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Slaughter practices and composition of dromedary camel (*Camelus dromedarius*) meat in relation to age and body condition in Eastern Ethiopia

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Abstract: This study was conducted to monitor the camel slaughtering practices, and evaluate meat composition in relation to age and body condition of camels. Fifty-four male Issa type camels of three age groups: group 1 (6-10 year-old), group 2 (11-17 year-old) and group 3 (≥ 18 year-old) where each age group classified to three body condition groups (poor, medium and good) were sampled from camels slaughtered in one of the abattoirs in eastern Ethiopia. The camels were monitored for slaughtering practices and their meat compositions were investigated following standard procedures. The results showed that camels were slaughtered inhumanly violating many of the basic requirements of humane and *halal* (permitted) slaughtering, including cruelly cutting *Achilles* tendon of hindlegs, severing the neck with more than one stroke, and sharpening knives and performing slaughtering in front of camels waiting for slaughter. Muscle, bone, and fat proportions were 54.9, 25.5, and 19.6%, respectively. Proportions of muscle (P<0.0008) and bone (P<0.004) decreased, but fat (P<0.0001) increased with age and body condition. The moisture, ash, crude protein (CP), and lipid contents were 78.3, 2, 20.14, and 9.45%, respectively. The ash (P<0.0074) decreased and lipid (P<0.05) increased with age. Moisture (P<0.05) and CP (P<0.0028) decreased, but lipid (P<0.0001) increased with body condition. Generally, all age groups of camels provide meat with comparable moisture and CP contents, but higher ash, lower lipid and fat proportion were found in camels aged 6-10 years. Camels in poor and medium body conditions provide meat with higher moisture, CP and muscle than good condition camels. Thus, camels aged 6-10 years at medium body condition could provide better nutritive value with less health risk associated to fat. To meet essential demands of meat consumers and future export market, the abattoir should design and adopt basic requirements of humane and halal slaughter.

Keywords: *Camel meat, physical composition, chemical composition, slaughtering.*

Introduction

Ethiopia has 4.5 million heads of dromedary camels (*Camelus dromedarius*) (Shapiro *et al.*, 2015) kept for various purposes. Camels are slaughtered during festive times and on daily basis at abattoirs in major towns such as Dire Dawa, Jijiga, Harar, Deghabur, Kebridehar, and Gode for local consumption (Bekele and Kebebew, 2002; Eyassu, 2009). However, there are no explicit rules and regulations regarding animal welfare in slaughterhouses in Ethiopia (Rich *et al.*, 2009). Only the abattoirs' operations from which the meat is exported to Middle East are monitored and the meat is certified by the Islamic Affairs Council ensuring that animals are slaughtered according to the proper Islamic killing procedures (EMPEA, 2015) to fulfill requirements of meat importers. It is equally important to adopt religious slaughter at abattoirs supplying meat for local consumption to fulfill local meat consumers' requirements.

Religious slaughter is a binding requirement for followers of a particular faith since meats from animals that have not been religiously slaughtered are invariably rejected (Schyff, 2014).

The *halal* (lawful or permitted) slaughter places great emphasis on humane treatment of animals before and during slaughter such as giving the animal proper rest and water, minimizing stress, not sharpening knives nor slaughtering animals in front of animals waiting for slaughter, and using a very sharp knife (Regenstein *et al.*, 2005). Slaughtering of animals outside of abattoir (at homestead) usually fulfills these basic requirements of religious slaughter since it is performed by religious individuals. Slaughtering camels at abattoirs is more plausible than slaughtering at homestead due to their large size and the veterinary inspection conducted at abattoirs. At the abattoir under consideration, all camels are slaughtered in the abattoir unit used to slaughter animals by Muslims. Since almost all the camel meat produced at the abattoir is consumed by Muslims, the slaughtering should follow the *halal* procedure. However, information lacks regarding the camel slaughtering practices pertaining to fulfilling the basic requirements of *halal* slaughter at the abattoir. Preslaughter water deprivation, which is against the humane treatment of animals, found to affect chemical composition of meat (Vogel *et al.*, 2011) and such preslaughter information should be observed to expect the chemical composition of camel meat.

