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FULL LENGTH ARTICLE

Effect of gender on quality and nutritive value of dromedary camel (*Camelus dromedarius*) *longissimus lumborum* muscle

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Dromedary camels;
Nutritive value;
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Abstract This study aimed to determine the effect of gender on nutritive value of dromedary camel *longissimus lumborum* (collagen content, amino acids and fatty acids). Fourteen *longissimus lumborum* (LL) muscles (from 7 males and 7 females) were collected from 2 to 3 year old camels. Animals were fattened by herders and slaughtered following commercial slaughterhouse procedures in Sudan. Samples were collected between the 1st and 5th lumbar vertebrae of the right carcass side. There was no effect of gender on intramuscular fat content, insoluble OH proline and total OH proline (μg/DM). Additionally no significant differences were found in amino acid composition between genders. However, muscles from female camels had significantly ($P < 0.05$) higher arginine content (1460 mg/100 g) than males (1460 mg/100 g). The results showed no significant differences between genders for total saturated fatty acid (SFA), mono-unsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) proportions in camel meat. In contrast significant differences were revealed for some specific MUFA and PUFA (18:1 delta 10–11 *trans*, × 1.51, ($P = 0.05$), CLA (*trans* 11, *cis* 9 18:2, × 1.33% ($P = 0.11$) and *trans* 10, *cis* 12 18:2, × 5.7, ($P = 0.03$) in female muscles). PUFA/SFA ratio was found closer to the recommended value for human nutrition (0.45). Also the n-6/n-3 ratio was lower than the recommended values for healthy human diets (4.0).

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Altogether, these results indicated high nutritive value of dromedary camel meat compared to meat from other farm animals.

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1. Introduction

Sudan ranks the second in the world after Somalia with 4.787 million heads of camels and camel meat production of 140,000 tons (FAOSTAT, 2013). The role of camel as food source is being accepted and camel scientists have noted that the camel has an unrealized potential for satisfying the dietary and medical needs of humans (Faye and Esenov, 2005). The local consumption of camel meat had increased especially from young camels due to their nutritional value (Kadim et al., 2008). The demand for camel meat appears to increase for health reasons, as camels produce meat with relatively less fat than cattle and sheep (El-Faer et al., 1991; Dawood and Alkanhal, 1995; Kadim et al., 2008). Camel meat production has a good potential in arid tropics and developing countries and also beneficial for fever patients due to the low fat content (Mahmud et al., 2011). In some areas, camel meat is also used as a cure for diseases such as hyperacidity, hypertension, pneumonia and respiratory disease (Kurtu, 2004). The mature, fattened one-hump camel dresses out at 55.8% of live body weight (456 kg) and 63.6% of empty body weight yielding 56% meat, 19% bone and 13.7% fat (Yousif and Babiker, 1989). The nutritive value of camel meat could be similar or sometimes superior compared to meats from other animals as indicated previously in the literature. Camel meat has been compared with meat from other farm animals (beef, lamb, goat and chicken) and found to have more moisture, less fat, less ash and similar protein contents (Elgasim and Alkanhal, 1992; Dawood and Alkanhal, 1995; Kadim et al., 2008). The ratio of indispensable to dispensable amino acids in camels was 0.85, very similar to 0.86 reported for cattle, 0.83 for lamb and 0.90 for goat (Elgasim and Alkanhal, 1992; Dawood and Alkanhal, 1995). Its muscle content of insoluble and total collagen hydroxyproline (OH-proline) was 28.7 and 46.11 μg/g fresh muscle was reported previously in Arabian camels (Siddiqi et al., 2000). In addition to protein, fat is a vital nutrient with many functions in the human body (e.g. energy provider, carrier of fat-soluble vitamins, component of cell membranes, the basic substance of hormones, and second messengers) and also important for sensory characteristics of food (e.g. flavour and texture), and as such plays an important role in meat quality. However dietary fat intake is also associated with health problems (McAfee et al., 2010; Schmid, 2011). It is known that not only the amount but also the nature of the fatty acids (saturated *vs*. unsaturated fatty acids, n-6/n-3 ratio, etc.) plays a major role in maintaining human health (Dilzer and Park, 2012). As a baseline the fatty acid profile of camels is comparable to other camelids such as the llama (Rawdah et al., 1994; Polidori et al., 2007). The manipulation of feeding regimes has been proved to lower the effect of rumen hydrogenation on fatty acids in beef and increasing favourable lipids in cattle meat (omega-3 acid, C18:3, the UFA C18:1, as well as the SFA's palmitic and stearic acid), in particular the feeding of roughage and especially pasture (Dimov et al., 2012a,b).

