Effect of age on concentrations of nutrients in four muscles of the Sudanese dromedary (Camelus dromedaries) camel

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ABSTRACT

The aim of the present study was to determine the effect of age (3–4 and 6–7 years old) on concentration of amino acids, fatty acids, minerals, vitamins and collagen in the longissimus thoraces (LT), biceps femoris, semitendinosus and semimembranosus muscles of 12 Sudanese camels. There were significant effects of age and muscle type on moisture, fat and protein contents. The LT muscle had significantly (P < .05) higher fat than other muscles. The proportion of polyunsaturated to saturated fatty acids, which ranged from 1.0 to 1.07, was above the minimum ratio of 4.0 recommended to reduce the risk of coronary diseases in humans. The most abundant essential amino acid in camel muscles was lysine, followed by leucine, phenylalanine, isoleucine, threonine and methionine. Muscles from 6- to 7-year-old camels had slightly higher insoluble collagen than those from 3- to 4-year-old camels. There was a general trend for mineral content of camel meat increasing with age with significant effect on Ca and Pb concentrations. The Sudanese camel meat is also an important source of several vitamins. This study indicated that concentrations of nutrients among muscles were affected by age and the knowledge of these factors allow for better marketing and processing of camel meat.

1. Introduction

The perception of conventional red meat is relatively negative due to its high content in fat and saturated fatty acids, cholesterol, sodium and any other substances that may be involved in most prevalent diseases like cardiovascular diseases and diabetes (Micha et al. 2010) and cancer (Cross et al. 2010; Santarelli et al. 2010). As an alternative to red meats, camel meat is considered a good source of high-quality protein with less fat, less cholesterol and a relatively higher amount of polyunsaturated fatty acids (Kadim et al. 2008). These attributes coupled with an increase in demand for high-quality protein sources have led to an increase in the consumption of camel meat and meat products (Al-Owaimer et al. 2014). Relatively low and competitive prices compared to other meats, the absence of cultural or religious obstacles, and dietary and nutritional properties are the main factors explaining camel meat’s attractiveness (Kadim et al., 2008).

The biological value of meat is determined by completeness of its concentrated essential nutrients for optimal human growth and development (Higgs, 2000). Regarding nutritional aspects and human health, camel meat satisfactorily fulfils the current consumer demand for a low-fat meat (Barroeta 2007). Camel meat is also considered as functional food that provides bioactive substances with favourable effects on human health. These include conjugated linoleic acid, vitamins and antioxidants, and a balanced n-6 to n-3 polyunsaturated fatty acid ratio (Bekhit & Farouk 2013). Marketing on carcass cuts based on an individual-muscle basis may increase the demand for camel products. However, such a marketing system requires more information on the characteristics of individual muscles. Such information might enhance marketing of camel meat, and encourage camel farmers to produce more attractive cuts with known quality characteristics. However, there are no detailed studies on the concentrations of nutrients of Sudanese dromedary camel meat. The aim of this study was to determine chemical composition, minerals, fatty acids, amino acids, vitamins and collagen contents of LT, ST, SM and BF muscles of Sudanese dromedary camels.

2. Materials and methods

2.1. Sample collection and preparation

Forty-eight muscle samples were collected from 12 Sudanese camels representing 2 age groups: group 1 (3–4 years old) and group 2 (6–7 years old). They were slaughtered at the Tambol slaughterhouse (yard) at Al-Butana State, Sudan. Animals were slaughtered and dressed following routine commercial slaughterhouse procedures. LT, ST, SM and BF muscles were dissected from the left side of each carcass within 60 min postmortem. Each individual muscle was trimmed off external fat, kept in zippered plastic bags, transported in an insulated cool box and kept in −18°C for 7 days in the University of Khartoum, College of Animal Production Lab. They were then transported to the Meat Lab at the Department of Animal and...
2.2. Chemical analysis

