e mail: mk@iehinc.com), Department of Animal Production, College of Food and Agricultural Sciences.

set at 177°C and cooked to an internal temperature of 70°C. Internal temperatures were monitored by inserting a thermocouple probe into the geometric centre of the steak. Cooking time was recorded for each sample. Steaks were weighed before and after cooking to determine cooking loss.

Slice shear force (SSF): SSF for LD and BF was conducted as described by Shackelford *et al.* (1999, 2010). The difference between SSF and WBSF is the sample obtained from the cooked steak. For WBSF, 1.27 cm cores were removed and sheared with an instrument with a Warner-Bratzler attachment. For SSF measurement, single 1 cm thick and 5 cm long slice was removed and sheared with an instrument with a modified blade attachment. Because the size of the SSF sample was much larger, the SSF value was much higher than the WBSF value. The following equation can be used for conversion: $WBSF = (0.106283 \times SSF) + 2.27$. This equation is provided for a general estimate of WBSF from SSF.

Experiment 2: Nine *Longissimus dorsi* (LD) muscles were obtained from 9 other mature (> 8 years) male camels. Three steaks (2.54 cm thick) from each muscle were divided into 3 postmortem storage period groups (2, 7 and 14 days). To prevent the location effect, steak locations were rotated among the 3 periods. Steaks were vacuum-packaged and stored at 4°C. Slice shear force was conducted as described in Experiment 1. The measurement of cooking loss and cooking time were conducted as in experiment 1.

Myofibril fragmentation index (MFI): The myofibril fragmentation index (MFI) of LD was determined after 2, 7 or 14 days of postmortem storage using the procedures described by Culler *et al.* (1978). Duplicate 4 g samples of scissor-minced muscle were homogenised in a blender with 10 volumes of cold buffer (MFI isolating buffer 100 mM KCl, 20 mM potassium phosphate [pH 7], 1 mM EGTA, 1 mM MgCl₂, and 1 mM NaN₃). After several washes, the absorbance of a 0.5 mg/ml solution at 540 nm was determined. MFI was determined by multiplying the absorbance at 540 nm by 200.

Sarcomere length (SL): After 2, 7 or 14 days of postmortem storage, the SL of the LD was determined by removing three longitudinal samples (3 cm × 3 cm × 2 cm) and storing in 5% glutaraldehyde solution for 4 h at 4°C. The SL was determined by laser diffraction (Cross *et al.* 1981).

The data were analysed according to the GLM procedure (SAS 2000). One way analysis of variance was used to analyse the effect of blade tenderisation (0, 1 and 2 passes) and postmortem storage periods (2, 7 and 14 days). Means were considered statistically significant at $P < 0.05$.

RESULTS AND DISCUSSION

In Saudi Arabia, livestock are slaughtered, processed and consumed on the same day or within 24 h of slaughter. Peak meat toughness (particularly that of the LD) is attained about 9–12 h after slaughter in a system in which carcasses are

chilled right after slaughter (Wheeler and Koohmaraie 1994). The exact time when peak toughness is reached in a system that does not chill carcasses is not known. However, it would be safe to assume that under the conditions used in Saudi Arabia and much of the rest of the world, meat is cooked before the development of full rigor or soon after rigor is completed. Our objective was to determine the SSF of LD and BF at the time that it is consumed by Saudi citizens and to determine the beneficial effects of BT and PM using mature camel meat obtained from a local market.

Experiment 1: The results for the effect of blade tenderisation (BT) on slice shear force, cooking loss and cooking time of LD and BF of meat of mature male camels are presented in Table 1. Slice shear force (SSF) for both LD and BF decreased significantly ($P < 0.05$) with 2 BT passes. For BF, SSF decreased ($P < 0.05$) with each successive BT (SSF of 2BT < 1BT < control). Differences in cooking loss and cooking time for control, 1, and 2 BT passes were not significant ($P > 0.05$). For LD, the difference in SSF between control and 1 BT pass was significant, while the SSF of 2 BT passes was significantly less than that of control and 1 BT pass. Two BT passes reduced the SSF of LD and BF by 22.4% and 21.6%, respectively, compared to control treatment. Differences between control, 1 BT pass and 2 BT passes for cooking loss and cooking time were not significant ($P > 0.05$). Because of the physical disruption of the muscle tissue after BT treatment, it is expected that BT treatment would increase cooking loss (CL). Although not statistically different ($P > 0.05$), cooking loss was increased with each BT pass, which is consistent with previous reports about BT (Wheeler *et al.* 1990).