Concurrently with these facts, it is important to investigate the nutritional value of dromedary camel meat. Little information is available regarding meat chemical composition, collagen content, amino acids and fatty acids composition in both genders of the dromedary camel. The aim of the present study was to determine the effect of gender on the nutritive value of the one humped desert camel *longissimus lumborum* muscle.

2. Materials and methods

2.1. Animals and muscle samples

Fourteen (2–3 year-old) dromedary camels (7 from each sex) were used. Animals were slaughtered in a commercial slaughterhouse in Omdurman province, Sudan, as described previously by Yousif and Babiker (1989). Samples of *longissimus lumborum* (LL) muscle were removed from the right carcass side between the 1st and 5th lumbar vertebrae, and then transported to a meat science laboratory (Faculty of Animal Production, University of Khartoum, Sudan) in an insulated box filled with ice 60 min postslaughter. Connective tissues and visible fat were removed from each muscle sample, placed in plastic bags and kept for 24 h at 2–3 °C. Muscle colour coordinates (*L*, *a* and *b*) and muscle pH were determined using a Minolta CR100 chromametre (Minolta Co., Ltd., Japan) and portable pH meter (Hanna waterproof pH meter, Model H I 9025, Italy) with temperature adjusting probe inserted at the same depth each time into a fresh section of the muscle. Samples were then vacuumed and stored at −18 °C and transported to France in insulated box filled with dry ice. Chemical composition was determined at CIRAD – Baillarguet, Montpellier, France, after grinding of muscle samples to a homogeneous mass then dried over night at 80° C according to the standard methods of AOAC (2000). The following chemical analyses were achieved at INRA-Theix, France.

2.2. Muscle collagen content

One to two hundred grams of LL muscle was chopped into cubes (2–3 cm), vacuumed and stored at −20 °C until the subsequent collagen analysis. Approximately 100 g of the frozen samples was homogenized using a household cutter, freeze-dried for 48 h then ground using coffee grinder to produce a fine powder and stored at 4 °C in plastic bottles sealed with parafilm. The stored samples were solubilized following the procedure of Hill (1966) and Listrat et al. (2001). Freeze-dried samples were rehydrated for 1 h in 15 ml of buffer (0.23 M NaCl, 25 mM Tris–HCl, pH 7.4) and heated in water bath at 75 °C for further 1 h, and then centrifuged for 15 min at 4000*g* at room temperature. The supernatant which represents the soluble collagen was discarded and the pellet (insoluble collagen) was dried in oven for 1 h at 45 °C to eliminate the remaining supernatant. Ten millilitres of 6 N HCl was added to the dried pellets (insoluble collagen) and, for total collagen

measurement, to 50 mg of freeze-dried muscle and then hydrolysed overnight at 105° C. After incubation with activated charcoal (Norit A), they were filtered (OOB filter papers) and then diluted (5× in dH_2O). OH-proline content was determined according to the procedure of Woessner (1961). Optical densities were read at 557 nm. OH-proline was chosen as the standard to compare results and a standard curve was plotted to determine OH-proline concentrations. The data are represented as means of triplicates and expressed in micrograms of hydroxyproline per milligram of dry matter.

