Meat Quality and Composition of *Longissimus thoracis* from Arabian Camel (*Camelus dromedaries*) and Omani Beef: A Comparative Study

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ABSTRACT

The aim of the study was to compare meat quality and composition between Omani camel and beef meats at similar age range. Samples of left *longissimus thoracis* muscle (10^{th} -13^{th} ribs) were collected from 15 (2-4 years old) Arabian camels (*Camelus dromedaries*), and 20 Omani beef cattle (2-3 year-old). Moisture, protein, fat and ash were determined on freeze-dried ground muscle samples. Macro- and micro-mineral contents were determined using an Inductively Coupled Plasma Emission Spectrometer (ICP). Meat quality including ultimate muscle pH, Warner-Bratzler shear force, sarcomere length, myofibrillar fragmentation index, expressed juice, cooking loss percent, and colour *L**, *a**, *b** were measured using standard methods. The camel longissimus muscle had slightly lower moisture (70.8% vs. 72.3%), protein (21.6% vs. 22.2%), ash (1.3 vs. 1.5) but significantly (P<0.01) lower fat (2.8 vs. 7.8%) than beef muscle. The calcium contents of camel and beef *longissimus thoracis* muscle were 23.9 vs. 19.4, magnesium 51.0 vs. 66.1, potassium 762 vs. 1326 (P<0.01), sodium 181 vs. 166 and phosphorus 417 vs. 522 mg/100g, respectively. Camel muscles had similar Warner Bratzler-shear force value (6.98 vs. 6.45 kg) and sarcomere length (1.89 vs. 1.83 µm) to beef muscles. However, expressed juice was significantly (P<0.05) lower for camel (21.3 cm^2/g) than for beef (34.8 cm^2/g) muscles. Camel meat had slightly darker colour than beef based on *L** (31.5 vs. 33.7), less red *a** (16.3 vs.18.4) and *b** (7.6 vs. 6.6). These results indicated that meat quality and composition of Arabian camel *longissimus thoracis* muscle is comparable to that of Omani beef muscle, when slaughtered at similar age range.

Key Words: Camel, Beef, Longissimus thoracis, Meat quality, Meat composition

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1. Introduction

The came is a good source of meat in areas where the climate adversely affects other animal's production efficiency. Camel can provide a substantial amount of high quality meat. The demand for camel meat appears to be increasing due to health reasons, as they produce carcasses with less fat as well as having less cholesterol and relatively high polyunsaturated fatty acids than other meat animals (Knoess, 1977; Mukasa-Mugerwa, 1981; Elgasim et al., 1987; El-Faer et al., 1991; Elgasim and Alkanhal, 1992; Rawdah et al., 1994; Dawood and Al-Alkanhal, 1995). This is an important factor in combating the risk of cardiovascular disease, which is attributed to saturated fat consumption (Giese, 1992). Camel meat is also used for remedial purposes for diseases such as hyperacidity, hypertension, pneumonia and respiratory disease as well as an aphrodisiac (Kurtu, 2004).

Meat is one the major products of camel (Wilson, 1978). The Arabian camel is perhaps the most neglected species among the domestic animals (Knoess, 1977) as it is predominantly found in semi-arid, arid tropical areas where poor nutrition and husbandry are the major shortcomings. Camel meat should be efficiently exploited to meet the increasing demand for more

animal protein, as malnutrition is still a serious problem for poorer people in the less developed countries. Compared to other livestock, the camel is unique for having an exceptional ability to survive and thrive under adverse climatic conditions of high ambient temperatures, low rainfall and scarcity of feed.

Currently, general consumers view is that camel meat is unacceptably tough because, camel meat comes mostly from old females and males that are primarily kept for milk, racing, and transportation rather than for meat production (Kurtu, 2004). However, some information indicated that the quality of meat from young camels is comparable to beef (Kattami, 1970; Knoess, 1977; Elqasim et al. 1987; Finke, 2005). The quality of camel meat has recently became an important aspect in the marketing of meat products. An efficient marketing system for the camel meat needs more information on meat quality in relation to other species. The aim of this study was to compare the Arabian camel *longissimus thoracis* muscle chemical composition, macro- and micro-minerals and meat quality characteristics with the Omani beef muscles slaughtered at comparable age range.