All visible fat was removed from the muscles. Approximately 100 g of meat samples from each muscle were chopped into small pieces, weighed into pre-weighed containers then immediately frozen (−20°C) and dried in a freeze dryer (MODULOD Freeze Dryer thermo electronic corporation) for seven days under 100-mbar pressure at −50°C. The samples were reweighed after complete drying, then ground to a homogeneous mass through a 1 mm mesh in a micro-Wiley mill, stored in plastic airtight containers and kept at −4°C for chemical analysis. Protein (Kjeldal (AOAC 2000) 976.06), fat (Ether extract (AOAC 2000) 920.39), ash ((AOAC 2000) 927.02) analyses were carried out in duplicate following the standard methods of AOAC (2000).

2.3. Fatty acid composition

Fatty acid compositions of all muscle samples were determined following the procedure described by Pedro et al. (2008). Briefly, to 0.2 g of each sample were added 4 ml of chloroform in a 10 ml Sovirell Pyrex tube and then vortexed for 30 s and left at −20°C overnight. The evaporated solvent was dissolved in 6 ml of diethyl ether and dried under a stream of nitrogen. One ml of NaOH in methanol was added and the mixture heated for 15 min at 100°C. After cooling, 2 ml of BX3/CH3OH was added, mixed and heated for 5 min at 100°C. One ml of cooled hexane and 2 ml of water was added, mixed for 15 s and centrifuged at 3000 rpm. Two ml hexane was collected and submitted to GC analysis.

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\text{Fatty acid mg/g} = (\text{weight of tricosanoic acid mg}) \times (\text{area of fatty acid/weight of sample}) \times (\text{area of internal standard}).
\]

2.4. Amino-acid analysis

The amino acid composition of LT, ST, SM and BF muscles were determined following the procedure described by Raiymbek et al. (2015). Briefly, 1 g of sample was mixed 25 ml of with 2.5 mM Nle L-Norlencine and 10 ml of 6 M hydrochloric acid phenol reagent in a screw-cap bottle. The bottle was placed in an oven at 110°C for 24 h. The cooled content was filtered into a 50 ml volumetric flask, made up to 50 ml with High Performance Liquid Chromatography (HPLC) water. Twenty ml of methanol–0.5% sodium acetate–triethanolamine (2:2:1) was added to each sample, mixed and dried. Twenty ml of methanol–water–TEA–phenylisothiocyanate (7:1:1:1) was added to each sample, the bottle was sealed, then vortexed and left to stand for 20 min and again dried. Finally, 500 m of 5 mM sodium phosphate, pH 7.6, containing 5% acetonitrile was added to each sample to dilute and the liquid sample was filtered and then injected. Total amino acids’ profile was analysed using a Dionex UltiMate 3000 HPLC System. The amount of individual amino acid in the sample was calculated by dividing the peak area of each amino acid using an internal standard, which was used to correct for losses during the hydrolysis analysis.

2.5. Macro- and micro-minerals

The ash sample was dissolved in 10 ml of 6 M hydrochloric acid and heated at 200°C until dried. The residue was moistened with 2 ml of concentrated HCl and boiled for 4–5 min. and then transferred to 100 ml volumetric flask and diluted to 100 ml with deionized water. The dilute sample was filtered and used for total mineral analysis which was carried out on an Atomic Absorption Spectrophotometer system type Shimadzu Model AA-6800 equipped with GFA-EXV CE Graphite Furnace, HVG-Hydride Vapor Generator, MVU-IA Mercury Vaporizer and ASC-6100 Auto Sampler (Japan). Iron (Fe), Copper (Cu), calcium (Ca), Lead (Pb), Selenium (Se), Zinc (Zn) and Magnesium (Mg) was analysed using a automatic absorption spectrophotometry. Sodium (Na) and Potassium (K) were analysed using a flame photometer (Sc/00901). Phosphorus was determined using ash solution and absorbance was measured using spectrophotometry (Spectronic 20) at 560 nm. The absorbance value was plotted (y-axis) verses mineral concentration from the drawing graph. The mineral concentration in the test sample was calculated by drawing a standard graph for the element tested.