2.3. Amino acid composition

Nitrogen content of muscles was determined by elemental analysis (Vario Isotope Cube, Elementar, Lyon, France). Protein content was estimated using the conversion factor of 6.25. For amino acid determination, four different conditions of protein hydrolysis have been applied. Three acidic hydrolysis (HCl 6 N, 110 °C) was realized, for 24 h after performing oxidation for sulphur amino acids, and 48 h for branched chain amino acids in addition to one basic hydrolysis ($BaOH_2$, 4 N, 110 °C, 16 h) for tryptophan determination. Samples were accurately weighed, and an internal standard (norleucine), stable during hydrolysis, was added for adjustment due to dilution steps and amino acid analysis. Immediately after hydrolysis HCl or $BaOH_2$ was removed under vacuum and the amino acids were dissolved in loading buffer. They were separated by ion-exchange chromatography (ICP) and the following reactions were detected with ninhydrin (Bio-Tek Instruments A.R.L., St Quentin Yvelines, France). Cysteine and methionine were detected as cysteic acid and methionine sulphone, respectively.

2.4. Fatty acid composition

Muscle tissues were mixed in nitrogen liquid to produce a homogenous powder stored at −20 °C until lipid analysis. Total lipids in *longissimus lumborum* muscle were extracted by mixing 5 g of meat powder with chloroform/methanol (2:1, v/v) according to the method of Folch et al. (1957) and determined gravimetrically. Fatty acids (FA) were extracted from muscle total lipids and transmethylated at room temperature first with sodium methylate (1 M) and second with boron trifluoride in methanol (14%, v/v). The qualitative and quantitative FA analysis was achieved by gas–liquid chromatography (GLC) using the Perichrom 2000 chromatograph (Perichrom, Saulx-les-Chartreux, France) fitted with the CP-Sil 88 glass capillary column (length: 100 m, i.d.: 0.25 mm) with H_2 as the carrier gas. The chromatographic conditions were as follows: the oven temperature was set at 70 °C for 30 s, then ramped from 70 to 175 °C at 20 °C/min, held at 175 °C for 25 min, ramped from 175 to 215 °C at 10 °C/min, and finally held at 215 °C for 41 min; injector and detector temperatures were 235 and 250 °C, respectively. Hydrogen was the carrier gas (H_2 flow: 1.1 ml/min) in conditions of split injection (1:50). Total FA was quantified by using C19:0 as the internal standard (Supelco, Bellefonte, PA). Response coefficient of each individual FA was calculated by using the quantitative mix C4–C24 FAME (fatty acid methyl ester) (Supelco, Bellefonte, PA).

Table 1 Mean ± standard error of ultimate pH, colour, proximate composition and collagen content of *longissimus lumborum* dromedary camel muscles.

Parameter	Male	Female	*P* value
Ultimate pHu	6.10 ± 0.10	6.15 ± 0.11	0.80
Dry matter (%)	22.9 ± 0.27	24.2 ± 0.11	0.0005
Ash (%)	0.89 ± 0.04	0.94 ± 0.03	0.34
Protein (mg/100 g)	19.3 ± 0.14	20.1 ± 0.62	0.0004
Intramuscular fat (mg/100 g)	2.31 ± 0.04	2.35 ± 0.08	0.96
Meat colour			
Lightness (*L*)	24.5 ± 0.53	24.5 ± 0.45	0.47
Redness (*a*)	15.1 ± 1.05	15.8 ± 0.63	0.30
Yellowness (*b*)	5.6 ± 0.45	5.9 ± 0.37	0.30
Insoluble OH proline (μg/mg DM)	2.55 ± 0.14	2.46 ± 0.17	0.68
Total OH proline (μg/mg DM)	3.47 ± 0.18	3.31 ± 0.18	0.54
OH proline solubility (%)	26.3 ± 2.24	25.9 ± 1.88	0.89

2.5. Statistical analysis

Data were analysed using a Student's *t* test to determine significant differences in the studied parameters (collagen content, amino acids and fatty acids) between males and females.