2. Materials and Methods

2.1. Sample Collection

Fifteen and 20 *longissimus thoracis* samples were randomly collected from intact male Arabian one-humped camels (2-4 year) and 20 Omani beef (2-3 year) slaughtered at the Muscat Municipality slaughterhouse, Sultanate of Oman. Animals were slaughtered after having been held in a lairage for one to two hours and dressed following routine commercial slaughterhouse procedures according to Halal method. The *Longissimus thoracis* muscles of each left side, between the 10-13 ribs (weighing 500-600 g) were removed within 60 minutes post slaughter. Samples were kept in zipped plastic bags and transported in an insulated cool box. They were then transferred to a chiller (2-3^{o}C) within about 2-2.5 hrs post mortem for 48 hrs before running chemical composition and quality measurements.

2.2. Chemical Analysis

All visible fat was removed from the muscle samples before they were placed in plastic containers and dried in an Edward freeze dryer (Modulyo) for 5 days under 80-mbar pressures at –60ºC. They were then ground to a homogenous mass in a grinder then used for chemical analyses. The proximate chemical composition of the muscle tissue was determined according to standard methods of AOAC (2000). Crude protein was determined using a Foss Tecator Kjeltec 2300 Nitrogen/Protein Analyzer. Fat was determined by Soxhlet extraction of the dry sample, using petroleum ether. Ash content was determined by ashing samples in a muffle furnace at 500ºC for 24 hr.

Determination of macro- and micro-mineral levels in *longissimus thoracis* muscle was carried out after complete digestion using a microwave laboratory system type Milestone 1200 MDR, with a maximum temperature of 200^{o}C in closed polytetrafluoroethylene (PTFE) bombs. A mixture of concentrated HNO_3 and 30% H_2O_2 was used for the digestion of samples. An Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) type Perkin Elmer Model 3300, equipped with a low- flow Gem Cone nebulizer in addition to an ultrasonic nebulizer for the detection of very low concentrations was used for chemical analyses.

2.3. Meat Quality

Meat quality measurements including ultimate pH, expressed juice, cooking loss,

Warner-Bratzler shear force, Sarcomere length, Myofibrillar fragmentation index, and colour *L**, *a**, *b** were determined. The ultimate pH was assessed in homogenates at 20-22^{o}C (using an Ultra Turrax T25 homogeniser) of duplicate 1.5-2 g of muscle tissue in 10 ml of neutralized 5-mM sodium iodoacetate and the pH of the slurry measured using a Metrohm pH meter (Model No. 744) with a glass electrode. Chilled muscle samples (13 mm x 13 mm cross section) for assessment of shear force by a digital Dillon Warner-Bratzler (WB) shear device from muscle samples cooked in a water bath at 70^{o}C for 90 min. Sarcomere length by laser diffraction was determined using the procedure described by Cross et al. (1980/1981). Myofibrillar fragmentation index (MFI) was measured using a modification of the method of Johnson et al. (1990). This basically measured the proportion of muscle fragments that passed through a 231-µm screen after 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 5 drops of antifoam A emulsion (Sigma Chemical) in a 50 ml graduated cylinder, and homogenized at ¼ speed using an 18 mm diameter shaft on an Ultra-Turrax homogenizer for 30-secomd periods separated by a 30 second rest period. The homogenate was poured into a pre-weighed filter (231 x 231 µm holes). The filter typically ceased dripping after 2-3 hrs, at which time they were dried at 26-28^{o}C in an incubator for 40 hrs before being re-weighed. The MFI values presented herein were calculated as 100 minus the percentage of the initial meat sample weight that remained on the filter. Expressed juice was assessed by a filter paper method, as the total wetted area less the meat area (cm^2) relatively to the weight of the sample (g). Approximately 60 min after exposing the fresh surface, CIE *L**, *a**, *b** light reflectance coordinates of the muscle surface were measured at room temperature (20±2^{o}C) using Minolta Chroma Meter CR-300 (Minolta Co., Ltd., Japan).

2.4. Statistical Analysis

The general liner model (GLM), ANOVA procedure within SAS (1993) was used to compare the differences in chemical composition, mineral content and meat quality characteristics of *longissimus thoracis* muscles between the Arabian (one-humped) camel and Omani beef. Significant differences between means were assessed using the least-significant-difference procedure.