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\text{Mineral in ppm (mg/1)} = \text{ppm from calibration graph} \times \text{dilution factor/sample weight}
\]

2.6. Total and soluble collagen contents

Twenty ml of 0.1 M sodium phosphate buffer (pH 7.0) were added to 4.00 g of a finely minced meat sample and homogenized in a centrifuge tube. Samples were heated at 77°C in a water bath for 70 min with stirring every 10 min and then cooled in ice for 30 min and centrifuged at 60,000g for 10 min. The supernatant and the sediment were hydrolysed in 12 N HCl. The amount of hydroxyl proline in the supernatant and sediment was converted to soluble and insoluble collagens using the factors 7.25 and 7.52, respectively (Cross et al. 1973). Hydroxyproline content was determined by a spectrophotometer assay from the absorbance at 558 nm (AOAC 2000).

2.7. Vitamin determination

Forty grams of meat sample were mixed with 20 ml of hot water and blended to obtain a homogeneous sample, which was transferred to a sealed 100 ml amber glass. The bottles were placed in a boiling water bath at 100°C for 30 min. Eight grams of boiled sample was transferred into a 50 ml centrifuge tube. One gram of TCA was added to the sample, thoroughly mixed and centrifuged at 3000 rpm for 10 min. Then, 3 ml of 4% TCA were added to the upper layer and centrifuged at 3000 rpm for 10 min. The solid phase was discarded and the two acid extracts were combined and placed at −20°C for 10 min. The acid extracts were centrifuged at 4000 rpm for 5 min and placed at −20°C for 5 min. The layer of the fat was discarded using a spatula, and the acid extract was centrifuged.
again. Then the extract was filtered through a 0.45 μm filter before the HPLC injection.

2.8. Statistical analysis

The data were analysed using the General Linear Model’s procedure (SAS 1993) to compare the effect of the four muscle types (LT, ST, SM and BF) and two age groups (3–4 and 6–7 years old) on proximate composition, mineral, fatty acid, amino acid, vitamin and collage contents. Significant differences between means were assessed using the least-significant-difference procedure.

3. Results and discussion

3.1. Chemical composition

The effect of camel age on proximate chemical composition of four muscles is presented in Table 1. The ranges of moisture, protein, fat and ash were within the values reported for dromedary camel meat (Kadim et al. 2006, 2008, 2013). With exception of LT, there were no significant differences in moisture contents between the two age groups within each muscle. The LT muscle had significantly (P < 0.05) lower moisture content than BF, ST and SM. In contrast, Kadim et al. (2006) and Kadim and Mahgoub (2008) reported no significant effect of age on moisture content of the LT muscle of Omani dromedary camels. The wide variation between different studies in moisture content of dromedary meats may be due to physiological factors such as type of feed and different environment, which may play a major role in determining the moisture contents in camel meat.