3. Results and discussion

3.1. Chemical composition of camel meat

Ultimate pH (pHu) in male (6.10) and female (6.18) muscles showed no significant differences. It was higher (Table 1) compared to that reported by Babiker and Yousif (1990) who reported a pHu of 5.80 in *longissimus dorsi* muscle of camels from the same region. Kadim et al. (2006) also reported a pHu of 5.9 for camel *longissimus dorsi* muscle. The high muscle pHu in the present results could be due to low stored muscle glycogen. In fact, camel muscles have different properties of their muscle fibres compared to bovine which may result in high pH values (Abdelhadi et al., 2012).

Dry matter and protein were significantly ($P < 0.05$) higher in females (24.2% and 20.1%) than in male camels (22.9% and 19.3%), while no significant differences were observed in intramuscular fat and ash (2.35% and 0.94% *vs.* 2.31 and 0.89). These values were lower than those reported by Abdelhadi et al. (2012) for camel calves with similar ages and from the same region. These differences could be attributed to differences in the muscle type evaluated and feeding system, which is suggested by Paula and Ana (2013) who stated that fat content varies depending on species, origin, feeding system and the cut. The high dry matter content of *longissimus lumborum* muscle from female camels could be due to the expected higher fat content of females over males.

Total and insoluble hydroxyproline (OH proline) contents did not differ between males and females (Table 1). In contrast Babiker and Yousif (1990) and Siddiqi et al. (2000) reported different values of collagen content in camel's muscles. These differences could be attributed to the differences in muscle

Table 2 Mean ± standard error of amino acids profile of *longissimus lumborum* dromedary camel muscles.

Amino acids (mg/100 g fresh muscle)	Male	Female	*P* value
Indispensable (IDAA)			
Histidine	862 ± 51.9	897 ± 60.1	0.66
Isoleucine	1174 ± 31.4	1230 ± 33.8	0.25
Leucine	1937 ± 69.2	2010 ± 68.4	0.46
Lysine	1868 ± 44.9	1909 ± 46.8	0.28
Methionine	741 ± 31.0	825 ± 17.2	0.17
Phenylalanine	665 ± 45.8	646 ± 16.6	0.71
Threonine	1164 ± 56.0	1214 ± 46.3	0.50
Tryptophan	354 ± 26.6	342 ± 23.8	0.73
Valine	1130 ± 40.0	1199 ± 43.1	0.26
Dispensable (DAA)			
Alanine	1330 ± 28.5	1347 ± 55.9	0.80
Arginine	1430 ± 43.4	1604 ± 56.0	0.03
Aspartic acid*	2298 ± 45.2	2246 ± 47.4	0.44
Cysteine	494 ± 42.6	546 ± 38.8	0.16
Glutamic acid*	4268 ± 93.0	4251 ± 75.2	0.89
Glycine	956 ± 31.5	960 ± 42.5	0.95
Proline	1164 ± 33.2	1074 ± 45.5	0.18
Serine	887 ± 40.7	923 ± 28.1	0.48
Tyrosine	929 ± 95.8	933 ± 82.0	0.97
IDAA/DAA	0.92	0.97	

types studied, and in the methods used. In bovine muscle, using the same method, Listrat et al. (2001) reported values of total collagen 3.74 and 5.18 (OH-proline μg/mg DM) from Blonde d'Aquitaine and Charolais breeds which is slightly higher than the present results. However, Jurie et al. (2006) reported lower values of total and insoluble OH-proline 2.60 and 2.25 μg/mg DM in bovine LT muscle which is comparable to the present results. Lepetit (2007) stated that total and soluble collagen contents have a relationship with bovine meat tenderness. Furthermore, strong correlations between insoluble collagen content and Warner–Bratzler shear force values of raw beef meat were reported by Stolowski et al. (2006). However, Christensen et al. (2010) found a correlation between collagen and toughness for raw *m. longissimus thoracis* (LT) muscles only.

There were no significant differences in muscle colour between male and female camels. The *L* and *b* values (Table 1) were lower than the results obtained by Abdelhadi et al. (2012) from camels in the same region who reported *L* and *b* values of 34.0 and 11.2, respectively. These differences could be linked to the relatively high muscle pH and low intramuscular fat content in the present study. Priolo et al. (2001) reported that many factors affect meat colour in ruminants, including feeding diets (Scollan et al., 2014), muscle pH (Bruce et al., 2004), muscle fat content (Farouk and Lovatt, 2000) and physical activity (Vestergaard et al., 2000).