Meat is an excellent source of many nutrients (Kadim and Mahgoub, 2013b). The chemical composition of camel meat indicates its functionality. Moisture content plays a role to food processors and consumers (Nielsen, 2003) and affects preservation and eating qualities of camel meat (Kadim *et al.*, 2008). The ash represents the total mineral content (Nielsen, 2003), and protein and fat dictate palatability and manufacturing quality of meat (Kadim, 2013). Camel meat is a healthier meat source due to its low fat (Al-Ani, 2004; Kadim *et al.*, 2008). However, there are some reports of higher fat contents where the composition varies mainly due to age, condition, breed, sex, and site on the carcass (Sales, 1995). Camel meat is the least studied type of meat and is believed to be of lower nutritive value (Abdelhadi *et al.*, 2013).

The abattoir used to slaughter camels mainly of Issa type for local consumption. The camels slaughtered in the abattoir are heterogeneous in age and body condition. However, there is limited information as to the effects of age and body condition on composition of camel meat. The local camel meat consumers and an efficient marketing system of the meat industry need more information on slaughtering practices and meat composition. The proportions of muscle, fat, and bone in the carcass described as physical composition and the proportions of chemically measured amounts of water, protein, lipid, and ash are helpful to describe body composition of animals (Regenstein *et al.*, 2005). The aim of this study was, therefore, to monitor the camel slaughtering practices and evaluate the effects of age and body condition on meat compositions of camels slaughtered in one of the abattoirs in eastern Ethiopia.

Materials and methods

Experimental animals

Fifty four Issa type male dromedary camels representing 3 age groups: group 1 (6-10 year-old), group 2 (11-17 year-old), and group 3 (≥ 18 year-old), and 3 body condition groups (poor, medium, and good) (Table 1) were sampled randomly from the routinely slaughtered camels in one of the municipality abattoirs in eastern Ethiopia. The camels were assigned chronologically to the different age groups at the time of slaughter based on dentition (Payne and Wilson, 1999; Rollefson *et al.*, 2008) that was substantiated by information from experienced person (Khan *et al.*, 2003). Body condition score (BCS) was assessed on a scale of 1 to 5 (Faye *et al.*, 2001; Gaden, 2005) and camels were further classified to the 3 body condition groups as described by Robinson (2010).

Table 1 – Number of camel used in the study.

Age		Body condition group			Total
Group	Range (years)	Poor	Medium	Good	
Group 1	6-10	6	6	6	18
Group 2	11-17	6	6	6	18
Group 3	≥18	6	6	6	18
	Total	18	18	18	54

Slaughtering and carcass physical composition

Animals were exposed to normal pre-slaughter handling conditions and subsequently held in a lairage for 3-5 h, followed by slaughtering and dressing based on the routine abattoir procedures. The abattoir's routine camel slaughtering practices were, therefore, monitored or observed to note the extent of *halal* or humane practices of slaughtering.

The physical components (muscle, bone, and fat) of carcasses were partitioned at butcheries following the routine dissection and trimming practices of butchers. The left side of the longitudinal half of the carcass was fabricated into front leg (shoulder), hump, rib, brisket, hind leg, loin, and flank wholesale cuts according to the traditional fabrication practiced in the abattoir. The neck was additionally fabricated into a single wholesale cut. The weight of each wholesale cut was measured using a hanging scale of 100 kg to the nearest 0.1 kg (Model NTA, Camry, China). Except the neck, the weight of each wholesale cut was doubled to which the weight of the neck was summed up to give the hot carcass weight (HCW). The weights of hump fat, subcutaneous fat, abdominal fat, kidney fat and intermuscular fat were summed up to give the total fat (TF). An insignificant amount of gut fat (omental and mesentery) was disposed with the gut content at the abattoir and was not considered. After collecting all the fat, each wholesale cut was then physically separated into dissectible muscle and bone components and the weights of each component were summed up to give the total muscle and total bone weights. Each physical component was expressed as percentage of the weight of the component to total weight of all components (HCW).

