A Review of the Nutritive Value and Meat Quality Characteristics of the Dromedary (*Camelus dromedaries*) Camel Meats

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Abstract

The dromedary camel is a good source of milk and meatin harsh areas where the climate adversely affects the survivalof other livestock. The dromedary has unique physiological characters, including a great tolerance to various temperatures, solar radiation, water scarcity, rough topography and poor vegetation. Dromedaries are mostly raised under traditional systems on low feeding system and slaughtered at old ages. In general, dromedary camel carcasses contain about 57% muscle, 26% bone and 17% fat with fore-quarters significantly heavier than the hind halves. Camel lean meat contains about 78% water, 19% protein, 3% fat, and 1.2% ash with a small amount of intramuscular fat, which renders it a healthy food forgrowing human population. The amino acid and mineral contents of camel meat are often higher than other meat animals, probably due to lower intramuscular fat levels.Camel meat has been processed into burgers, patties, sausages and shawarma to add value. Future research efforts need to focus on exploiting the potential of the camel as a source of meat through multi-disciplinary research into efficient production systems, and improved meat technology and marketing.

Keywords: *Camel, meat quality, nutritive value, meat composition, meat processing.*

Introduction

The dromedary is an important domestic animal in various countries for producing valuable milk and meat and for its adaptation to extremely harsh environments (Kadim *et al.*, 2008). It can survive on sandy terrain with poor vegetation and may chiefly consume feeds unutilized by other domestic species (Tandon *et al.*, 1988). The dromedary camel meat is described as tough, coarse, watery and sweetish in taste compared to meats from beef.This may be partly attributed to the fact that camel meat is usually a by-product of primitive traditional systems of production where it is mainly obtained from old camels that have become less effective in their primary roles of providing milk, racing, or as breeding females (Kadim *et al*,. 2008). However, evidence suggests that quality characteristics of camel meat are not much different from beef if animals are slaughtered at comparable ages (Elgasim *et al.*,1987; Tandon*et al.*, 1988; Kadim et al., *2011*).

Although the marketing systems for dromedary camel meat are not developed, there is evidence of a high demand for camel meat among societies herding dromedaries (Kadim *et al*., 2008). Dromedary meat could be a cheap sourceof meat to meet the growing needs for high protein in developing countries especially for low income population groups (Kadim *et al*., 2008). Generally, dromedary meat is a significant source of high quality protein and preferred over other meat animal species due to believe in it medicinal benefits and its availability at affordable prices. This review outlines the nutritional and health value, quality characteristics and the availability of muscle bioactive compounds in Dromedary camel meats. A comparison of the nutritional properties of Dromedary camel meat with other species wasalso highlighted.

Chemical composition

Dromedary meat composition is generally similar to other red meat animals where an inverse correlation between the moisture and fat contents and varied according to breed, age, sex, condition and site on the carcass (Table 1). Dromedary meat composition is an important indicator of protein functionality and quality characteristics. Moisture content plays an important role in preserving and eating qualities of dromedary meat (Kadim *et al.*, 2008) whereas protein and fat contents dictate the palatability and manufacturing quality of meat.

Moisture content of Dromedary individual muscles ranged from 63.0 to 77.7% (Table 1). Gheisari *et al.* (2009) found no differences in moisture content between dromedary camel meat and meat from other species at a similar age and sex. Individual muscles from the same camel appear to have similar moisture contents with the exception of*Longissimus thoracis* muscle (Babiker and Yousif, 1990; Gheisari *et al*., 2009; Kadim *et al*., 2013). The range of moisture contentof *Biceps femoris* (71.4-74.3%)and *Triceps brachii* (70.5-77.7%) muscleswas higher than those from *Longissimus thoracis* muscle (65.7-75.9%) due to the higher fat content in the *Longissimus thoracis muscle* (Kadim *et al*., 2013). Kadim *et al.* (2006) found that moisture content of the Dromedary meat decreases with the increase in the animal age. The differences between the maximum and minimum moisture contents of camel *Longissimus thoraces* were 3.2%, 6.4% and 12.3% for 1-3, 3-5 and 6-8 years age groups, respectively (Kadim *et al*., 2006). This indicates that the variation in moisture content within the samples is greater in older animals.

Table 1 show that the protein content of Dromedary individual muscles is in the range of 17.1 to 23.7%. It appears that slight differences between individual muscles and different age groups (El-Faer *et al*., 1991; Kadim *et al*., 2006, 2012, 2013). Meat from young dromedaries has similar protein content to those found in young cattle, lamb and goat meats (Elgasim and

Alkanhal, 1992; Kadim *et al*., 2009b). Protein contents of *Semitendinosus, Infraspinatus, Semimembranosus, Biceps femoris, Triceps brachii and Longissimus thoracis*musclesin dromedary were investigated by Kadim *et al*. (2013). The highest protein content was found in *Semimembranosus*muscle contained the highest protein content (Kadim *et al*., 2013). Total collagen content is higher in camel *Longissimus thoracis* muscle than in *Semitendinosus* or *Triceps brachii* muscles possibly due to morphological requirement for stabilizing the hump attached to the *Longissimus thoracis* (Babiker and Yousif, 1990).

The fat content of individual dromedary camel muscles ranged from1.1 to 6.2 % (Table 1). Differences in the fat content were reported in different dromedary muscles with significant variation in fat content between different studies was also reported. Similar to other meat animals, camel's age have great effect on the fat content with dromedary meat from older animals' containing higher fat than younger animals (Kadim *et al.,* 2006). Nutritional status, breed, sex, and health are among other factors appear to affect the fat content of camel meat within similar age groups (El-Faer *et al*., 1991; Elgasim and Alkanhal, 1992; Kadim *et al.*, 2006, 2008, 2009a,b; Gheisari*et al.,* 2009).

The ash content in the dromedary individual muscles has been reported in

Table 1: Percentage of chemical composition of dromedary camel individual muscles.

Muscle Type	Moisture	Protein	Fat	Ash	
Longissimus thoracis	73.8	19.0	6.2	0.85	
Infraspintus	73.2	18.2	5.3	0.96	
Triceps brachii	77.7	17.1	1.9	1.00	Kadim et al. (2013)
Semitendinosus	75.4	18.5	3.1	0.91	
Semimembranosus	63.0	22.1	2.5	0.93	
Biceps femoris	74.3	20.8	2.5	1.00	
Longissimus thoracis	65.7	19.5	2.1	1.20	Kadim *et al*. (2011)
Longissimus thoracis	73.8	23.7	3.6	-	Al-Bachir and Zeinou (2009)
Biceps femoris	73.0	22.8	1.1	0.75	Gheisari et al., (2009)
Triceps brachii	72.0	21.2	1.4	0.81	
Longissimus dorsi	68.3	21.5	1.6	0.69	
Biceps femoris	71.4	22.2	1.6	0.98	
Triceps brachii	70.5	20.3	2.4	1.06	
Longissimus dorsi	67.8	20.5	2.5	0.95	
Longissimus thoracis	74.8	21.1	2.8	1.34	Kadim *et al*. (2009a)
Longissimus thoracis	71.7	22.7	4.4	1.10	Kadim *et al.* (2006)
Longissimus dorsi	75.9	21.6	1.4	1.05	Babiker and Yousif (1990)
Semitendinosus	75.8	21.4	1.4	1.38	
Triceps brachii	75.2	22.1	1.4	1.22	

the range of 0.75 to 1.38% (Table 1). Many researchers reported that ash content were varies with muscles and between muscles (Babiker and Yousif, 1990; Dawood and Alkanhal, 1995; Gheisari*et al*., 2009; Kadim *et al*., 2013). Gheisari *et al*. (2009) found that age had a significant effect on ash content of dromedary meat, whereas others found no effect of age on ash content (El-Faer*et al*., 1991; Al-Shabib and Abu-Tarboush, 2004; Shehata, 2005; Kadim *et al*., 2006, 2008). Dromedary meat has relatively lower ash content than beef, lamb and goat meat (Elgasim and Alkanhal, 1992; Gheisari*et al.,* 2009; Kadim *et al*., 2008).