3.2. Amino acid profile of muscle proteins

There were no significant differences between males and females in indispensable amino acid (IDAA) and dispensable amino acid (DAA) content of the LL muscle proteins (Table 2), except for arginine which was significantly ($P < 0.05$) higher in females. Leucine and lysine were the most abundant indispensable amino acids and glutamic acid, aspartic acid, arginine, alanine and proline were the highest indispensable amino acids in proteins of camel LL muscles. These results are in agreement with those reported by Kadim et al. (2011) who reported that lysine was the major indispensable amino acid in male camel LT muscle. In cattle, similar results were obtained by Hollo et al. (2007) who reported that leucine and lysine were the IDAAs with the highest concentrations and arginine, aspartic and glutamic acid were the highest among the DAAs. When examined on a g/g of protein basis, the results of the present study are very close to those reported by Kadim et al. (2008), but higher than those reported by Dawood and Alkanhal (1995), Rawdah et al. (1994) and Kadim et al. (2011) in camels. The differences between the present values and those reported by the later authors could be attributed to breed differences and/or nutritional status of the animals. The current results were comparable to those reported by Hollo et al. (2007) and Dimov et al. (2012). The present results showed that glutamic, aspartic, leucine and lysine were the main amino acids in dromedary LL muscle when sorted according to their quantity as shown in Fig. 1.

The IDAA/DAA ratio of amino acids was 0.92 in males, higher than that reported by Elgasim and Alkanhal (1992) who indicated a ratio of 0.85 for camel, 0.86 for beef, 0.83 for lamb and 0.90 for goat meat. Similarly, the ratio of IDAA/DAA in the present results was higher than the calculated ratio from Kadim et al. (2011) in fresh camel meat. The concentration of amino acids found in this work was higher than that reported in other animal species such as cattle (Nicolette and Schönfeldt, 2013) and lamb (Peraza-Mercado et al., 2010). These levels are sufficient for the recommended daily intake (RDI) for indispensable amino acids reported by FAO/WHO/UNU (2007). This could confirm that camel meat is healthy with similar or superior amounts of amino acids than other livestock species.

3.3. Fatty acid profile of muscle lipids

No significant differences due to gender were observed in total lipids, total fatty acids and the ratio of fatty acids/lipids ($P > 0.05$) (Table 3). Total lipid values of males and females were comparable to those in LD muscle of Barrosa veal (2.32 mg/100 g) (Alfaia et al., 2007).

Total saturated fatty acid (SFA) proportions in total FA in camel meat were within the range of total SFA reported for bovine (43–52%) and lambs (46–54%) by Aro et al. (1998).

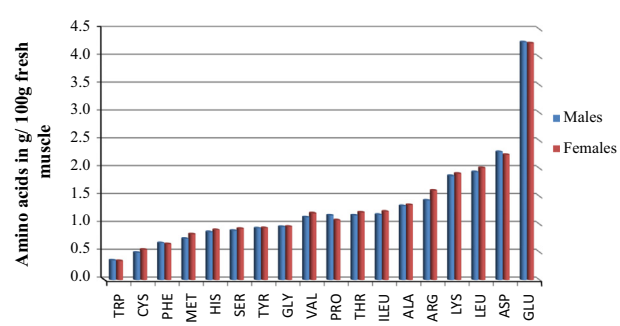

Figure 1 Amino acids profile (g/100 g fresh muscle) of dromedary LL muscle sorted according to their ascending quantity.

Table 3 Mean ± standard error of total lipids and total fatty acids (mg/100 g fresh and centesimal composition of fatty acids (% total FA) muscle) of *longissimus lumborum* dromedary camel muscles.