Meat sample collection

The *M. longissimus thoracis* muscle of the left side of each camel carcass was dissected within 4 h postslaughter for proximate analysis. The samples were wrapped in polyethylene bags, coded, transported in cool box containing ice to Haramaya University laboratory, all visible fat and connective tissue removed, vacuum-packed and kept in a chiller (4°C) for 24 h. Then, meat samples were frozen at -20°C until proximate analysis was performed (Kadim and Mahgoub, 2013b; AMSA, 2015).

Chemical composition

The proximate chemical composition of samples was determined in duplicates according to the standard methods of the AOAC (1999). Partially dried samples were ground to a homogeneous mass in a grinder (FRITSCH, Stainless Steel Pulverisette 16 Cross Beater Mill, RoHS, Serial No. 16.3020/00244, Germany) for chemical analyses. The moisture content was determined by drying 2 g sample in oven at

102°C for 16 h (AOAC method 950.46). It was obtained by weight loss determined using a precision weighing balance (Pioneer PA214, 210 g Capacity with 0.0001 g Readability, Serial No. 8729349454, China) readings before and after drying. Dried samples were incinerated in a muffle furnace at 550°C for 5-6 h to determine ash content. Crude protein was determined by Kjeldahl method (AOAC method 981.10) using Selenium as catalyst and the crude protein was calculated by multiplying the percent N with 6.25 (Nielsen, 2003; Greaser, 2009). Lipid was determined by Soxhlet extraction (AOAC method 960.39) where a 2 g sample was extracted repeatedly for 8 h by reflux with petroleum ether.

Statistical analysis

For the experiment, data were analyzed by General Linear Model (GLM) procedure of SAS 9.1 (SAS Institute Inc., Cary, NC, USA) (SAS, 2008) using PROC means to compare the effects of age and body condition on physical and chemical compositions of camel meat. Least squares means (LSMEANS) were separated by PROC GLM with the PDIFF option for treatments with significant effects at $P<0.05$ by employing Tukey's multiple comparison procedure. Results were reported as LSMEANS with accompanying standard error (SE).

A 3 × 3 two-way factorial experiment was used in a completely randomized design (CRD) with the following model:

$Y_{ijk} = \mu + A_i + B_j + E_{ijk}$, where

Y_{ijk} = the response variable

μ = overall mean

A_i = the i^{th} age effect

B_j = the j^{th} body condition effect

E_{ijk} = random error.

Results

The camel slaughtering practices at the abattoir

It was observed that all the sampled camels (54) were handled in the abattoir and slaughtered in a similar procedure. The slaughtering began by cruelly cutting the *Achilles* tendons at the hocks of camels' hindlegs with a machete so as to immobilize animals during slaughtering (Figure 1). The slaughtering practice violated several other basic requirements of humane and *halal* slaughter such as stressing animals by sharpening knives and/or slaughtering a camel in front of camels waiting for slaughter (Figure 2), and neck severing was not performed instantaneously with one stroke since camels were not restrained. Animals were also withdrawn from water for about 24 h. Figure 3 depicts the slaughtering process in the abattoir.

(A) (B) (C)

Figure 1 - Slaughtering commences just by cutting the Achilles tendon inhumanly (A and B) using a machete (C) without restraining in a crouching position

