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The influence of seasonal temperatures on meat quality characteristics of hot-boned, *m. psoas major* and *minor*, from goats and sheep

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Abstract

Samples of *psoas major and minor* muscles were randomly collected weekly from 203 (99 hot and 104 cool seasons) Omani goats, 215 (106 hot and 109 cool seasons) Omani sheep, 212 (104 hot and 108 cool seasons) Somali goats, 242 (127 hot and 115 cool seasons) Somali sheep and 211 (110 hot and 101 cool seasons) Australian Merino sheep slaughtered at the Central Slaughterhouse in Oman to investigate the effect of season on meat quality. The collection period was during November 2004–October 2005 and divided into two seasons according to ambient temperatures and relative humidity. These were termed: cool season (average temperature of 21 °C and 59% relative humidity and hot season (average temperature of 35 °C and 47% relative humidity). Muscles collected during the hot season had significantly ($P < 0.05$) higher ultimate pH values (5.78) than those collected during the cool season (5.65). Myofibrillar fragmentation index was significantly ($P < 0.05$) higher for hot season samples (86.88%) than for cool season samples (85.59%). Expressed juice was significantly ($P < 0.05$) higher for cool season samples (36.84) than for hot season samples (35.74). Goat meat from the hot seasonal group was significantly ($P < 0.05$) darker than the cold season group based on L^* (37.6 vs. 39.6), a^* (20.0 vs. 23.3) and b^* (3.6 vs. 4.2) colour measurements. These results indicated that high ambient temperatures had caused an increase in muscle ultimate pH leading to significant effects on meat quality.

Keywords: Sheep; Goat; *Psoas major and minor*; Warner–Bratzler shear force; Meat quality; Sarcomere length; Myofibrillar fragmentation index

1. Introduction

Animal performance is adversely affected with a combination of any of high ambient temperatures, relative humidity, air movement and solar radiation (Hahn & Mader, 1997). Numerous energetic adaptations have evolved that attenuate the animal's response to hot environments which may limit its ability to cope with specific types of environmental stressors (Nelson & Drazen, 2000). Body temperature increases when the ambient temperature is above the upper critical temperature of 32 °C which may cause several physiological side effects and economic impact on animal output (Anderson, 1989; Degen & Young, 2002).

High environmental temperatures depress utilisation of energy (Denek et al., 2006). However, there would be marked rise in energy expenditure from animal's body reserves due to endocrine responses to encounter the effects of heat stress (Costa et al., 2006; Nelson & Drazen, 2000; Shinde, Raghavendra, Sankhyan, & Verma, 2002). This would lead to depletion of muscle glycogen the major source of energy for muscle metabolism low glycogen in muscles before slaughter subsequently increases the ultimate pH of meat, and results in low residual levels of glucose (Bray, Graafhuis, & Chrystall, 1989). A high post-mortem pH is accompanied with high water-holding

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capacity, sticky texture, low shear force value and a dark colour, which is probably due to low muscle glycogen storage (Grandin, 1996; Kreikemeier, Unruh, & Eck, 1998). Seasonal high temperatures (>35 °C) may affect muscle glycogen level and subsequent ultimate pH, which could present one of the significant factors which cause deterioration of meat quality characteristics.

The aim of the present study was to investigate the influence of ambient temperatures on meat quality characteristics of three breeds of sheep and two breeds of goats *m. psoases major and minor*.

2. Materials and methods

2.1. Environmental parameters

Weather data including temperature and relative humidity were recorded at the area of study by a weather monitoring station at the Agricultural Experiment Station, Sultan Qaboos University close by to the slaughterhouse.