Fatty acids (%)	Male	Female	*P* value
Total lipids (mg/100 g fresh muscle)	2316.7 ± 535.6	2353.3 ± 390.5	0.96
Total fatty acids (mg/100 g fresh muscle)	1541.7 ± 444.4	1634.7 ± 296.9	0.86
Fatty acids/lipids	61.4 ± 4.29	68.7 ± 2.46	0.17
Linear SFA			
14:0	4.83 ± 0.55	5.20 ± 0.24	0.20
15:0	0.58 ± 0.15	0.65 ± 0.06	0.27
16:0	22.4 ± 1.10	23.0 ± 0.43	0.25
17:0	0.76 ± 0.05	0.89 ± 0.05	0.11
18:0	16.9 ± 1.20	17.1 ± 0.71	0.69
Monounsaturated FA			
16:1 delta 9 *cis*	3.43 ± 0.60	3.51 ± 0.24	0.78
17:1 delta 9 *cis*	1.16 ± 0.20	1.06 ± 0.09	0.43
18:1 delta 9 *cis*	25.9 ± 1.96	24.9 ± 0.85	0.34
18:1 delta 11 *cis*	2.57 ± 0.16	2.49 ± 0.10	0.46
18:1 delta 10–11 *trans*	1.07 ± 0.17	1.33 ± 0.18	0.05
18:1 delta 12 *trans*	0.19 ± 0.04	0.17 ± 0.44	0.46
Polyunsaturated FA			
18:2 n-6 *cis cis* (LA)	6.61 ± 1.70	6.16 ± 0.87	0.73
18:3 n-3 (ALA)	0.68 ± 0.10	0.87 ± 0.07	0.16
20:3 n-6	0.47 ± 1.70	0.43 ± 0.06	0.65
20:4 n-6 (ARA)	2.59 ± 0.76	2.36 ± 0.40	0.65
20:4 n-3 (ETA)	0.08 ± 0.13	0.05 ± 0.01	0.40
20:5 n-3 (EPA)	0.70 ± 0.07	0.72 ± 0.16	0.86
22:5 n-3 (DHA)	1.09 ± 0.17	1.09 ± 0.17	0.98
22:6 n-3 (DPA)	0.14 ± 0.29	0.14 ± 0.04	0.87
cis 9, *trans*1118:2 (CLA)	0.45 ± 0.06	0.52 ± 0.06	0.11
*trans*10 *cis* 12 18:2 (CLA)	0.01 ± 0.06	0.05 ± 0.02	0.03
Total SFA	48.2 ± 1.89	51.4 ± 0.99	0.17
Total MUFA	36.9 ± 1.85	35.1 ± 0.90	0.41
Total of CLA	0.53 ± 0.78	0.72 ± 0.67	0.09
Total PUFA	13.6 ± 3.09	12.3 ± 1.56	0.72
Total PUFA n-6	10.2 ± 2.61	8.57 ± 1.28	0.58
Total PUFA n-3	2.89 ± 0.57	3.05 ± 0.38	0.82
n-6/n-3	3.36 ± 0.44	2.83 ± 0.32	0.34
18:2 n-6/C18-3 n-3	11.5 ± 3.88	7.11 ± 1.65	0.31
16:0/18:0	1.37 ± 0.14	1.38 ± 0.05	0.95
PUFA/SFA	0.30 ± 0.8	0.24 ± 0.04	0.55

No gender differences were found in SFA although females showed high percentage *vs*. males. SFA in both genders was dominated by palmitic (16:0) and stearic (18:0) acids, myristic acid (14:0) and to a lesser extent by pentadecanoic fatty acid (15:0). Similar trends have been reported by Kadim et al. (2011) in LT muscle from male camels and by Mahmud et al. (2011). Percentages of pentadecanoic, palmitic and stearic acid in the former study were high compared to the present results, except for myristic acid which was higher in male muscles in the present study (4.8% *vs*. 3.1%).