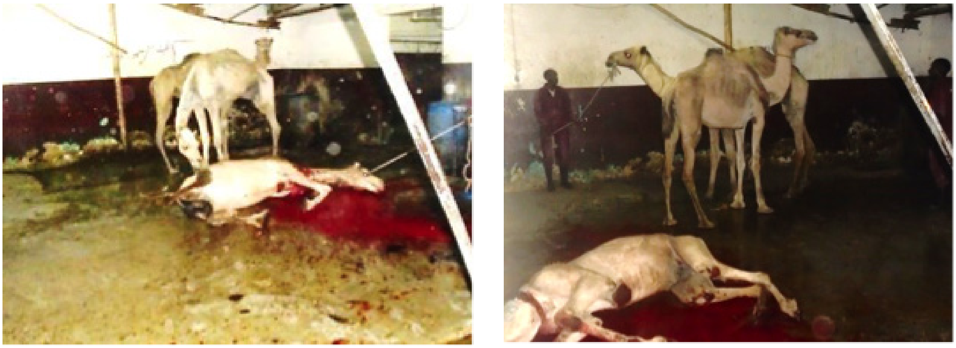
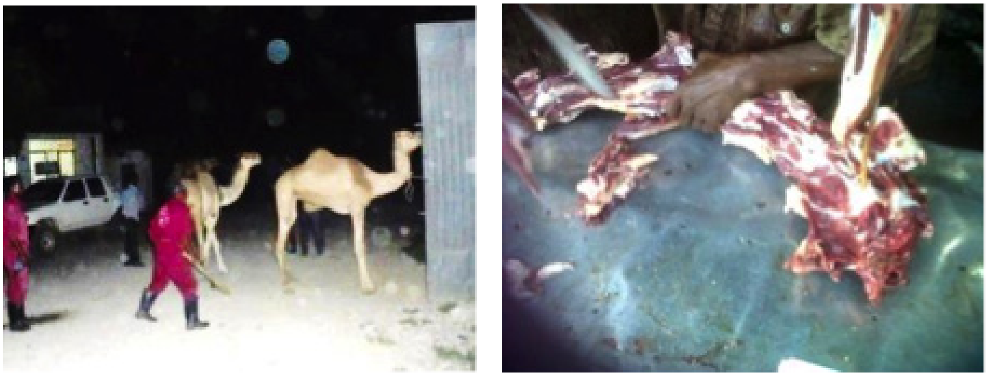


Figure 2 - Slaughtering a camel in front of other camels waiting for the slaughter.

(A) (B) (C)

Figure 3 - The slaughtering process: (A) camel awaiting area, (B) short period waiting shed just before slaughter, (C) abattoir, (D) camels getting into abattoir for slaughter at mid-night, and (E) butchery shop.



(D) (E)

Figure 3 - continued

Carcass physical composition

The age and body condition of camel had a significant effect on the proportion of carcass components (muscle, bone and fat). Camels of age groups 1 and 2 yield significantly higher (*P*<0.0008) proportions of muscle than group 3 camels. Significantly higher (*P*<0.004) proportion of bone was obtained from group 1 camels than camels in groups 2 and 3. The proportions of fat varied significantly (*P*<0.0001) among the age and body condition groups where values increased with increasing age and improving body condition of camels. Higher proportions of muscle (*P*<0.0002) and bone (*P*<0.05) were obtained from camels with poor and medium body condition groups than camels with good body condition group (Table 2).

Table 2 - Mean (±SE[1]) proportions of the physical compositions of camels carcasses at different age and body condition groups (N = 54).

Treatment Factors	Muscle (%)	Bone (%)	Fat (%)
Age group (A)			
Group 1	56.8±0.8[a]	27.7±0.7[a]	15.5±0.4[c]
Group 2	55.6±0.8[a]	24.6±0.7[b]	19.8±0.4[b]
Group 3	52.2±0.8[b]	24.2±0.7[b]	23.6±0.4[a]
Body condition group (B)			
Poor	57.4±0.8[a]	26.3±0.7[a]	16.3±0.4[c]
Medium	55.1±0.8[a]	26.3±0.7[a]	18.6±0.4[b]
Good	52.1±0.8[b]	23.8±0.7[b]	24±0.4[a]
A × B	ns[2]	ns	ns

[a,b,c] Means in the same column within the age groups or within the condition groups followed by the same superscript letters are not significantly different (*P*>0.05); [1]Standard error; [2]Not significant

