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Effects of Hot Boning and Postmortem Aging Time on Camel Meat Tenderness

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Abstract. An experiment was conducted to determine the effects of hot boning and postmortem aging time on camel meat tenderness. Six male camels (average carcass weight 133 kg) were used. Longissimus muscles were excised at 1 or 24 h postmortem and aged at 2 °C for 1, 3, 7, 10, 14 d postmortem. At the end of each period, shear force, myofibril fragmentation index (MFI), sarcomere length, drip and cooking losses were determined. Hot boning significantly ($p < 0.05$) increased shear force at day 3 and 7 compared to intact muscle. Postmortem aging has reduced shear force during the first 7 days of postmortem. Most of the increases in myofibril fragmentation index (MFI) happened within the first 7 days of postmortem and MFI was reduced by hot boning compared to intact muscle. Sarcomere length decreased ($p < 0.5$) by hot boning on day 3 and 7 compared to intact muscle. The results of this investigation indicate that hot boning had no effect on camel meat tenderness within the first 24-h postmortem, and camel meat tenderness can be improved by aging up to 7 days of postmortem.

Introduction

Meat tenderness plays an important role for consumer satisfaction and meat price. Consumer satisfaction is the main goal for meat producers and retailers. One of the most important factors affecting consumer satisfaction is meat tenderness. There are different factors affecting meat tenderness, including animal age [1], sex [2], and muscle fiber size [3]. Also, postmortem aging time has been reported to improve meat tenderness in different animal species [4-6]. However, Koohmaraie [7] concluded that beef should be stored for 10-14 d, lamb for 10 d, and pork 5 d to get the maximum benefits of improving meat tenderness during postmortem storage.

The desert Arabian camel (*Camelus dromedarius)* constitutes 17 million heads in the world [8]. In certain areas, camel meat replaced beef and mutton [9]. Camel meat preference comes third [10] and fifth [11] meat of choice among Saudi Arabian citizen.

Several studies have been published concerning the physical characteristics, chemical composition, sensory properties and nutritive values of Najdi camel meat [12-15]. Informations relating to the effect of hot boning and postmortem aging time on camel meat tenderness are needed. Therefore, the objective of the present study is to investigate the effect of hot boning and aging time on the tenderness of camel longissimus muscle.

Materials and Methods

Six Najdi male camels of similar background were slaughtered at Labone farm (Al-Kharj, Saudi Arabia), adressed and weighed. Within 1 h postmortem, the longissimus dorsi muscle (LM) of the right side was hot-boned from each carcass between the 7^{th} and 11^{th} rib region, whereas, the left side was intact and both were shipped to Meat Lab at King Saud University, Riyadh. All hot-boned muscles and intact sides were chilled for 24 h at 2 °C, thereafter, the LM of the intact side was separated from the bone. The muscles were cut into one inch steaks, vacuum-packaged using Turbovac vacuum machine (Model SB45H, hertogenbosch, the Netherlands), and stored at 2 °C for 3, 7, 10, and 14 days. With the exception of drip loss, all measurements were made at 1, 3, 7, 10 and 14 days postmortem for both hot boning and intact muscles.

Drip loss

At 3, 7, 10 and 14 days postmortem, meat samples were removed from the vacuum packages and purge were weighed and percentage of drip loss were calculated.

Cooking loss

Two steaks from each hot boned and intact muscles were weighed and cooked on Teval superbarbecue electric broiler (Teval, France) to an internal temperature of 70°C. Steaks were turned over after reaching 40°C. Internal temperature was monitored by Fisher alarm thermometer (Model No. 15-077-8B, Fisher Scientific, USA). After cooking, steaks were allowed to equilibrate to room temperature (23°C), then weighed and percentage of cooking loss was calculated.

Shear force

Steaks used for cooking loss experiment were used. Six 1.27 cm diameter cores from each steak were removed parallel to the long axis of the muscle fibers, then the cores were sheared perpendicular to the long axis of the fibers using the Warner-Bratzler shear force instrument, and the average value were recorded in kilogram/cm^2.

Myofibril fragmentation index

At 1, 3, 7, 10, 14 d postmortem, myofibril fragmentation index (MFI) were determined on fresh muscle samples according to the procedure of Culler *et al.* [16].

Sarcomere length

Three myofibrils were taken from each cut using forceps and surgical plate. The sarcomere lengths of the myofibrils were determined using the Laser head (Model 2.0MW) according to the method of Cross *et al.* [17].

Statistical analysis

Data were analyzed by split plot design using GLM procedure of SAS [18]. Animal represented the whole plot while, hot boning and intact muscles defined the spilt plot. Treatment effect included five aging times. The means were consider significant at P level of < 0.05.