Amino acids composition

It has been reported that essential amino acid content of dromedary meat is not affected by the animal age (Dawood and Alkanhal, 1995). Dromedary meat has a comparable essential amino acid contents to beef, lamb and goat meat (Table 2). The amount of camel meat required to supply the daily requirements of essential amino acids for adult consumer is similar to that from lamb (based on methionine which has the lowest content in meat) but is less than the amount required from beef.

Table 2 shows that leucine (7.1 to 9.5% of protein) and lysine (8.3 to 9.4% of protein) are among the highest essential amino acids in dromedary meat (Table 2). The camel meat essential amino acids contents varied slightly among individual muscles. The essential amino acid contents in *Longissimus dorsi*and *Semitendinosus* muscles differed by >2.1% with the exception of leucine, methionine and tryptophan, which differed by 18.5, 25.4 and 14.6 %, respectively (Al-Shabib and Abu-Tarboush, 2004). Similarly, essential amino acid contents in the *Infraspinatus*, *Longissimus dorsi*and *Semitendinosus* muscles differed by > 4.2% with the exception of isoleucine, methionine, threnonine, tryptophane and valine which differed between 8 to 42% (Dawood and Alkanhal, 1995). H0wever, differences in essential amino acids reported across different dromedary muscles ranged between 0.5 to 9.5% (Elgasim and Alkanhal, 1992; Dawood and Alkanhal, 1995; Al-Shabib and Abu-Tarboush, 2004). Tryptophan concentration in dromedary meat was lower than in other red meats (Dawood and Alkanhal, 1995). Al-Shabib and Abu-Tarboush (2004) stated that tryptophan concentration was 1.76% of the total amino acids which was higher than the 1.28% reported for beef (Kadim *et al.*, 2008).

The amino acid profiles in dromedary individual muscles were studied by Kadim *et al*. (2014; Table 3). The reported that in the essential fraction, leucine, histidine, methionine, threonine and valine were higher (g/100 g protein) in *Semitendinosus*muscle while isoleucine was higher in *Longissimus thoracis* muscle. The differences in essential amino acids reported in various dromedary muscles (Elgasim and Alkanhal, 1992; Dawood and Alkanhal,

Table 2: Essential amino acid composition in Dromedary camel meat (mg/100g).

	Amino acid[1]									
	His	Ileu	Leu	Lys	Met	Phe	Thr	Trp	Val	
Longissimus thoracis	4.4	4.7	8.3	9.4	2.9	4.3	4.5	-	5.6	Kadim *et al.* (2011)
Longissimus Dorsi	3.4	4.2	7.1	9.1	1.6	5.6	4.8	1.6	4.7	Al-ShabibandAbu-Tarboush (2004)
Semitendinosus	3.4	4.3	8.4	9.1	1.3	5.5	4.8	1.9	4.6	
Infraspinatus	4.7	5.3	8.6	8.4	2.6	4.1	4.2	0.5	4.9	Dawood and Alkanhal (1995)
Longissimus Thoracis	4.3	5.4	8.3	8.6	2.2	4.4	4.7	0.7	5.3	
Semitendinosus	4.5	4.9	8.3	8.3	2.5	4.2	4.2	0.6	5.4	
Longissimus dorsi and Semitendinosus	5.6	5.9	9.5	8.9	3.6	4.7	4.8	-	6.3	Elgasim and Alkanhal (1992)

[1]Amino acids: His Histidine, Ileu: Isoleucine, Leu: Leucine; Lys: Lysine, Met: Methionine; Phe: Phenylalanine; Thr: Threonine; Trp: Threonine and Val: Valine

Table 3: Effect of feeding level and type of muscle on Amino acid composition of Bactrian camel *Infraspinatus* (IS), *Triceps brachii* (TB), *Longissimus thoracis* (LT), *Semitendinosus* (ST), *Semimembranosus (SM)*, and *Biceps femoris* (BF) (Kadim et al., 2014).

	IS	TB	LT	ST	SM	BF	SEM[1]
Essential Amino Acids							
leucine	6.54	9.61	8.78	9.58	9.49	6.46	0.722
Phenylanine	6.66	5.38	6.02	6.87	6.02	5.94	1.278
Lysine	6.35	5.21	7.19	6.58	6.19	5.35	1.278
Histidine	7.81	6.22	4.15	7.81	4.15	6.84	0.532
Methionine	6.25	6.85	7.03	7.16	7.03	7.21	0.101
isoleucine	5.64	5.39	7.61	4.53	7.61	6.93	0.337
Threonine	8.01	6.66	7.51	9.71	7.51	7.03	0.664
Tryptophan	1.40	0.57	0.42	0.31	0.42	0.44	0.073
Valine	5.56	6.92	6.58	10.79	6.58	6.10	0.632
Non-essential amino acids							
Aspartic	8.92	8.23	7.92	9.09[c]	9.95	10.07	1.024
Glutamic	6.25	8.09	9.17	10.27	9.17	5.75	0.293
Serine	4.43	3.09	2.19	3.63	3.19	4.27	0.217
Tyrosine	5.04	6.78	7.59	7.22	7.50	7.32	0.207
Arginine	5.47	6.51	5.55	10.95	5.55	5.55	0.647
Alanine	2.40	4.54	3.55	3.35	3.55	3.83	0.137
Proline	9.06	7.36	8.82	16.74	8.82	7.42	1.000
EAA:NEAA	1.40	1.18	1.23	1.07	1.17	1.18	0.201

[1]SEM: standard error for the mean. Means in the same row with different superscripts are significantly different ($P<0.05$).