3. Results and Discussion

3.1. Chemical Composition

The mean and range of moisture, protein, fat and ash of the Omani camel and beef *longissimus thoracis* samples are given in Table 1. Generally the values for chemical composition were within the reported range for camel meat (Babiker & Yousif, 1990; El-Faer et al., 1991; Elgasim and Alkanhal, 1992; Pérez, et al., 2000; Cristofanelli et al., 2004; Kadim, et al., 2006) and beef meat (USDA, 1986; Mills, et al., 1992). However, the present study showed that the Arabian camel meat contained slightly lower moisture, protein and ash levels than the Omani beef meat (Table 1). The importance of moisture is in its pronounced effects on meat shelf-life, processing potential and sensory characteristics. In agreement with the present finding, Elgasim and Alkanhal (1992) reported that camel meat has slightly less protein content than that of beef. However, protein content in camel is apparently related to animal age (Kadim et al., 2006). Naser et al. (1965) reported that meat of less than five years old camel has similar protein as in meat of steer, while

meat of camels more than 5 years old contains higher protein than of bull, cow and steer. In contrast, Babiker and Tibin (1986) found that camel meat has significantly (P<0.05) greater total protein than beef. Nevertheless, it may be concluded that the camel meat is a good potential source of high quality protein in harsh climate arid regions.

Fat content of *longissimus* muscle in the Omani beef (7.8%) were significantly (P<0.01) higher fat % than camel meat (2.8%). Compared to the study of Finke (2005) on beef, dromedary meat appears to contain lower fat. In contrast, Hammam et al., (1962) reported that camel *longissimus* muscle had more fat and less moisture and protein contents than beef. The lower range of fat content of the current study confirmed that camel meat could be much leaner than beef meat, especially if it is slaughtered at a younger age. These results support the potential understanding that the camel meat is healthier than other red meats (Elqasim et al., 1987; El-Faer et al., 1991; Elqasim and Alkanhal, 1992; Dawood and Al-Alkanhal, 1995). Similarly Elgasim and Alkanhal (1992) reported that camel meat has a fat content of 2.6%, which was lower than that of beef (4.7%). The moisture to protein ratio of the camel meat was similar to those of beef (3.28 vs. 3.26). The moisture to protein ratio is a reflection of the suitability of meat for processing (Forrest et al., 1975). The camel meat in the present study had a slightly less ash content (1.3%) than that of beef (1.5%), which is in agreement with the finding of Elgasim and Alkanhal (1992), who reported that 0.9% and 1.5% ash for camel and beef meat, respectively.

Table 1. Means and standard error of mean (SEM) for chemical composition of camel and beef *M. longissimus thoracis* slaughtered at similar age range

Measurement	**Species**	**Mean**	**SEM**	**Min**	**Max**
Moisture%	Camel	70.8	1.23	69.2	72.8
	Beef	72.3	1.35	70.4	74.3
Significance[1]		NS			
Fat%	Camel	2.8	0.95	2.1	4.6
	Beef	7.8	1.01	5.9	9.8
Significance[1]		**			
Protein%	Camel	21.6	0.65	19.4	24.5
	Beef	22.2	0.99	20.2	24.9
Significance[1]	-	ns			
Ash%	Camel	1.3	0.03	1.1	1.5
	Beef	1.5	0.06	1.3	1.6
Significance[1]		ns			

[1] Significance: ns not significant, * P<0.05, ** P<0.01.

3.2. Mineral Composition

The levels of macro- and micro-elements in Tables 2 and 3 for the Arabian camel and Omani beef meats are within the range reported for camel (El-Faer, et al., 1991, Elgasim and Alkanhal, 1992;) and beef (USDA, 1986). They indicate that camel meat is comparable in mineral composition to beef except for potassium content. Camel and beef meat like other red meats contained higher levels of potassium than the other minerals (Greenfield et al., 1987a,b; Elgasim and Alkanhal, 1992). Beef had significantly (P<0.01) higher potassium than camel meat (1326 versus 762 mg/kg). Potassium was the most abundant element followed by phosphorus, sodium, magnesium and calcium, respectively. Similar findings were reported by Elgasim and Alkanhal (1992), Dawood and Alkanhal (1995), El-Faer et al. (1991) and Kadim et al. (2006) for Arabian camel.

Table 2. Mean and standard error of mean (SEM) of macro elements (mg/100g) for the Arabian camel and beef *M. longissimus thoracis* slaughtered at similar age range.