The present study revealed no significant differences in protein content between the two age groups (3–4 vs. 6–7 years old) within all muscles. The lack of significant differences in protein content between the two age groups in the current study is supported by the report of Kadim et al. (2006), who found that protein content remained unaffected between 3 and 5 and 6–8-year-old camels. In contrast, Kadim and Mahgoub (2008) reported that 4–8-year-old camels had significantly lower protein (20.5%) than 2–4-year-old (22.7%) camels. The LT muscle from group 2 (6–7 years old) had significantly (P < 0.01) higher fat content than group 1 (3–4 years old). The maximum value recorded for fat in the present study (12.4% in LT muscle for the 6–7-year-old group) indicated that fat content of camel meat increases significantly with age. This study confirmed that meat from camels above 6 years contained significantly (P < 0.01) higher fat than meat from camels below 4 years old. In agreement with the current results, Kadim and Mahgoub (2008) reported that the LT muscle from 4- to 8-year-old dromedary camels had significantly (P < 0.05) higher fat content than that from 2- to 4-year-old camels. The high fat content in old animals is a well-documented phenomenon in meat animals as they deposit more body fat with progressing age because fat is a late-maturing body tissue. This implies that the meat industry should target younger camels for prime meat production, which is in line with recommendations for slaughtering camels at less than 3 years of age Kadim et al. (2006). However, Kadim et al. (2006) studied the effects of camel age on LT chemical composition and found no significant differences between 3–5 and 6–8 years of age. In the present study, there were no significant differences in ash content between the two age groups within each muscle, which is in agreement with the results of Kadim et al. (2006, 2008) who reported no significant effect of age on ash content. As for other species, ash content of camel meat varies widely most probably because of differences in sampling methods and the sites in the carcass (Kadim et al. 2008).

3.2. Fatty acid composition

The current study revealed small non-significant differences in different classes of fatty acids and individual fatty acids between the four muscles and age groups of Sudanese dromedary camels (Table 2). Palmatic acid (C16:0) was the most abundant saturated fatty acid in Sudanese dromedary meat intramuscular fat with a percentage of 26.4% (25.4–27.2%) followed by stearic acid (C18) with percentage of 8.5% (7.97–8.90%) and myristic acid (C14:0) with 8.5% (8.19–8.9%). Oleic acid (C18:1n9c) was the main monounsaturated fatty acids with 24.9% (23.4–25.9%) followed by myristoleic acid (C16:1) with a value of 6.22% (5.98–7.51%). The highest palmitic acid (C16:0) values were in SM and ST muscles with values of 27% and 26.4%, respectively. The current study showed that age and muscles type had no significant effect on total saturated, mono- and polyunsaturated fat, and individual fatty acids. In contrast to reports in dromedary camels (Rawdah et al. 1994; Al-Bachier & Zeinou 2009; Kadim et al. 2011, 2013), the predominant fatty acids in Sudanese dromedary camel muscles were unsaturated fatty acids with an average value 50.78% (50.0–51.6%) of total methyl esters. The highest values for unsaturated fatty acid were found in the LT (51.35%) and the lowest was in the SM (50.6%) muscles. The predominant monounsaturated fatty acid was oleic acid (C18:1n9c), resembling 70.81% of the total intramuscular monounsaturated fatty acids. The proportion of monounsaturated fatty acids in the current study is slightly lower than the proportions reported by Rawdah et al. (1994); Al-Bachier and Zeinou (2009) and Kadim et al. (2011, 2013) for the dromedary camel meat. The highest values of monounsaturated fatty acids were found in the SM muscle (73.34%) and the LT muscle (72.91%) and the lowest in the ST muscle (68.08%). Similar proportions of oleic acid (C18:1n9c) were reported by Kadim et al. (2013) in Omani dromedary camel muscles. For proportions of total fatty acids, the highest values were found in LT and SM muscles with values of 25.65% and 25.78%, respectively, while ST and BF had the lowest values of 23.95% and 24.3%, respectively. For the polyunsaturated fatty acid, linoleic acid (C18:2n6c) was the most abundant polyunsaturated fatty acids with a value of 13.6% (12.7–14.8%). The highest Linoleic acid (C18:2n6c) values were found in ST and BF with values of 14.4% and 14.1%, respectively. In the current study, the proportion of linoleic acid (C18:2n6c) was 85%. The highest values were in the ST muscle (90%) and lowest in the LT muscle (80%). In line with the current study, Kadim et al. (2013) stated that more than 50% of the polyunsaturated fatty acids in the dromedary camel muscles was linoleic acid (C18:2n6c). The proportion of polyunsaturated to saturated fatty acids in Sudanese dromedary camel ranged from 1.00 to
1.07 (Table 2) and was significantly higher than the minimum of 0.40 recommended by the British Department of Health (1994) to contribute to a reduction in the risk in coronary diseases in humans. The average proportion of polyunsaturated to saturated fatty acids in the Sudanese dromedary camel meat was 1.03, which was high and beneficial for human health compared with cattle, sheep and goat meats. The present study indicated no significant differences between the four muscle and two age groups in the proportion of polyunsaturated to saturated fatty acids.