1995; Al-Shabib and Abu-Tarboush, 2004), which are less than the present values. The quality of meat protein lies in the extent of the availability of essential amino acids such as lysine and leucine in proportions required by human (Casey, 1993). The amount of camel meat required to supply the daily requirements of essential amino acids for adults is similar to that from lamb but is less than the amount required from beef. According to FAO/WHO/UNU (2007), the lysine and leucine requirements for a 70 kg human are 2.1 and 2.7 g/day, respectively, therefore, 100 grams of dromedary camel meat will cover the daily requirement for lysine and leucine. Within essential amino acids, the ST muscle had the highest value of histidine (6.97 mg/100g), methionine (6.87 g/100g), Theronine (8.75 mg/100 g) and valine (10.18 mg/100 g). The LT and SM muscles had the highest contents of isoleucine (6.39g/100 g) each. The essential amino acid requirement for an adult person weighing 70 kg is about 12.90 g/day (FAO/WHO/UNU, 2007), therefore, 100 g of edible camel meat would be an excellent source of high quality proteins because it contains the major essential amino acids in an appropriate proportions.

The glutamic and aspartic acids are the major non-essential amino acids in dromedary meat ranged from 15.9 to 18.6% and from 9.3 to 10.8% of protein, respectively (Table 4). Similar to the essential amino acids, non-essential amino acids contents also slightly variedbetween muscles and large variationsare found between different studies. In general, dromedary meat maybe a better source of non-essential amino acids compared to beef, lamb, and goat meats (Table 4). Although, Elgasim and Alkanhal (1992) found low alanine level in dromedarymeat compared to other red meats, Dawood and Alkanhal (1995), Al-Shabib and Abu-Tarboush (2004) and Kadim *et al*. (2011) found similar concentration of alanine in dromedary meats and other red meats.

Similar to the essential amino acids, non-essential amino acids contents also significantly varied between dromedary individual muscles (Table 3). Aspartic acid, gultamic acid and proline were the most abundant non-essential amino acids. The lowest mean values were alanine and serine. The *Semitendinosus* muscle had highset aspartic content, glutamic acid and proline, while *Longissimus thoracis*muscle had the highest tyrosine than other muscles. In general, dromedary meat may be a better source of non-essential amino acids than beef, lamb, and goat meats (Kadim *et al*., 2011, 2013) also found low alanine levels in dromedary meat compared to other red meats. High essential /non-essential amino acids ratio was recorded for *Infraspinatus*and *Biceps femoris* muscles, while the *Semitendinosus*muscle had the lowest ratio (Table 3).

Fatty acids composition

Fatty acid composition (saturated and unsaturated fatty acids) of dromedary meat is of great concern to public due to its important effects on human health. Reduction of saturated fatty acid intake is essential to prevent obesity, hypercholesterolemia and reduce the risk of cancer (Chizzolini *et al*., 1999). Studies showed that diets containing lipids with a high level of monounsaturated fatty acids and polyunsaturated fatty acids have been shown to be effective in lowering serum cholesterol levels (LDL and HDL) (Mensink and Katan, 1989). Table 4 shows that 22 fatty acidsin dromedary camel meat were identified by Rawdah *et al*. (1994). Major fatty acids in dromedary meat were also reported by Al-Bachir and Zeinou (2009) and Kadim *et al.* (2011). The composition of major fatty acids appears to be variable partially due to the number of fatty acids which affects the percentage of individual fatty acids (Table 5). Rawdah*et al.* (1994) reported levels of 18.9% oleic (C18:1) and 12.1% linoleic acid (C18:2) in the dromedary camel meat. However, about twice the percentage of oleic (C18:1) and less than

Table 4. Non-essential amino acid composition in Dromedary camel meat (mg/100g).

	Amino acid[1]								
	Ala	Arg	Asp	Glu	Gly	Pro	Ser	Tyr	
Longissimus thoracis	6.5	6.6	9.3	15.9	4.3	3.9	3.6	3.5	Kadim *et al*. (2011)
Infraspinatus	6.3	7.5	9.3	17.1	6.0	5.4	3.5	3.0	Dawood and Alkanhal (1995)
Longissimus dorsi	6.2	7.1	9.3	17.3	5.9	4.9	3.8	3.4	
Semitendinosus	6.3	7.5	8.6	16.4	5.9	5.9	3.6	3.3	
Longissimus dorsi and *Semitendinosus*	3.9	7.1	10.8	18.6	6.1	3.9	3.2	3.8	Elgasim and Alkanhal (1992)
Longissimus dorsi	6.5	6.9	9.7	17.0	6.2	-	4.3	3.3	Al-Shabib and Abu-Tarboush (2004)

[1] Amino acid: Ala: Alanine; Arg: Arginine; Asp: Aspartic acid; Glu: Glutamic acid; Gly: Glycine; Ser: serine: Tyr: tyrosine

Table 5: Fatty acid composition of the fatty acids in camel meat.

Fatty acids (%)	Rawdah*et al.* (1994)	Al-Bachir and Zeinou (2009)	Kadim *et al.* (2011)
Saturated (S)			
14:0	7.68	4.53	3.10
15:0	1.66	-	2.10
16:0	25.9	30.29	28.50
17:0	1.48	2.54	-
18:0	8.63	25.51	19.30
Monounsaturated (MUS)			
14:1	1.0	-	1.60
16:1	8.06	-	6.30
17:1	0.94	-	-
18:1	18.9	32.01	33.50
20:1	trace	-	-
Polyunsaturated (PS)			
18:2w6	12.1	5.13	3.20
20:2w6	0.11	-	-
18:3w3	0.52	-	1.20
20:3w9	0.37	-	-
20:3w6	0.30	-	-
20:4w6	2.84	-	1.20
22:4w6	0.10	-	-
20:5w3	0.32	-	-
22:5w3	0.48	-	-
22:6w3	0.10	-	-
P/S	0.36	-	0.11
Total saturated	51.5	-	53.00
Total MUSFA	29.9		41.40
Total PUSFA	18.6	-	5.60
w3/w6	0.09	-	-

half the percentage of linoleic acid (C18:2) were reported by Al-Bachir and Zeinou (2009) and Kadim *et al.* (2011). According to Wood *et al*. (2008), linoleic acid is derived entirely from the diet (Wood *et al.*, 2008) and such differences between studies are not unexpected due to different regions and feeding regimes. The major saturated, monounsaturated and polyunsaturated fatty acids in dromedary meat are (C16:0), (C18:1) and (C18:2), respectively (Table 5). While the total saturated fatty acids% among the published reports (52 -53%) was closely reported; more variable for monounsaturated (30 and 41%) and polyunsaturated (6% and 19%) fatty acids have been reported (Rawdahb*et al.*, 1994; Kadim *et al.*, 2011).