2.2. Muscle samples

Animals were slaughtered following routine commercial slaughterhouse procedures according to Halal methods. Samples had been randomly collected from animals slaughtered in both seasons where Omani goats and sheep were exposed to similar routine pre-slaughter handling procedures. Animals are generally transported in open trucks for distances up to 100 km. They are subsequently held in the slaughter house lairage for 1–2 h before slaughter. Australian sheep and Somali sheep and goats are kept in the lairage for 2–3 days. Muscle samples were randomly collected during the period November 2004–March 2005 (cool season: average temperature of 21 ± 1.4 °C and 59 ± 1.6% relative humidity) and April 2005–October 2005 (hot season: average temperature of 35 ± 1.7 °C and 47 ± 7.5% relative humidity) from 1083 sheep and goats slaughtered at the Muscat Municipality slaughterhouse, Sultanate of Oman (Table 1). All animals slaughtered during a random day per week during the collection period were sampled (21 and 31 collection days for cool and hot seasons, respectively). Samples of *psoas major and minor* muscles were collected from 203 (99 hot and 104 cool seasons) Omani goats, 215 (106 hot and 109 cool seasons) Omani sheep, 212 (104 hot and 108 cool seasons) Somali goats, 242 (127 hot and 115 cool seasons) Somali sheep and 211 (110 hot and 101 cool seasons) Australian Merino sheep.

Table 1
Seasonal condition and distribution of the experimental animals

	Hot season	Cool season
Ambient temperature (°C)	32.1–36.4	20.0–23.6
Relative humidity (%)	38.1–60.7	56.8–60.1
Omani goat		
Number of animal	99	104
Carcass weight (kg)	18–19	18–20
Somali goat		
Number of animal	104	108
Carcass weight (kg)	12–13	12–15
Omani sheep		
Number of animal	106	109
Carcass weight (kg)	20–25	20–28
Somali sheep		
Number of animal	127	115
Carcass weight (kg)	15–17	15–18
Australian Merino		
Number of animal	110	101
Carcass weight (kg)	30–35	30–38

Following slaughter, carcasses were placed in a room at 20–25 °C (in hot season) and 18–22 °C (in cool season) for 30 min, and then the whole right and left *m. psoases major* and *minor* were removed using a scalpel blade and scissors. They were kept in zipped plastic bags and transferred to the meat laboratory in a cool box, then placed in a chiller (3–4 °C) for 24 h before analysis.

2.3. Meat quality

Muscle pH of *m. Psoas major* and *minor* was measured at 40 min then hourly between 2 and 12 h post-mortem using a portable pH meter (Hanna waterproof pH meter, Model Hi 9025) fitted with a polypropylene spear-type gel electrode (Hanna Hi 1230) and a temperature adjusting probe. At 24 h post-mortem, meat quality measurements included ultimate muscle pH, sarcomere length, expressed juice, myofibrillar fragmentation index and colour (CIE L^*, a^* and b^*) were determined. The ultimate pH was assessed by homogenizing 1.5–2 g muscle tissue in 10 ml of neutralized 5 mM sodium iodoacetate at 22 °C. Muscle samples were randomly C (Ultra Turrax T25 homogenizer) and measuring the pH with a Metrohm pH meter (Model No. 744) with a glass electrode.

Sarcomere length was measured using a helium–neon laser with wavelength of 632.8 nm (Spectra-physics model 102 2 mW laser head). Sarcomere lengths were calculated using a conversion table using an equation described by Bouton, Carroll, Harris, and Shorthose (1973).

Expressed juice was assessed using a filter paper method, as the total wetted area less the meat contact area (cm^2) relative to the weight of the sample (g). Approximately 60 min after exposing the fresh muscle surface, CIE L^*, a^*, b^* light reflectance coordinates of the muscle surface were measured at room temperature (25 ± 2 °C) using a Minolta Chroma Meter CR-300 (Minolta Co., Ltd., Japan), with a colour measuring area of 1.1 cm diameter.

Myofibrillar fragmentation index (MFI) was measured using a modification of the method of Johnson, Calkins, Huffman, Johnson, and Hargrove (1990). This measured the proportion of muscle fragments that passed through a 231-μm filter after the sample had been subjected to a standard homogenization treatment. A 5 g (±0.5 g) sample of diced (6 mm^3 pieces) was added to 50 ml of cold physiological saline (85% NaCl) plus five drops of antifoam A