Measurement	**Species**	**Mean**	**SEM**	**Min**	**Max**
Calcium (Ca)	Camel	23.9	8.90	19.2	27.3
	Beef	19.4	7.81	17.9	23.4
Significance[1]		NS			
Magnesium (Mg)	Camel	51.0	3.52	44.7	57.3
	Beef	66.1	4.95	58.6	70.2
Significance[1]		ns			
Sodium (Na)	Camel	181	18	105	248
	Beef	166	13	120	226
Significance[1]		NS			
Potassium (K)	Camel	762	59	471	1003
	Beef	1326	72	817	1550
Significance[1]		**			
Phosphorus (P)	Camel	417	38	250	574
	Beef	522	34	301	671
Significance[1]		ns			

[1] Significance: ns not significant, * P<0.05, ** P<0.01

Table 3. Mean and standard deviation of mean (SEM) of micro elements (mg/100g) for the Arabian camel and beef *M. longissimus thoracis* slaughtered at similar age range

Measurement	**Species**	**Mean**	**SE**	**Min**	**Max**
Cadmium (Cd)	Camel	0.012	0.002	0.005	0.024
	Beef	0.001	0.001	0.001	0.001
Significance[1]		ns			
Chromium (Cr)	Camel	0.025	0.0026	0.020	0.048
	Beef	0.030	0.0018	0.020	0.037
Significance[1]		ns			
Nickel (Ni)	Camel	0.101	0.0159	0.050	0.113
	Beef	0.153	0.0112	0.067	0.198
Significance[1]		ns			
Lead (Pb)	Camel	0.066	0.0131	0.010	0.114
	Beef	0.020	0.0041	0.011	0.084
Significance[1]		ns			
Cobalt (Co)	Camel	0.010	0.0011	0.010	0.011
	Beef	0.011	0.0007	0.010	0.012
Significance[1]		ns			
Molybdenum (Mo)	Camel	0.040	0.0037	0.024	0.132
	Beef	0.021	0.0047	0.012	0.048
Significance[1]		ns			
Beryllium (Be)	Camel	0.012	0.0016	0.005	0.023
	Beef	0.014	0.0013	0.007	0.019
Significance[1]		ns			
Vanadium (V)	Camel	0.014	0.0014	0.013	0.104
	Beef	0.018	0.0021	0.014	0.101
Significance[1]		ns			

[1] Significance NS not significant

3.3. Meat Quality Characteristics

The mean and range of meat quality characteristics of the camel and beef meats are given in Table 4. Values for meat quality characteristics including ultimate pH, shear force value, sarcomere length, myofibrillar fragmentation index, expressed juice, cooking loss, colour (*L**, *a**, *b**) were within the range reported for camel meat (Babiker and Yousif, 1990; Cristofanelli, et al., 2004, Shariatmadari and Kadivar, 2006; Kadim et al., 2006).

Table 4. Means and standard error of mean (SEM) for meat quality characteristics of the Arabian camel and beef *M. longissimus thoracis* slaughtered at similar age range

Measurement	**Species**	**Mean**	**SEM**	**Min.**	**Max.**
Ultimate pH	Camel	5.89	0.134	5.56	6.61
	Beef	5.75	0.144	5.51	5.89
Significance[1]		ns			
Shear value (kg/cm^2)	Camel	6.98	0.813	5.45	9.79
	Beef	6.45	0.837	5.25	9.71
Significance[1]		ns			
Sarcomere length (µm)	Camel	1.89	0.022	1.67	1.99
	Beef	1.83	0.018	1.65	1.89
Significance[1]		ns			
Myofibrillar fragmentation Index%	Camel	81.9	1.83	76.70	93.75
	Beef	80.2	1.95	77.69	89.25
Significance[1]		ns			
Expressed juice	Camel	21.3	1.19	18.15	28.63
	Beef	34.8	1.21	29.92	39.80
Significance[1]		*			
Cooking loss %	Camel	26.1	1.06	24.9	27.5
	Beef	31.2	1.10	27.4	35.7
Significance[1]		*			
Colour parameters					
*L** (lightness	Camel	31.5	1.45	29.5	33.2
	Beef	33.7	1.61	31.3	36.2
Significance[1]		ns			
*a** (redness)	Camel	16.3	1.02	14.7	19.1
	Beef	18.4	1.11	16.9	20.1
Significance[1]		ns			
*b** (yellowness)	Camel	7. 6	0.48	5.9	9.8
	Beef	6.6	0.77	4.3	7.8
Significance[1]		ns			

[1] Significance: ns not significant, * P<0.05

The ultimate pH value of the Arabian camel meat was within the normal range of most meat animals (Greaser, 1986; Cristofanelli et al, 2004: Shariatmadari and Kadivar, 2006: Kadim et al., 2006), but camel meat had slightly higher ultimate pH value (5.89) than of beef meat (5.75). Ultimate pH at 72 h post-mortem was significantly (P<0.05) higher (5.90) in three year-old camel leg meat relative to