The fatty acid composition, total saturated, unsaturated, monounsaturated and polyunsaturated fatty acids of *Infraspinatus*, *Triceps brachii*, *Longissimus thoraces*, *Semitendinosus*, *Semimembranosus*, and B*iceps femoris* muscles of the dromedary are presented in Table 6 (Kadim *et al*., 2013). The fatty acid composition of the individual muscles was generally similar with the exception of palmetic (C16:0) and oleic (C18:1n9). The *Semitendinosus* muscle had lower palmetic fatty acids (C16:0) than *Infraspinatus*, *Triceps brachii*, *Longissimus thoraces* and *Semimembranosus* muscles. The *Infraspinatus* muscle contained lower oleic acids (C18:1n9) than other muscles. Total saturated fatty acid, total monounsaturated fatty acid, and polyunsaturated fatty acid were 51.8, 50.8, 51.3, 48.6, 49.9 and 49.0 g/100 g of total fatty acid for *Infraspinatus*, *Triceps brachii*, *Longissimus thoraces*, *Semitendinosus*, *Semimembranosus*, and B*iceps femoris*muscle samples, respectively (Table 6). Palmetic (C16:0) is the most abundant saturated fatty acid in Dromedary camel intramuscular fat of the individual muscles followed by stearic (18:0), and myristic (C14:0). The main monounsaturated fatty acids in the Dromedary individual muscles were oleic (C18:1n9c) followed by palmitoleic (C16:1). The main polyunsaturated fatty acids in the individual muscles were linoleic (C18:2n6c) and archidonic (C20:4n6). The percentage of polyunsaturated fatty acids in dromedary meat (18.6%) was within the range reported for beef (8.8%) and buffalo (28.6%) and deer (31.4%) (Sinclair*et al*.,1982). The ratio of linoleic and linolenic acids in camel meat is about 10.9 whereas is much higher than that of the meat of cattle, sheep or goat (2.0, 2.4 and 2.8, respectively) (Sinclair*et al*., 1982).

The camel hump is important and commonly used for cooking in camel rearing regions. On fresh weight basis, the camel hump contributes about 64-85% fat with very high content of saturated fatty acids of about 63% (Rawdah*et al.,* 1994; Kadim *et al.,* 2002). Researchers therefore, focused on the composition of the hump (Mirgani, 1977; Emmanuel and Nahapetian, 1980; Abu-Tarboush and Dawood, 1993; Kadim *et al*., 2002). Palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1) are the most abundant fatty acids in the hump. The composition of the hump fatty acids is affected by the animal age, season, nutrition and breed. The highest percentage of unsaturated fatty acids and lowest percentage of saturated fatty acids were in animals of less than one year whereas an opposite trend was in animals in the 1-3 years old age group (Kadim *et al.*, 2002).

Cholesterol

The adipose fat from dromedary carcass contained similar content of cholesterol to the hump (139 mg/100g fresh weight). This is lower than levels in lamb and beef adipose tissues (196 and 206 mg/100g fresh weight,

Table 6: Fatty acids composition (%) of the *Infraspinatus* (IS), *triceps brachii*(TB),L*ongissimus thoraces* (LT),*Semitendinosus*(ST),*Semimembranosus*(SM), and *Biceps femoris* (BF) muscles of the dromedary camel (Kadim*et al.,* 2013).

	Muscle						
	IS	TB	LT	ST	SM	BF	SEM[1]
Saturated fatty acid							
12:0	1.71[c]	1.42	1.13[a]	1.66	1.53	1.44	0.186
13:0	1.22	1.13	1.24	1.24	1.24	1.21	0.066
14:0	7.62	7.78	7.16	7.24	7.48	7.83	0.544
15:0	2.32	2.14	2.39	2.40	2.35	2.12	0.095
16:0	27.6	27.3	26.9	25.1	26.5	26.2	2.378
17:0	2.38	2.17	2.46	2.21	2.38	2.15	2.088
18:0	8.79	8.90	9.82	8.71	8.37	8.02	2.277
20:0	0.08	0.03	0.09	0.02	0.04	0.03	0.022
21:0	0.03	0.00	0.03	0.01	0.01	0.00	0.007
22:0	0.02	0.01	0.02	0.01	0.00	0.02	0.004
Mono-unsaturated fatty acids							
14:1	1.63	1.62	1.35	1.73	1.63	1.62	0.112
15:1	1.04	1.03	1.01	1.01	1.03	1.02	0.051
16:1	8.88	8.56	8.25	8.79	8.66	8.57	2.233
17:1	0.16	0.14	0.14	0.15	0.11	0.11	0.039
C18:1n9	25.0	26.3	26.2	26.4	26.8	26.9	2.182
Poly-unsaturated fatty acids							
C18:2n6	7.14	7.83	7.11	7.79	7.98	7.94	0.207
C18:3n3	0.64	0.43	0.59	0.62	0.54	0.54	0.122
C20:2	0.52	0.34	0.62	0.64	0.43	0.42	0.016
C20:3n6	0.33	0.23	0.34	0.43	0.42	0.41	0.009
C20:4n6	2.81	2.72	2.84	2.83	2.55	3.51	0.033
Total saturated FA (SFA)	51.8	50.8	51.3	48.6	49.9	49.0	8.942
Total unsaturated FA (USFA)	48.2	49.2	48.7	50.4	50.2	51.0	2.311
Total Mono- unsaturated FA (MUSFA)	36.8	37.6	37.2	38.1	38.2	38.2	2.174
Total poly- unsaturated FA (PUSFA)	11.44	11.55	11.50	12.3	11.92	12.8	0.217
SFA:USFA	1.08	1.03	1.05	10.9	0.99	0.98	3.869
SFA: MUSFA	1.41	1.35	1.38	61.2	1.30	1.28	4.113
SFA: PUSFA	4.54	4.40	4.46	83.95	4.18	3.82	4.120

[1]SEM: standard error for the mean. Means on the same row with different superscripts are significantly different (P<0.05).

respectively) (Abu-Tarboush and Dawood, 1993).This supported the earlier reportsof low cholesterol content of dromedary camel meat compared to beef and lamb (Elgasim and Elhag, 1992). The cholesterol content in dromedary meat increases with increasinganimal age.It was 135 mg/100 g fresh weight for 8 months old vs. 150 mg /100 g fresh weight for 26 months old dromedaries). This is particularly important inregionsbreeding dromedaries where the eating habits and cooking styles are different from other regionsand the use of animal fat in cooking is very common.

The cholesterol levels in dromedary individual muscles were investigated by Kadim *et al.* (2014). The cholesterol concentration of the muscles was in the following order: *Semitendinosus* > *Biceps femoris* > *Semimembranosus* > *Infraspinatus* >*Longissimus thoracis* >*Triceps brachii* muscle. They stated that differences in cholesterol contents between dromedary individual muscles might be due to variation in the amount of intramuscular fat and/or muscle fibre types. There was a variation between the muscles in the amount of fat and proportion of muscle fiber types. Differences in muscle fiber types and intramuscular fat content have been reported to cause differences in cholesterol content of meat collected from different anatomical locations (Dinh *et al.*, 2011).

Mineral composition

Minerals are generally classified as essentialelements that are required for growth and health or toxic elements, which poses health risk to dromedaries. Both the deficiency and excess intake of essential elements as well as exceeding the safe limits of toxic elements can be detrimental to human health. Table 7 gives essential mineral contents of various cuts of dromedary camel meat.