Result and Discussion

Cooking and drip losses

The effect of hot boning and aging time on cooking and drip losses are presented in Table 1. Storage time and hot boning had little effect on cooking and drip losses. Parrish *et al.* [31] found that until 7 days postmortem storage time, there were no effect on cooking loss. Cooking characteristics were not affected by postmortem aging and hot-boned treatment [20, 22]. Conflicting study was reported by Klont *et al.* [29] who noted that deboning at 24 h after slaughter had led to significantly higher drip loss at 3, 7, and 14 d postmortem compared to 48 h deboning.

Shear force

The Warner-Bratzler shear force results revealed that hot-boned samples had higher ($P < 0.05$) shear force values on days 3 and 7 compared to the intact samples (Table 1). On day one, hot boning had no effect on shear force of camel longissimus muscle compared to intact muscle and this is beneficial to camel meat industry and Saudi consumers who mostly consume camel meat within 24 h of postmortem. This result was in agreement with Whealer *et al.* [19] who noted that hot boning had no effect ($P > 0.05$) on shear force of beef biceps femoris muscle. Schmidt and Keman [20] found that no differences in any palatability traits of longissimus muscle biceps, femoris or semimembranosus muscle that were hot-boned at 1 h postmortem compared with conventional process cuts.

The effect of postmortem aging time on shear force was presented in Table 1. Shear force value decreased gradually as the postmortem aging time increased in both hot boning and intact samples. There was no significant difference on tenderness after 7 and 10 days for the intact and hot boned samples, respectively. These results were in agreement with study of Koohmorie *et al.* [21] who reported that as the postmortem storage time increased, shear force values decreased for beef, lamb and pig and the majority of the improvement in tenderness occurred within 7 d of aging postmortem time. However, increasing aging time far over 7 days has no improvement in beef tenderness [22-24].

Table 1. Effects of hot boning and postmortem aging time on camel meat traits

Measurements	Postmortem (day)	Hot-boned	Intact
Cooking loss			
	1	$28.00^{a}{}_{w}$	$35.53^{b}{}_{w}$
	3	$30.04^{a}{}_{w}$	$29.71^{a}{}_{y}$
	7	$37.90^{a}{}_{yx}$	$37.70^{a}{}_{w}$
	10	$35.03^{a}{}_{yz}$	$36.60^{a}{}_{w}$
	14	$31.05^{a}{}_{wxz}$	$39.00^{b}{}_{w}$
Drip loss			
	1	ND	ND
	3	$3.50^{a}{}_{w}$	$3.38^{a}{}_{w}$
	7	$6.50^{a}{}_{w}$	$4.52^{a}{}_{w}$
	10	$6.26^{a}{}_{w}$	$9.57^{a}{}_{y}$
	14	$5.12^{a}{}_{w}$	$9.50^{b}{}_{y}$
Shear force (Kg/cm^2)			
	1	$4.02^{a}{}_{w}$	$4.11^{a}{}_{w}$
	3	$4.36^{a}{}_{w}$	$3.47^{b}{}_{wx}$
	7	$3.75^{a}{}_{wx}$	$2.98^{b}{}_{yx}$
	10	$3.03^{a}{}_{yx}$	$3.01^{a}{}_{wx}$
	14	$2.81^{a}{}_{y}$	$2.90^{a}{}_{yx}$
MFI			
	1	$25.21^{a}{}_{w}$	$29.71^{a}{}_{w}$
	3	$36.52^{a}{}_{y}$	$51.30^{b}{}_{y}$
	7	$62.93^{a}{}_{x}$	$79.05^{b}{}_{x}$
	10	$86.30^{a}{}_{z}$	$83.02^{a}{}_{xz}$
	14	$90.02^{a}{}_{z}$	$91.01^{a}{}_{z}$
Sarcomere length (μm)			
	1	$1.72^{a}{}_{w}$	$1.67^{a}{}_{w}$
	3	$1.34^{a}{}_{y}$	$1.63^{b}{}_{w}$
	7	$1.51^{a}{}_{yz}$	$1.70^{a}{}_{w}$
	10	$1.57^{a}{}_{wxz}$	$1.73^{b}{}_{w}$
	14	$1.48^{a}{}_{yxz}$	$1.71^{b}{}_{w}$

^{ab} means in the same row followed by different superscripts are significantly different ($p<0.05$).
$^{w-z}$ means in the same column followed by different supscripts are significantly different ($p<0.05$).
ND = Not determined.
N = 6.

The little change in shear force after 7 and 10 day of postmortem may be due to the connective tissue component rather than myofibril components [25]. The response of connective tissue to aging is generally theorized to be less than that of myofibril component [26].