Holstein cow (5.63) (Shariatmadari and Kadivar, 2006). The ultimate pH value of meat is the result of combination of many factors including pre-slaughter handling, post mortem treatment and muscle physiology (Marsh, 1977; Thomason, 2002). The low muscle glycogen stores at slaughter do not allow the development of a desirable pH of the lean tissue after slaughter (Ashmore et al., 1973). The slight difference in ultimate pH between the two species in the present study might not be due to species differences only but due to differences in age caused by proportions of muscle fiber types or lower muscle glycogen stores at the time of slaughter. Fiber types have been shown to differ at various stage of development and therefore have different metabolic functions in the body (Ashmore, et al., 1972).

Of all the attributes meat quality, tenderness is rated most important by the average consumer and appears to be sought at the expense of other traits such as flavour or color (Lawrie, 1979). The value for shear force was similar between camel (6.98 kg/cm^2) than for beef meat (6.45 kg/cm^2). This study indicated that camel can produce a tender meat, which comparable to beef, when slaughtered at below three years old. Similar conclusion was reported by Kadim et al., (2006). Similarly, myofibrillar fragmentation index shows slight difference between the two species in the present study (Table 4**).** However, Shariatmadari and Kadivar (2006) found that three year old one-humped camel had significantly lower shear force value (5.09) than Holstein cows (6.39). In excised muscles that are cooled while still a pre-rigor condition, cold shortening might take place. Therefore, some of the muscles in the present study might have undergone cold-shortening, which has been shown to be associated with high shear force and low sarcomere length. Any differences due to species may be related to histological changes that make place in muscle structure and composition as animals mature, particularly in the connective tissue (Asghar and Pearson, 1980). The difference in shear force values between the camel and beef meat in the present study was not significant, suggesting that it may be due to connective tissue content.

Meat from camel *longissimus* muscle was slightly darker (31.5 vs. 33.7 *L**), less redder (16.3 vs. 18.4 *a**) and more yellow (7.6 vs. 6.6 *b**) than that of beef (Table 4). The colour values of the present study for both species were relatively higher than those reported by Shariatmadari and Kadivar (2006) for Iranian camel and Holstein cow. The latter authors found that the camel meat had slightly higher *L** (43.2 vs. 39.0), *a** (12.7 vs. 11.4) and *b** (12.0 vs. 10.3) than cow meat. This darker color is more likely a result of increased myoglobin content (Lawrie, 1979) due to species differences. Other factors causing this phenomenon include muscle fiber type (Faustman & Cassens, 1990; Abril et al., 2001). Post-mortem protein degradation increases light scattering properties of meat and thereby increase *L**, *a** and *b** values (Offer, 1991), which is also directly related to the pH (Abril, et al., 2001). In the present study, the moderately high pH values from camel meat might have led to degradation of more protein. Abril et al. (2001) reported that reflectance spectrum value for beef *longissimus thoracis* was higher at ultimate pH above 6.1.

Expressed juice is an important meat quality characteristic because of its influence on the nutritional value, appearance and palatability. In the present study, expressed juice was significantly affected by species, with camel meat having lower ($P<0.05$) values than beef (21.3 vs. 34.8 mg/cm^3) (Table 4). In contrast, Shariatmadari and Kadivar (2006) found no significant difference in expressed juice between camel and cow meat. The difference in expressed juice of

the present study may have also been due to variations in fat content. Miller et al. (1968) found a decrease in water-holding capacity as fat levels increase due to an increase in the ratio of moisture to protein. The current findings are for muscles removed from the carcass pre-rigor, which may cause some muscle stimulation. This cause a strong contraction that takes place when muscle is removed soon after slaughter (Bendall, 1973). Meat of a high pH value has a greater water holding capacity than low pH (MacDougall, 1982; Abril, et al., 2001). Moreover, camels *longissimus* muscle had significantly ($P<0.05$) lower cooking loss percent than beef muscle (Table 4). The decreased binding ability of meat, higher moisture content and lower degree of marbling may contribute to the variations.

4. Conclusion

This study indicated that camel meat is comparable to the beef in nutritive value and meat quality characteristics. Moreover, it has an edge over beef due to its low intramuscular fat content. In view of the findings of present study and its unique adaptability to the harsh environmental conditions, the Arabian camel probably a useful potential source of meat particularly in the arid tropics.

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