Calcium content (mg/100g fresh weight) were reported to be in the range of 4.7- 10.2 (Table 7). The level of variation in camel meat indicates that physiological factors play a major role in determining the calcium contents in camel meat. Small variations in calcium content arefound among different meat cuts (Table 7). The calcium content between different dromedary meat cuts range was 19-27% (Dawood and Alkanhal, 1995; Rashed, 2002) whereas there was up to 54% variation in calcium content between different meat cuts. Cobalt and chromium contents were in the range of 0.003-0.004 and 0.008- 0.03 (mg/100g fresh weight) (Kadim *et al.*, 2006). Copper contents in dromedary meat ranged between 0.04 to 0.12 mg/100g fresh weight (Table 7). The foreleg contains have higher copper content compared with other meat cuts (Rashed, 2002). Iron content in camel meat (1.16-3.39 mg/ 100 g fresh meat) varied among different dromedary meat cuts (Table

Table 7: Mineral concentrations in camel meat (mg/100g fresh weight.

	Mineral[1]													
Factor	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	P	S	Zn	
Rump	-	0.004	-	0.12	2.5	-	-	-	0.04	-	-	-	-	Badiei *et al.* (2006)
Intercostal	8.5	0.29	0.42	0.13	51.0	515	29.5	0.19	-	300.5	-	-	74.0	Rashed (2002)
Scapula	10.0	0.35	0.32	0.21	54.5	670	51.0	0.22	-	225.0	-	-	58.0	
Sirloin	10.2	0.27	0.41	0.16	44.0	446	28.0	0.16	-	188.5	-	-	66.0	
Flank	8.4	0.32	0.33	0.12	49.0	811	49.5	0.19	-	223.0	-	-	69.5	
Front knuckle	8.4	0.26	0.42	0.25	44.5	630	37.0	0.17	-	299.5	-	-	73.5	
Front limb	9.8	0.19	0.37	0.26	50.5	548	42.5	0.19	-	312.5	-	-	85.5	
Chuck	11.5	-	-	-	3.2	249	17.4	-	-	73.5	-	-	3.7	Dawood and Alkanhal (1995)
Ribeye	8.1	-	-	-	2.9	231	16.3	-	-	67.1	-	-	3.7	
leg	10.3	-	-	-	3.4	251	17.1	-	-	69.7	-	-	3.9	
Leg+loin	4.9	-	-	0.04	1.9	228	17.7	0.01	-	47.9	-	-	3.2	Elgasim and Alkanhal (1992)[2]
Shoulder	5.1	-	0.01	0.07	1.2	357	20.6	0.01	-	69.1	196	56.1	3.5	El-Faer*et al* (1991)
Thigh	5.4	-	0.01	0.09	1.4	361	21.0	0.01	-	70.4	199	55.0	3.1	
Ribs	4.7	-	0.01	0.07	1.2	324	18.5	0.01	-	84.1	181	58.0	3.9	
Neck	5.6	-	0.03	0.09	1.4	338	18.5	0.01	-	87.3	181	64.4	4.8	

1 Mineral: Ca: Calcium; Co: cobalt; Cr: Chromium; Cu: Copper; Fe: Iron; K: Potassium; Mg: magnesium; Mn. Manganese; Mo: Molybdenum; Na: Sodium; P; Phosphorus; S; Sulfate Zn: Zinc

7) which is most probably due to the different physiological requirements of myoglobin of different muscles. As with other red meat species, dromedary cuts containing oxidative muscles has higher iron content than glycolytic muscles. Potassium is the major element in dromedary meat (231- 379.1 mg/100g fresh weight) and magnesium content in dromedary meat range between 10.41- 21.03 mg/100g fresh weight (Kadim *et al.*, 2009). Dromedary meat cuts from the limbs have higher potassium and magnesium contents compared with the loins and ribs (Table 7). Meat from Dromedary camel contained similar manganese content (0.01 mg/100g fresh weight) across various meat cuts (El-Faer*et al.*, 1991; Elgasim and Alkanhal, 1992). However, meat from dromedary camels appears to have higher manganese content (mg/100g dry matter) and the concentration varied among different meat cuts (Rashed, 2002). Sodium content in camel meat was in the range of 40.2-87.3 mg/100g (Table 7). The loins cut had the lowest sodium content among the different meat cuts (Elgasim and Alkanhal, 1992; Rashed, 2002; Kadim *et al*. 2006). Phosphorus is the second most abundant element in camel meat (105.6-199.0 mg/100g fresh weight) and the leg and shoulder muscles have slightly higher phosphorus than ribs and neck muscles (El-Faer*et al.*, 1991). Sulfur content was in the range of 54.9-136.6 mg/100g fresh weight. The sulfur content in four dromedary meat cuts was varied by 17% only (El-Faer*et al*., 1991). Red meat is an important source of zinc. Dromedary meat contains about 3.1 to 4.8 mg/100g fresh weight (Table 7). The variation between different muscleswas 7.6% (Dawood and Alkanhal, 1995) but higher percentage of variation (47-56%) has been reported in different studies (El-Faer*et al*., 1991; Rashed, 2002).

The mineral concentrations of *Infraspinatus*, *Tricepsbrachii*, *Longissimus thoraces*, *Semitendinosus*, *Semimembranosus*, and *Biceps femoris* muscles of the dromedary (Kadim *et al*., 2013) are presented in Table 8. The phosphorus magnesium, sodium, potassium and iron contents of Dromedary muscle samples varied between muscles. The *Tricepsbrachii* and muscles and had the highest mean value of phosphorus, calcium, magnesium and potassium (Table 7).The *Semitendinosus* muscle in the Dromedary had more magnesium than *Infraspinatus*, *Tricepsbrachii*, *Longissimus thoracis*, and *Biceps femoris* muscles. The *Semitendinosus* and *Semimembranosus* muscles had more iron than other muscles in Dromedary. The *Longissimus thoracis* muscle had a lower and the *Tricepsbrachii* higher ($P<0.05$) potassium than other muscles (Table 8). For trace elements (zinc, iron, lead, selenium, copper), there was small variation between muscles of dromedary and Bactrian camels (Table 8).

Table 8: Macro and micro-element levels (mg/100g) in *Infraspinatus*(IS),*Triceps brachii*(TB), *Longissimus thoraces* (LT), *Semitendinosus* (ST), *Semimembranosus* (SM), and *Biceps femoris* (BF) muscles of the dromedary (Kadim et al., 2013).

	Muscle						SEM[1]
	IS	TB	LT	ST	SM	BF	
Phosphorus	6.49	7.76	5.23	6.39	7.96	6.79	0.233
Calcium	0.07	0.08	0.05	0.07	0.08	0.07	0.004
Magnesium	1.73	2.21	1.37	3.39	2.17	1.84	0.147
Sodium	6.33	5.98	5.18	7.38	5.78	6.93	0.285
Potassium	81.7	103	25.2	71.3	80.9	85.6	3.400
Zinc	0.01	0.01	0.01	0.01	0.01	0.01	0.001
Iron	0.02	0.06	0.03	2.42	2.52	0.05	0.318
Lead	0.001	0.01	0.01	0.01	0.03	0.002	0.014
Selenium	0.003	0.003	0.004	0.004	0.003	0.003	0.001
Copper	0.002	0.001	0.001	0.05	0.07	0.004	0.007

[1]SEM: standard error for the mean. Means on the same row with different superscripts are significantly different (P<0.05).

Table 9: Toxic/non-essential elements concentrations (mg/100g)offresh weight.