As shown in Fig. 2, oleic, palmitic and stearic proportions were the highest in the present work when sorted according to their ascending quantity. Oleic acid in the human diet acts to lower blood cholesterol, to reduce the risk of stroke and to decrease systolic and diastolic blood pressure (Kris-Etherton, 1999), while stearic acid has a neutral effect on total blood cholesterol and low density lipoprotein (LDL) (Mensink, 2005). As palmitic acid contributes to the total SFA, it was lower (48% and 51% in male and female muscles respectively) when compared to data reported by Kadim et al. (2011) and

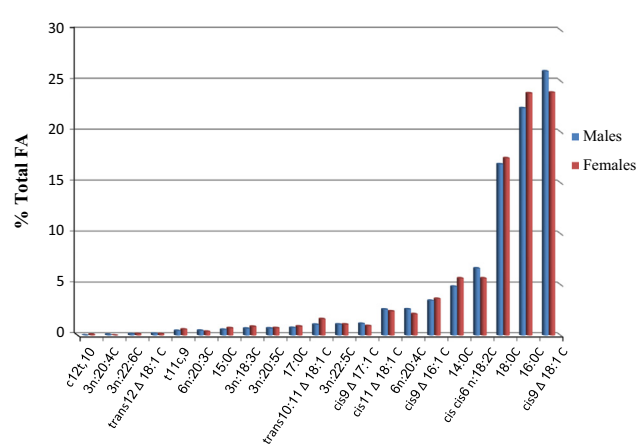

Figure 2 Fatty acids profile of dromedary camel LL muscle sorted according to their ascending quantity.

Kadim et al. (2013) for camel LT muscle (53% and 51.3%, respectively). The differences between the present results and these studies could be attributed to variation between muscle types. Stearic acid is known to have little or no influence on the plasma cholesterol concentration and was quite abundant in our present results (16.9%). Its proportion was higher than that reported by Rawdah et al. (1994) in camel meat (8.6%); however, the proportion of myristic acid in the present study was found to be lower (4.8%) when compared to the former study (7.68%). This indicates that the percentage of stearic acid found in meat could vary greatly depending on species, breed, and rearing conditions especially feed.

Similarly, monounsaturated fatty acids (MUFAs) showed no gender differences ($P > 0.05$), except for 18:1 delta 10–11 *trans* ($P < 0.05$) which was 24.3% higher in female muscles compared to males. The major MUFAs were oleic (18:1 delta 9 *cis*), palmitoleic (16:1 delta 9 *cis*) and cis vaccenic (18:1 delta 11 *cis*), respectively. Kadim et al. (2011) reported higher values of oleic acid (33.5%) and total MUFA (41.4%) in camel LT muscle compared to our results (Table 3). These discrepancies are attributed to the type of muscles used in both studies, the LL *vs*. LT, which have different functions and composition. The results reported by Kadim et al. (2013) for oleic acid (26.2%) and MUFA (37.2%) in camel LT muscle approximately match the values reported in our results. In general, these values were lower than those observed in other species such as cattle and sheep. Nuernberg et al. (2005a) reported high level of oleic acid in LT muscle of German Holstein (39.3%) and Simmental (37.3%) bulls fed on concentrates; however, in sheep fed on concentrates, Nuernberg et al. (2005b) reported 36% oleic acid which was high compared to the present findings (26% and 23.9% in male and female camels, respectively). It is important to note that higher consumption of monounsaturated fatty acids (such as oleic acid) and particularly polyunsaturated fatty acids (e.g. linolenic acid, 18:3 n-3) in humans was reported to lower plasma cholesterol level (Glatz et al., 1993). Concurrently with the present results, these fatty acids were found to be the major contributors to total MUFA and PUFA. Monounsaturated fatty acids generally account for around 40–50% of total fatty acids in fresh meat products (Schmid, 2011); which is in agreement with the present results.