Myofibril fragmentation index MFI

The effect of hot boning and postmortem aging time on MFI of camel meat are presented in Table 1. MFI increased progressively during the first 7 days postmortem, however, 58% and 80% of the changes in MFI values occurred during the first 7 day postmortem for hot boning and intact muscles, respectively. Little changes have been

observed for MFI from day 7 to day 14. The changes in MFI have been reported to relate to the degradation of the myofibrilar protein during postmortem storage [27]. Taylor *et al.* [23] found that 46% of the increase in MFI had occurred by 3 d postmortem. Wheeler *et al.* [28] reported that MFI significantly increased after 3 d postmortem storage. Other study by Koohmaraie *et al.* [23] monitor postmortem changes in MFI begin immediately after slaughter and continuing until 7 and 14 d postmortem and found that 61 to 64% of the increase in MFI had occurred by 3 days of postmortem compared with 7 or 14 d. In this study, the parallel increases in MFI values and decrease shear value from day 1 to day 7 are the most dramatic and the change from day 7 to day 14 in shear value are in turn reduced.

Sarcomere length

Sarcomere length was decreased significantly ($p< 0.05$) by hot boning from day 1 to day 3 (table 1); the decrease was 22.1% on day 3 compared to day 1. This result was supported by klont *et al.* [29] who reported that sarcomere length was significantly ($P< 0$ .05) shorter for loin deboning at 24 h than for loin from the same carcass deboning at 48 h. Herring *et al.* [30] noted that sarcomere of bovine muscle length was shorter when excised from its attachment. Despite the small decrease in sarcomere length on day 3 for the intact sample, there was no significant change on day 3, 7, 10, and 14 postmortem compared to day 1. This result in agreement with the study of Parrish *et al.* [31] who noted that the improvement of bovine muscle did occur in tenderness between 1 and 3 days postmortem, but very little change occurred in sarcomere length. Improved tenderness during postmortem aging, therefore, seems related to the fragmentation of myofibrils than to the changes in sarcomere length. Wheeler *et al.* [32] concluded that the increases in tenderness during aging were due to proteolysis degradation not to the increases of sercomere length. Other study reported that the increase in tenderness does not seem to parallel increases in sarcomere length [31].

Based on our results, we concluded that camel meat could be hot-boned and consumed within 24 h and the optimum aging time for improving camel meat tenderness was 7 days.

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تأثير فصل العضلة عن اللحم والتعتيق على فترات زمنية مختلفة على طراوة لحوم الإبل

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ملخص البحث. أجريت هذه التجربة لدراسة تأثير فصل العظم من اللحم بعد الذبح مباشرة والتعتيق على فترات زمنية مختلفة على طراوة لحوم الإبل. تم أخذ العضلة العينية ما بين الضلع ٧-١١ من كلا الجانبين من ٦ ذبائح من الإبل (متوسط وزن الذبيحة ١٣٣ كجم) ثم إزالة وتقطيع العضلة العينية إلى شرائح بسمك ٢،٥ سم بعد ساعة واحدة و٢٤ ساعة بعد الذبح، ومن ثم تغليفها تحت التفريغ الهوائي وتخزينها لمدة ١، ٣، ٧، ١٠ ، ١٤ يوم بعد الذبح على درجة حرارة ٢°م. عند نهاية كل فترة تخزين ، تم عمل القياسات التالية: قوة القطع للعضلة المطبوخة، درجة تكسير الليفة، طول السركومير وفقد الرطوبة أثناء الطبخ والتخزين. أوضحت النتائج أن فصل العضلة بعد الذبح مباشرة زاد من قوة القطع معنوياً ($P< 0.05$) في الأيام ٣ و٧ مقارنة بالعضلات المفصولة بعد ٢٤ ساعة من الذبح. وجد أن السبعة أيام الأولى من فترة التعتيق قللت بشكل واضح من قوة القطع أما في اليوم ١٠ و١٤ فكان التغير قليل. كان معظم التغير في درجة تكسير الليفة خلال السبعة أيام الأولى بعد الذبح وأن فصل العضلة عن العظم بعد الذبح مباشرة قلل من درجة تكسير العضلة مقارنة بالفصل بعد ٢٤ ساعة. انخفض طول السركومير معنوياً ($P< 0.05$)عند فصل العضلة عن اللحم بعد ساعة واحدة من الذبح في يوم ٣ و ٧ مقارنة بالفصل بعد ٢٤ ساعة. نستنتج من هذه الدراسة أن فصل اللحم عن العظم خلال ٢٤ ساعة الأولى من الذبح لا يؤثر على طراوة لحوم الإبل وانه بالإمكان زيادة طراوة لحوم الإبل بالتعتيق لمدة ٧ أيام بعد الذبح.