Experiment 2: This experiment was conducted to determine the effect of PM on LD. The results of the effects of PM on LD SSF, cooking loss, cooking time, MFI and SL

Table 1. The effects of the number of blade tenderisation (BT) passes on slice shear force (SSF), cooking loss (CL), and cooking time (CT) of *Longissimus dorsi* (LD) and *Biceps femoris* (BF) muscles of mature male camels

Parameter	Control	1 BT Pass	2 BT Passes	SE	P
n	18	18	18		
SSF (kg)					
LD	14.25 ^a	12.88 ^b	11.06 ^c	0.42	<.0001
BF	28.95 ^a	26.19 ^a	22.70 ^b	1.11	0.0010
CL (%)					
LD	21.06	22.67	23.69	1.35	0.3911
BF	28.87	30.01	33.09	1.68	0.1936
CT (min)					
LD	9.22	9.33	9.94	0.98	0.8548
BF	16.44	16.61	16.39	1.50	0.9941

^{abc} Means with different superscripts within a row differ significantly ($P < 0.05$).

Warner-Bratzler Shear Force (WBSF) = $(0.106283 \times SSF) + 2.27$.

Table 2. The effects of postmortem storage on slice shear force (SSF), cooking loss (CL), cooking time (CT), myofibril fragmentation index (MFI) and sarcomere length (SL) of *Longissimus longissimus dorsi* muscle from mature male camels.

Parameter	2 days	7 days	14 days	SE	P
n	9	9	9	—	—
SSF (kg)	13.98 ^a	9.37 ^b	6.08 ^c	0.56	<0.0001
CL (%)	19.87	24.01	26.29	1.95	0.0824
CT (min)	5.67	5.78	6.11	0.29	0.5430
MFI (%)	53.08 ^c	70.69 ^b	82.67 ^a	3.55	<0.0001
SL (µm)	1.86	1.87	1.88	0.04	0.9525

abc Means with different superscripts within a row differ significantly (P<0.05).

Warner-Bratzler Shear Force (WBSF) = (0.106283×SSF) + 2.27.

are reported in Table 2. Postmortem storage did not have a significant effect (P>0.05) on LD cooking loss or cooking time. The results of cooking loss percentage were consistent with those reported by Purchas *et al.* (1999), who found the cooking loss percentage of 156 beef *Longissimus thoracis* samples aged for 1 day ranged from 11.1 to 33.8% (mean=21.9%) and ranged from 11.9 to 36.5% (mean=22.5%) for samples aged for 20 days. In addition, Shanks *et al.* (2002) mentioned that the CL percentages of beef longissimus steaks were 19%, 23.7% and 24% after 1, 7 and 14 days of postmortem ageing, respectively.

The LD SSF decreased significantly from day 2 to day 7 (P<0.05) and from day 7 to day 14 (P<0.05). MFI also increased significantly from day 2 to day 7 (P<0.05) and from day 7 to day 14 (P<0.05). The obtained results indicated that the LD SSF after 7 or 14 days (9.37 and 6.08 kg, respectively) was lower than that of 1 (12.88 kg) or 2 (11.06 kg) BT passes. Postmortem storage of mature camel meat for 14 days was more effective in reducing SSF (reduction of 7.9 kg or 56.5%) than BT (two passes reduced SSF by 3.2 kg or 22.4%). The effect of postmortem storage on camel LD is very consistent with the effect of postmortem storage on LD of other species (Koohmaraie 1996, Koohmaraie *et al.* 2002, Veiseth and Koohmaraie, 2005, Koohmaraie and Geesink 2006, Hamling *et al.* 2008, King *et al.* 2008).

Resting sarcomere length is generally about 2.2 to 2.4 µm (Wheeler and Koohmaraie 1994). The changes associated with rigor mortis development cause sarcomeres to shorten to about 1.6 to 1.8 µm. The obtained results showed that the sarcomere length increased slightly or did not change with extended postmortem storage from 2 to 14 days (Koohmaraie 1996). Our data about the effect of postmortem storage on SL are consistent with previously published studies.

The results of these studies demonstrate that both BT and 14 days of postmortem storage at 4°C are effective for improving the attributes of mature camel meat under processing conditions used in developing and underdeveloped countries.

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