	Mineral[1]							
Factor	Ag	Al	Au	Cd	Ni	Pb	Sr	
Intercostal	0.07	-	0.11	-	0.24	-	-	Rashed (2002)
Scapula	0.06	-	0.10	-	0.38	-	-	
Sirloin	0.11	-	0.19	-	0.05	-	-	
Flank	0.09	-	0.12	-	0.13	-	-	
Front knuckle	0.12	-	0.17	-	0.19	-	-	
Front limb	0.11	-	0.21	-	0.21	-	-	
Shoulder	-	0.51	-	-	-	-	0.02	El-Faer*et al* (1991)
Thigh	-	0.15	-	-	-	-	0.03	
Ribs	-	0.12	-	-	-	-	0.02	
Neck	-	0.58	-	-	-	-	0.03	
Longissimus thoracis	-	-	-	0.003	0.025	0.015	-	Kadim *et al*. (2009b)

[1] Mineral: Ag: Silver; Al: Aluminum, Au: gold; CD: cadmium; Ni: nickel; Pb: Lead; Sr: Strontium

The concentrations of silver, gold and nickel in five camel meats have been reported at 0.06-0.12, 0.10-0.21 and 0.05-0.38 mg/100g dry matter, respectively (Rashed, 2002). The concentration of the three minerals varied among different muscles by 100%, 110% and 750% (Table 9). The concentrations of nickel, beryllium and vanadium increased in the Dromedary camel *Longissimus thoracis* with the increasing animal age (Kadim *et al.*, 2006). The level of lead in camel *Longissimus thoracis* was 2.5 times the concentration in beef *Longissimus thoracis* (Kadim *et al.*, 2009). Studies on the levels of trace and heavy elements in camel blood concluded that camel could be less efficient than other ruminants in detoxifying these elements in its body (Al-Qarawi and Ali, 2003). Therefore, monitoring of the toxic levels in biological materials from camel should get attention to (Faye *et al.*, 2008). Monitoring the level of toxic compounds in the offal should be of priority since it is regularly consumed by low income groups as a source of animal protein in many developing countries.

Farming conditions (management and nutrition) as well as the physiological conditions of the animals (breed, sex and age) seems to play an important role in determining the level of various elements in the meat and the camel blood (Faye *et al*., 2008). For instance, calcium content in the camel meat reported from the same laboratory (Kadim *et al*., 2006; 2011) or across different laboratories (Dawood and Alkanhal, 1995; Kadim *et al.*, 2006) supports this contention. It is worth mentioning that the biological variation of elements content even within the same herd that has similar farming background is very high (Kadim*et al.*, 2006).

Meat quality characteristics

Dromedary meat is often regarded astough, which may be attributed to reluctance of camel owners to sell their young animals and slaughter older camels at the end of their productive life. Therefore, majority of dromedary camel meat trade is from old animals which have a direct bearing on the extent of demand for meat outside the camel herding societies. Although, dromedary meat had a significantly lower level of sarcoplasmic proteins as a proportion of total proteins than beef (Babiker and Tibin, 1986), many researchers reported that meat quality characteristics from young dromedary camel are comparable to those of beef at a similar age (Leupold, 1968; Fischer, 1975; Knoess, 1977; Mukasa-Mugerwa, 1981; Kadim *et al*., 2006, 2009; Shariatmadari and Kadivar, 2006). In this respect, Kadim and Mahgoub (2006) found that dromedaries 2-4 years-old and beef 2-3 years-old had similar meat quality characteristics of the *Longissimus thoracis* muscle. The beef *Longissimus thoracis*, *Semitendinosus* and *Triceps brachii* muscles lose less water during cooking than camel (48% vs. 37%) while no tenderness differences were observed between the two species (Kamoun, 1995a,b). In contrast, Babiker and Tibin (1986) reported that beef meat hadmore cooking losses than dromedary meat. Effect of camel age on meat quality was studied by Kadim *et al.* (2006) and found that 1-3 years of age is the optimum age for slaughtering dromedary for better meat quality (Table 10). At this age the animals were not yet fully grown, they averaged about 60-70% of full live

Table 10: Effect of age on some meat quality characteristics of the dromedary camel*Longissimus thoracis*muscle (Kadim *et al.,* 2006, 2009b).

	Kadim *et al.* (2006) Age group (year)			Kadim *et al.* (2009b) Age group (year)	
	1-3	3-5	5-8	1-2	8-10
Ultimate pH	5.91	5.84	5.71	5.68	5.65
WB- Shear force value (Newton)	68.4	79.5	131.9	6.74	8.90
Sarcomere length (µm)	1.85	1.24	1.06	1.66	1.60
Myofibrillar fragmentation Index%	80.99	73.3	60.4	72.2	67.3
Expressed juice (cm^2/g)	29.6	27.36	21.26	38.1	37.4
Cooking loss %	26.06	23.72	22.42	23.4	22.0
Colour parameters					
*L** (lightness	37.74	34.03	31.69	39.1	38.1
*a** (redness	13.37	13.82	16.18	16.5	15.6
*b** (yellowness)	6.09	6.78	7.26	5.58	6.29

weight, therefore, their meat is tender.However, Kamoun (1995a,b) stated that camel age is not a predominant factor in meat quality if fed the same diet and slaughtered between one and four years of age.. At this age the animals were not yet fully grown, they averaged about 60-70% of full live weight, therefore, their meat is tender.

Meat quality characteristics of *Longissimus thoracis* and *Biceps femoris* muscles infour Indian dromedary camel breeds were compared by Suliman *et al*. (2011) and the results indicated little variation between the four breeds. The Shear force values in *Longissimus thoracis* muscles ranged from 6.5 kg in Magahem to 14.3 kg in Shoal, while in *Biceps femoris* muscles the ranges were between 19.4 kg for Wodoh to 23.3 for Shoal. On the other hand, various breeds exhibited a similar myofibrillar fragmentation index, ultimate pH and sarcomere length for both *Longissimus thoracis* and *Biceps femoris*. Dromedary muscles of the loin region were less tough than those from the leg.

Meat quality of individual muscles of the dromedary camel was studied by Kamoun (1995b) and concluded that the *Vastuslateralis* muscles had the highest weight and water losses (51.1% and 47.8%, respectively) whereas *Psoas major* muscles had the lowest (44.6% and 41.1% respectively) (Table 11). The *Triceps brachii* and *Vastuslateralis* muscles contained more soluble collagen than *Semitendinosus*, *Psoas major*, *Longissimus thoracis* and *Semimembranosus* muscles, possibly indicating a less thermal stable bond between collagen molecules and weaker connective tissue structures of those muscles (Kamoun, 1995b). The latter author found that the *Longissimus thoracis* muscle was tender and had less

Table 11: Eating quality attributes of the six major muscles (Kamoun 1995b)

parameter	Muscle[1]					
	PM	LT	SM	ST	VL	TB
Myoglobin mg/g	3.9	4.1	5.8	3.4	4.1	5.1
Collagen mg/g	3.3	4.1	5.0	7.5	6.6	5.6
Sensory tenderness	7.2	6.6	3.7	3.6	1.9	3.9
Collagen soluble%	29	29	30	34	42	41
Sensory juiciness	6.2	6.8	5.2	3.8	4.1	5.8
Cooking weight loss%	45	45	49	48	51	51
Cooking volume loss%	41	42	46	44	48	45

[1]Muscle:PM: *Psoas major,* LT: *Longissimus thoracis*, SM: *Semimembranosus*, ST: *Semitendinosus*, VL: *Vastuslateralis,* TB: *Triceps brachii.*

detectable connective tissue than the other muscles. The *Longissimus thoracis* muscle had the highest juiciness score and the *semitendinosus* and *Vastuslateralis* muscles were less juicy than *Psoas major*, *Semimembranosus* and *Triceps brachii* muscles.