Chemical composition of meat samples

The age of camels had a significant effect on ash ($P<0.0074$) and lipid ($P<0.05$) contents, but did not affect ($P>0.05$) moisture and crude protein (CP) contents. The ash content decreased but the lipid content increased with increasing age of camels. Meat from group 1 camels had higher ash content than camels of groups 2 and 3. The lipid content was lower in group 1 camels' meat compared to that of group 3. With the exception of ash content, body condition of camels significantly affected the proximate values. The moisture ($P<0.05$) and CP ($P<0.0028$) contents of camels meat with good condition were significantly lower than meats obtained from camels with medium and poor condition groups. On the other hand, camels with poor condition had significantly lower ($P<0.0001$) lipid content than the other body condition groups (Table 3).

Overall, there was an increase in lipid but a decrease in moisture, ash and crude protein contents with increasing age and body condition of camels. The inverse relationship between lipid and the other chemical compositions followed similar pattern to the relationship explained among physical components (muscle, bone and fat) discussed above. There was a significant ($P<0.0001$) positive correlation (r = 0.44) between fat proportion of the carcass and the lipid component determined from intramuscular fat. However, there was a significant negative correlation between fat proportion of the carcass with moisture and ash ($P<0.05$) and with crude protein ($P<0.01$) contents (Table 4).

Table 3 - Mean (±SE[1]) proximate compositions of camels M. longissimus thoracis muscles (N = 54).

Treatment Factors	Moisture (%)	Ash (%)	Crude Protein (%)	Lipid (%)
Age group (A)				
Group 1	78.58 ± 0.49^{a}	2.15 ± 0.06^{a}	20.08 ± 0.49^{a}	8.17 ± 0.65^{b}
Group 2	78.01 ± 0.49^{a}	1.94 ± 0.06^{b}	20.61 ± 0.49^{a}	9.81 ± 0.65^{ab}
Group 3	78.31 ± 0.49^{a}	1.92 ± 0.06^{b}	19.74 ± 0.49^{a}	10.35 ± 0.65^{a}
Body condition group (B)				
Poor	79.06 ± 0.49^{a}	2.02 ± 0.06^{a}	21.22 ± 0.49^{a}	6.18 ± 0.65^{b}
Medium	78.67 ± 0.49^{a}	2.05 ± 0.06^{a}	20.4 ± 0.49^{a}	10.24 ± 0.65^{a}
Good	77.16 ± 0.49^{b}	1.95 ± 0.06^{a}	18.82 ± 0.49^{b}	11.92 ± 0.65^{a}
A × B	ns[2]	ns	ns	ns
Range	73.27-85.10	1.24-3.54	12-27.4	2.69-20.67

[a,b] Means in the same column within the age groups or within the condition groups followed by a common superscript letter are not significantly different ($P>0.05$); [1]Standard error; [2]Not significant

Table 4 - Coefficients of correlation among proportions of meat composition variables.

Variables	Muscle	Bone	Fat	Moisture	Ash	CP	Lipid
Muscle	1	-0.27	-0.71	0.15	0.31	0.32	-0.32
Bone	ns	1	-0.49	0.28	0.03	0.10	-0.21
Fat	****	***	1	-0.35	-0.30	-0.36	0.44
Moisture	ns	*	*	1	0.27	0.28	-0.26
Ash	*	ns	*	*	1	-0.08	0.05
Crude protein (CP)	*	ns	**	*	ns	1	-0.39
Lipid	*	ns	***	ns	ns	**	1

* = P<0.05; ** = P<0.01; *** = P<0.001; **** = P<0.0001

Discussion

The camel slaughtering practices at the abattoir

The World Organization for Animal Health (OIE) Code specifies that immobilization by injuring such as breaking legs, leg tendon cutting, and severing the spinal cord which causes severe pain and stress in animals are always unacceptable restraint methods on animal welfare grounds (Vapnek and Chapman, 2011), suggesting the present slaughtering practice to be painful and cruel action. In line to the present study, Mitiku and Getachew (2015) observed cutting of the hindlegs at *Achilles* tendon (hock) to immobilize camels during slaughtering at two slaughterhouses in eastern Ethiopia.