Regarding PUFA, linoleic acid (LA, 18:2 n-6 *cis cis*), arachidonic (ARA, 20:4 n-6), docosahexaenoic (DHA, 22:5 n-3) and eicosapentaenoic (EPA, 20:5 n-3) were the major polyunsaturated fatty acids (PUFA) in camel LL muscle. The proportion of PUFA in camel muscle (13.6%) was higher in the present results compared to that in camel LT muscle (5.2%) reported by Kadim et al. (2011) and Kadim et al. (2013), but lower than in camel meat (18.6%) as reported by Rawdah et al. (1994). However, Kadim et al. (2013) reported higher LA (7.11%) and ARA (2.84%) proportions than in the present results (Table 3) in the LT muscle from camels fed on concentrates. These differences could be attributed to the muscle types and/or feeds in the present and the later studies. Compared to other animals, the proportion of total PUFA for male and female camels falls with the range indicated by Schmid (2011) of 10–20% of total FA for bovine and lamb muscles. In addition, EPA is believed to play a role in the prevention of cardiovascular disease, while DHA not only is a major fatty acid for brain and retina functions but also plays a positive role in the reduction of the risk of heart disease and the inhibition of the carcinoma cells in human colon by decreasing tumour cell growth (Schonberg et al., 2006). DPA, EPA and DHA were detected in male and female muscles in the present results with higher proportions than those reported in cattle muscles by Rawdah et al. (1994), Nuernberg et al. (2005b) and Gerber et al. (2009). ARA is an important dietary component necessary in the repair and growth of skeletal muscle tissue (Trappe et al., 2001). Peraza-Mercado et al. (2010) indicated the recommended maximum daily intake of ARA (0.01 g) and DHA (0.25 g) according to the European Food Safety Authority. Concurrently with these facts, the high amount of ARA in camel male and female meat could be a health issue for individuals having inflammatory diseases such as arthritis. In spite of their presence in low quantities in camel male and female muscles, the nutritive and health value of EPA (0.71%) and DHA (1.01%) cannot be neglected as they lower a number of pro-inflammatory chemicals in the blood levels.

According to previous reports, CLAs have major benefits to human health: anticarcinogenic, antidiabetic, antiadipogenic and stimulation of the immune system (Banni et al., 2002; Webb and O'nill, 2008). The concentration and relative abundance of conjugated linoleic acid (CLA) in ruminant meat are affected by diet as reported by Martins et al. (2007). A non-significant increase ($\times$ 1.33%, $P = 0.11$) was found in CLA such as rumenic acid (cis 9, trans 11, 18:2) in muscles from females compared to that of males, but a significant increase ($\times$ 5.7, $P = 0.03$) in trans 10, cis 12 18:2. It is known that diets high in LA, such as fresh grass, grass silage, linseed, and fish oil, result in increased deposition of *cis*-9, *trans*-11 18:2 in the bovine muscle (Bauchart et al., 2005; De La Torre et al., 2006; Nuernberg et al., 2005a).

The n-6/n-3 ratio is an index commonly used to evaluate the nutritional value of fats. A high ratio plays a key role in a number of human diseases. It is also a risk factor in cancers and coronary heart disease, especially the formation of blood clots leading to a heart attack (Harris and Schacky, 2004). Importantly, the n-6/n-3 ratio in camel meat (males and females) was lower (around 3) than the recommended values of human health diets that should not exceed 4.0 (British Department of Health, 1994) and lower than that of concentrate-fed bovines (>7) (Scollan et al., 2006). The PUFA/SFA ratio (around 0.3) was similar to that indicated by Cuvelier et al. (2006) in bovine LT muscle (0.2–0.8 depending on the breed), and relatively close to the recommended value for human nutrition 0.45 (British Department of Health, 1994). The high ratio of PUFA/SFA could result from forage feeding during finishing period which decreases SFA concentration and increases the concentration of MUFA in muscle (Shingfield et al., 2013).

4. Conclusions

Camel meat with its high protein and moisture content, low intramuscular fat, high ratio of IDAA/DAA, low n-6/n-3 ratio and reasonable PUFA/SFA ratio, together with the high percentage of *cis* 9, *trans* 11 18:2 in female muscles, could provide a reliable source of healthy meat for human consumers with a high nutritive value compared to other farm animals.

Conflict of interest

There is no conflict of interest.

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