Ultimate muscle pH

The ultimate pH of muscles is a consequence of lactic acid accumulation through postmortem glycolysis process that affects meat quality characteristics (Simek*et al.*, 2003). According to Laack*et al.* (2001), 40-50% of variation in ultimate pH is determined by glycogen concentration, which needs 0.81g/100g of glycogen to lower the pH of one kg of muscle from 7.2 to 5.5 (Warris, 1990). Ashmore*et al*,(1973) stated that the pH of muscles is the result of a combination of pre-slaughter handling, postmortem treatment, glycogen storage and muscle physiology. Low muscle glycogen stores at slaughter preventing the development of a desirable pH postmortem. A high ultimate pH in camel muscles is a consequence of low muscle glycogen as a result of pre-slaughter stress, including, poor nutrition, rough handling and long transportation. The ultimate pH has an effect on several properties like color, tenderness, water-holding capacity, cooking time, flavor, and drip loss all of which influences consumer acceptance of dromedary meat. Glycogen degradation speed differs between muscle fiber types. Type I muscle fiber characterized as slow contract fiber with oxidative metabolism and a low concentration of glycogen, which is actively degraded to glucose. Type II muscle fiber contract rapidly and have a high concentration of glycogen, normally with glucolytic metabolism and an active degradation to lactic acid (Lawrie, 2006). However, there is a variation in the pH between the muscles in different parts of the carcass; also the muscles position in the body affects its final pH (Kadim *et al.*, 2013).

The ultimate pH of dromedary camel meat ranges between 5.5 and 6.6 (Babiker and Yousif, 1990; Kadim *et al.*, 2006, 2009a,b; 2010, 2013). Generally, young camels tend to produce meat with a higher pH than older camels due to lower levels of glycogen. In this respect, Kadim *et al*. (2006) found that dromedaries younger than three years had a pH value (5.91) which was higher than dromedaries older than six years (5.71). The ultimate pH of L*ongissimus thoracis*muscles varied between 5.68 and 5.80 for dromedary camel (Kadim *et al*., 2009a). The breed of camels did not differ in terms of ultimate pH in *Longissimus thoracis* and *Biceps femoris* muscles (Suliman *et al*., 2011).

Tenderness (Shear Force Value)

Tenderness is the most important organoleptic characteristic and is the predominant quality determinant of meat at the expense of flavor and color (Koohmaraie, 1988). Muscle characteristics, glycogen content, collagen content, solubility, and the activities of proteases and their inhibitors are the most important physiological parameters that determine meat tenderness (Hocquette*et al*., 2005; Renand*et al*., 2001). The dromedary *Longissimus thoracis* muscle had more soluble collagen than the *Semitendinosus* and *Tricepsbrachii*muscles (Kamoun*et al.*, 1995b). The *Triceps brachii* muscle had the highest shear force values, maximum connective tissue strength and lowest collagen solubility than *Longissimus thoracis, Semitendinosus, Semimembranosus*, *Psoas major* and *Vastuslateralis* in dromedary indicating that it is the toughest muscle in this group (Babiker and Youssif, 1990). The *Psoas major* and *Longissimus thoracis* muscles were the most tender and had less detectable connective tissue than other muscles. Moreover, Kadim et al. (2013) found that *Infraspinatus, Triceps brachii* and *Longissimus thoracis*-dromedarymuscles had lower shear force values than *Semitendinosus*, *Semimembranosus* and *Biceps femoris* muscles, which might be due to less connective tissue (Table 12).

The tenderization process starts after slaughter and it varies among individual carcasses and depends on the postmortem activity of the calpainproteolytic enzymes that include calpastatin (Parr *et al.*, 1999). The most marked difference in meat quality characteristics between dromedary meat and other livestock is largely believed to be tenderness (Mukasa-Mugerwa, 1981). Dromedary camels are usually slaughtered at the end of their productive life (more than10 years) which is classified as of low quality compared with other meat animals. Average shear force value of camel meat at 5-8 years was 48% and 40% higher than those of 1-3 and 3-5 year olds, respectively (Kadim *et al.*, 2006). A number of studies have also shown that shear values of meat increase with increasing camel age (Dawood, 1995;

Table 12: Meat quality characteristics of individual muscles of the Dromedary camel (Kadim *et al.,* 2013).

Age (1.5-2 years)	Muscle[1]					
	IS	TB	LT	ST	SM	BF
Ultimate pH	5.64	5.73	5.61	5.67	5.83	5.74
Expressed juice	34.8	42.1	41.8	36.8	42.4	40.2
Cooking loss	31.6	29.2	33.5	28.5	30.6	29.5
WB-Shear force (kg)	6.3	6.7	6.5	9.0	12.9	10.3
Sarcomere length (µm)	1.7	1.7	1.7	1.5	1.4	1.5
Myofibrillar fragmentation index %	75.8	74.0	74.2	70.3	65.3	70.5
Colour L*	41.7	40.2	43.5	40.5	40.6	40.6
Colour a*	12.7	12.6	14.0	10.5	13.6	13.3
Colourb*	2.6	3.7	4.1	2.2	2.9	3.8

[1]Muscle: IS; *Infraspintus*, TB; *Triceps brachii*, LT; *Longissimus thoracis*, ST; *Semitendinosus*, SM; *Semimembranosus*, BF; *Biceps femoris*

Kadim *et al.,* 2006). Differences due to age may be related to changes in muscle structure and composition as animal matures, particularly in the nature and quantity of connective tissue (Asghar and Pearson, 1980), Significant differences (P<0.05) were found between the different ages (8, 16 and 26 months of age) and muscles for shear force values of male dromedary camels (Dawood, 1995).

Myofibrillar fragmentation index

Myofibrillar fragmentation index is a useful indicator of the extent of myofibrillar protein degradation of meat post-slaughter in dromedary camel (Kadim *et al.*, 2006, 2009a,b, 2011, 2013). The differences in rates of fragmentation of myofibrillar proteins may account for differences in the rate of postmortem tenderization of meat (Nagaraj*et al.*, 2005). The structural changes occurring in muscle tissue after slaughter are generally believed to be caused by alterations in and interactions of myofibrillar proteins in the tissue (Nagaraj*et al.*, 2006). Claeys*et al.*(1994) reported that at a higher pH, proteins preferentially solublized were titin, filamin, neubulin and myosin heavy chain. Except for myosin, all are preferentially degraded by calpains, which has an optimum effect on pH values near neutrality. Similarly, Silva *et al.* (1999) found that the myofibrillar-fragmentation index in meat was significantly higher at ultimate pH 6.5 than at 5.7. There is a correlation between myofibrillar fragmentation index and tenderness of meat (Veiseth *et al.*, 2001). Myofibrillar fragmentation index of camels above 6 years was lower than 1-3 years of age (Kadim *et al.*, 2008, 2009a).