In the study area and other parts of Ethiopia, meat is consumed mostly by Muslims provided that the permitted animals are slaughtered as per the *halal* slaughtering procedure. The *halal* slaughtering involves restraining, and severing of major vessels (trachea or windpipe, esophagus or throat, carotid arteries, and jugular veins) with one stroke using a very sharp knife (Riaz and Chaudry, 2004). According to Vapnek and Chapman (2011), many national animal welfare legislations such as the Tanzanian Animal Welfare Act (2008) stated that the killing of an animal may be performed only in such a manner as to avoid unjustified inflicting of pain, suffering, injury or fear on the animal, and an animal shall be slaughtered instantaneously. Thus, avoiding conditions that create stress, not slaughtering an animal in front of others of its kind, and not sharpening a knife in front of animals to be slaughtered are suggested humane treatment of animals during slaughtering (Nakyinsige *et al.*, 2013). The Zambian Prevention of Cruelty to Animals Act (1994) includes a provision that slaughtering an animal in sight of another constitutes cruelty (Vapnek and Chapman, 2011).

Animals were deprived of water at the abbatoir since butchers perceived that the meat will have more drip loss if camels are subjected to free water access before slaughter. This is against the scientific, religious and animal welfare grounds which recommend animals to have free access to water before slaughter (Warriss, 2000; Regenstein *et al*., 2005). Access to water decreases stress caused by hunger, enhances complete bleeding, results in a brighter coloured lean carcass and facilitates skin removal (Gregory, 1998; Aguilar-Guggembuhl, 2012; Kadim *et al*., 2013b). Increased deprivation of water for 36 h found to increase the percent crude protein but decrease the moisture content with no significant effect on ash and fat content of beef (Vogel *et al*., 2011). The current study confirmed the practice of water deprivation, but the effect of deprivation on camel meat composition inquires further investigation.

The butchers and camel meat consumers have no claim regarding the slaughtering procedure may be because of lack of information on how camels are slaughtered at the abattoir. Since religious slaughter is a matter of belief, the camel slaughtering at the abattoir should be as per the *halal* procedure. Adoption of the *halal* slaughtering will guarantee future marketing of camel meat in the domestic and export market. For instance, only *halal* meat could be imported into United Arab Emirates (UAE) from different countries (Farouk, 2013). All Ethiopian meat exported to Middle East is certified by the Islamic Affairs Council that monitors abattoir operations ensuring that animals are slaughtered according to the proper Islamic killing procedures (EMPEA, 2015) to fulfill requirements of meat importers. This inquires the need for the abattoir to design the slaughter hall to provide separate partitions of adequate dimensions sufficient for restraining and slaughter of each animal should be out of sight of other animals. Besides, a one stroke instantaneous slaughter should be adopted.

Carcass physical composition

The proportion of fat increased, but the proportions of muscle and bone decreased with age and body condition of camels. This supports the finding of Warriss (2000) who noted an increase in fat but a decrease in muscle and bone proportions of carcasses as animals get older and heavier. The variations in the proportions of physical components due to age and body condition were the result of the specific patterns of development of these components. The nervous system develops first followed by bones, muscular tissue, and fat deposition (Warriss, 2000; Lawrence and Fowler, 2002). The growth pattern of an animal, therefore, determines the composition of meat. The proportions of fat increase in older and heavier animals because fat is the last tissue to mature (Warriss, 2000). The proportion of bone decreases only slightly once an animal attained an adult growth stage (Davies, 2004).

The camel stores its energy reserves in the form of fat in various depots in the body such as the hump, the kidney, and in subcutaneous, intermuscular, abdominal, omental and mesenteric depots. Dromedary camels use their fat stores to maintain their productivity and/or survive by mobilizing adipose tissue (Kadim *et al.*, 2013b) in situations such as when the body condition decreases during starvation. Fat is the most variable tissue in the body and manipulation of carcass composition by genetic or nutritional means depends largely on controlling the proportion of fat (Berg and Butterfield, 2005).

Several previous studies on dromedaries confirmed the highest proportion of muscle where, for instance, in mature fattened male Sudanese camels, the proportions of muscle (lean meat), bone, and fat were respectively 56, 19, and 13.7% (Yousif and Babiker, 1989); 57, 25.5, and 16.9% in average camel carcasses (Wilson, 1998); and 68, 20, and 12% in Ogaden type camels in Ethiopia (Kurtu, 2004). Age has a significant effect on carcass components with distinct advantages in slaughtering camels at an early age (Kadim and Mahgoub, 2013a).

Chemical composition of meat samples

The age of an animal has a great effect on the lipid content with camel meat from older animals containing higher fat compared with meat from relatively younger animals (Kadim *et al.,* 2006). At early age of animals, water, protein and minerals (ash) consist higher proportion of the body while gain at latter growth contains a higher proportion of fat (McDonald *et al.*, 2010). Moreover, Davies (2004) noted a decline in the percentage of moisture, CP and ash with a corresponding increase in the fat content from birth to maturity. Gheisari *et al.* (2009) found a decrease in moisture and CP but an increase in ash and lipid contents with increase in age (1 vs 5 years old) of Iranian dromedary camels in meat samples collected from *biceps femoris, triceps brachii*, and *longissimus dorsi* muscles. Dawood and Alkanhal (1995) and Kadim *et al.* (2008) found no effect of age on ash content. Although there are some discrepancies in chemical composition among reports of various studies as attributed to age, muscle type, breed, nutritional status and sex of camels (Kadim *et al.*, 2006; Gheisari *et al.*, 2009; El-Waziry *et al.*, 2012; Kadim *et al.*, 2013a), the decrease in the proportion of moisture, protein and ash in general and increase in lipid contents with increasing age of camels in many of the findings is due to the change in body composition during animal growth. In accordance with the present finding, Berg and Butterfield (2005) reported a decrease in protein, ash, and moisture percentages with advance in age and fattening in cattle.

In the present study, a wide range of moisture (73.27-85.1%), CP (12-27.4%), ash (1.24-3.54%) and lipid (2.69-20.67%) contents were recorded. The range of moisture

(64.4-76.7%), CP (18.6-25%), ash (1-1.4%) and lipid (1.1-10.5%) contents recorded for Omani dromedary camels aged 1 to 8 years (Kadim *et al*., 2006) also show the high variation that existed among camels with different age groups. The wide ranges in proximate values in the current study are due to the use of camels that are heterogeneous in age and body condition.

Moisture is an important parameter in camel meat as it affects shelf-life, processing potential, quality and palatability or sensory characteristics of the meat (Kadim *et al*., 2006). The high moisture content affects palatability in that consumers usually prefer juicy over dry meat (Kadim *et al*., 2013a). The mean CP content was 20.14% implying that camel meat provides a good source of protein in arid environment where dromedary camels thrive better than other meat animals. The low lipid content makes camel meat a healthy option and advantageous in special diets (Bekhit and Farouk, 2013). The lipid content also enhances the palatability traits of meat products such as flavour, juiciness, and tenderness (Kadim and Mahgoub, 2013a).

Conclusion

The study revealed that the camel slaughtering practices at the abattoir did not fulfill the humanly slaughtering procedures. This would affect the consumption, preference, and future marketing of camel meat products. Although camels slaughtered at the abattoir were almost at adult age category, they provide meat with high proportion of muscle, high moisture, adequate amount of crude protein and ash, and low fat contents where the values varied with age and body condition. Camels aged 6-10 years at medium body condition produced meat having better nutritive value with less health risk associated to fat. Since consumers are becoming conscious about meat types (their origin), the way animals are slaughtered and healthy nutrition, the information generated from the current study is helpful to the abattoir and interested stakeholders to fulfill basic requirements in response to the needs and desires of consumers. However, information regarding the effect of water deprivation on camel meat composition inquires further investigation.

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