Water holding capacity (Expressed Juice)

Water retention in meat is primarily caused by immobilization of water within the myofibrillar system. Applying pressure can cause a shift of water from the interacellar to the extracellular space and then onto the meat surface as a result of structural alterations at the level of the sarcomeres or of the myofilaments structure. It affects the retention of minerals, vitamins and volume of water (Beriain*et al.*, 2000) and is influenced by muscle pH because of the electrostatic effects of meat proteins (Hamm, 1975). The dromedary camel meat contains higher expressed juice than other camelidae such as llama and alpaca, possibly because of the lower fat content (Cristofaneli*et al.*, 2004). The amount of water loss was likely due to the ultimate pH of the muscle, composition of muscle and denaturation of proteins by the ionic strength of the extracellular fluid and oxidation of lipids which decreases the solubility of proteins (Dyer and Dingle, 1967). Kadim *et al.* (2006) found that meat from camels slaughtered at 1-3 year had higher expressed juice values than those slaughtered at 5-8 year of age, probably due to variations in fat content and the binding ability of meat. The water-holding capacity decreases as fat levels increase due to an increase in the ratio of moisture to protein (Miller *et al.*, 1968). Dawood (1995) reported that young dromedary camel meat (8 months of age) had significantly higher water-holding capacities than meat from 26 month-old camels. The volume of the dromedary camel meat was reduced by 44.3% and weight by 48.2% after boiling in water for 40 min (Kamoun, 1995b). The *Longissimus thoracis* and *Biceps femoris* muscles from mature camels had 37.9 and 37.1% cooking loss which was higher than the 33.2 % cooking loss in *Semitendinosus* muscle,which coincided with its high water-holding capacity (Babiker and Yousif, 1990). An increase in cooking loss was observed in the *Longissimus thoraces* muscle (33.5%) when compared to the *Infraspinatus* (31.6%), *Triceps brachii*(29.2%), *Semitendinosus* (28.5%), *Semimembranosus* (30.6%) *Biceps femoris* (29.5%) with no significant differences between the last five muscles (Kadim *et al*., 2013). The variation between muscles might be due to location, activity, proportion of muscle fiber types, pH, intramuscular fat and the ratio of water to protein of individual muscles. However, Suliman *et al*. (2011) found that *Biceps femoris* muscles had higher cooking loss than *Longissimus thoraces* muscles in four different dromedary camel breeds. According to Shehata (2005), young dromedary camels (10-12 months old) had higher cooking loss than old animals. *Longissimus thoracis* from two to three years old dromedaris had significantly lower cooking loss (24.3%) than the values mentioned above (Kadim *et al.*, 2009a,b). The cooking loss of dromedary *Longissimus thoracis* was not different from that in cattle *Longissimus thoracis* of the same age.

Cooking loss is important because of its potential to change the level of nutrients in the meat once it is cooked. For example, while it generally regarded that the protein content of camel meat is similar to other red meats (Elgasim and Alkanhal, 1992; Gheisari *et al.*, 2009), the higher cooking loss in camel meat (33-38%), compared to beef (24.6%), will generate a more nutritionally dense cooked meat (Kadim *et al.,* 2009).

Color (L*, a*, b*)

Meat color is one of the most important sensory characteristics according to which consumers make judgments on meat quality. The degree of meat pigmentation is directly related to the chemical structure of myoglobin content. Myoglobin concentration within a given muscle will differ according to the species or age and is dependent on muscle fibre type proportions, muscle pH, age, intramuscular fat, and muscle texture (Gardner *et al.*, 1999; Lawrie, 2006). There was a negative linear relationship between color values and pH in *Longissimus thoracis* muscles (Menzies and Hopkines, 1996). Postmortem protein degradation is directly related to the ultimate pH, which increases light scattering properties of meat and thereby increases *L**, *a** and *b** values (Offer, 1991). Low ultimate pH meat samples might lead to more protein degradation resulting in higher color values than the high ultimate pH meat samples. Abril*et al.* (2001) reported that reflectance spectrum value for meat samples was higher for an ultimate pH above 6. Postmortem glycolysis decreases muscle pH making muscle surfaces brighter and superficially wet. If the ultimate meat pH is high, the physical state of the proteins will be above their iso-electric point, proteins associate with more water in the muscle and therefore, fibers will be tightly packed (Abril*et al.*, 2001). Babiker and Yousif (1990) reported that dromedary camel *Longissimus dorsi* muscles had higher lightness (*L**), redness (*a**) and yellowness (*b**) values than S*emitendinosus* and T*riceps brachii* muscles. Suliman *et al.* (2011) found that the color of the *Biceps femoris* muscle was not affected by breed of dromedaries, while the redness (*a**) values of *Longissimus thoracis* muscles appeared different. A high redness (*a**) color component in the dromedary *Longissimus thoracis* muscle was associated with a lower lightness (*L**), which might be due to an increase in myoglobin content. Dromedary muscle lightness *L** values indicated that the *Longissimus thoraces* muscle (43.5) had the lightest (P<0.05) lean color, which was possibly due to high fat content (Kadim *et al.*, 2013). The *Semitendinosus* muscle had the darkest colored lean compared to *Infraspinatus*, *Longissimus thoraces*, *Triceps brachii*, *Semimembranosus*, and *Biceps femoris* camel muscles. The *Longissimus thoraces*, *Semimembranosus* and *biceps femoris*dromedary camel muscles had higher redness (*a**) values than

Semitendinosus muscle, while a* value for *Infraspinatus* and *Triceps brachii* muscles were in between. CIE a* values were similar among *Longissimus thoraces*, *Semimembranosus* and *Biceps femoris* muscles (Kadim *et al.*, 2013). In camel, the highest average yellowness (*b**) value was recorded in the *Longissimus thoraces* muscle with comparable values to the Triceps*brachii* and *Biceps* femoris muscles.

The age of the camel has a significant effect on their meat color (Kadim *et al.*, 2006), with 6-8 and 10-12 year old dromedaries was darker (lower *L**), redder (higher *a**) and yellower (high *b**) than 1-3 year old dromedaries because of higher concentrations of myoglobin (Kadim *et al.,* 2006).

Conclusion

In general, the nutritional value of dromedary camel meat is similar to other red meats. However, meat from young dromedaries can be considered as a healthy option due to the low fat and cholesterol contents.The quality characteristics of dromedary camel meat are similar to beef meat quality when they slaughtered at similar age. The dromedary camel meat can be successfully marked alongside of other red meats. Pre and post mortem factors should be carefully considered to improve dromedary meat quality characteristics.

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