### 3.3. Amino acid profile

There were no significant differences between Sudanese dromedary camel muscles and two age groups on essential and non-essential amino acids (Table 3). Similarly, Al-Shabib and Abu-Tasboush (2004) and Dawood and Alkanhal (1995) found that muscle type had a significant effect on amino acid profile in dromedary camels. The most abundant essential amino acid in camel muscles was lysine (7.84–8.98 g/100 g protein), followed by leucine (6.59–8.11 g/100 g protein), phenylalanine (4.73–6.88 g/100 g protein), isoleucine (5.01–5.97 g/100 g protein), threonine (4.75–5.01 g/100 g protein) and methionine (3.03–3.88 g/100 g protein). Similar values of amino acid compositions in dromedary camel muscles were reported by Kadim et al. (2011). The Sudanese camel muscle has a comparable essential amino acid content to dromedary camels, beef, lamb and goat muscles (Kadim et al. 2008). There were small non-significant differences between 3–4 and 6–7-year-old camel muscle in the essential and non-essential amino acid fractions. In agreement with this study, Dawood and Alkanhal (1995) found that the essential amino acid content of dromedary camel was not affected by the animal age. A similar range of essential and non-essential amino acid concentrations in

### Table 1. Mean and standard error of mean (SEM) of chemical composition for two age groups (3–4 and 6–7 years old) of the Sudanese camel muscles.

| Composition | LD | BF | ST | SM | SEM |
|-------------|----|----|----|----|-----|
| Moisture    | 71.3b | 66.1a | 72.6bc | 74.9c | 74.0bc |
| Protein     | 17.7ab | 17.1a | 18.6ab | 17.1a | 18.8bc |
| Fat         | 7.84a | 12.40d | 2.49b | 1.57ab | 3.47cb |
| Ash         | 1.41 | 1.47 | 1.37 | 1.04 | 1.26 |

Means within each row with different letters were significantly different (P < .05).

### Table 2. Fatty acids composition of the LT, BF, semitendinosus (ST) and semimembranosus (SM) muscles of the Sudanese dromedary camels slaughtered at two different age groups.

| Fatty acid (%) | LD | BF | ST | SM | SEM |
|----------------|----|----|----|----|-----|
| Saturated fatty acids (SFAs) | | | | | |
| C14:0 | 8.88 | 8.90 | 8.78 | 8.19 | 7.94 |
| C15:0 | 0.53 | 0.49 | 0.82 | 0.90 | 0.66 |
| C16:0 | 26.1 | 25.9 | 25.4 | 26.9 | 26.4 |
| C17:0 | 0.77 | 0.69 | 0.75 | 0.72 | 0.81 |
| C18:0 | 12.0 | 11.8 | 12.2 | 12.7 | 12.6 |
| C18:1 | 0.40 | 0.38 | 0.38 | 0.37 | 0.38 |
| C18:2 | 0.22 | 0.19 | 0.20 | 0.19 | 0.20 |
| C20:1 | 0.04 | 0.06 | 0.05 | 0.05 | 0.05 |
| Monounsaturated fatty acids (MUFAs) | | | | | |
| C14:1 | 0.87 | 0.67 | 0.77 | 0.74 | 0.87 |
| C16:1 | 6.09 | 7.51 | 5.98 | 5.99 | 6.45 |
| C17:1 | 0.63 | 0.61 | 0.68 | 0.71 | 0.52 |
| C18:1 | 1.42 | 1.44 | 1.39 | 1.43 | 1.41 |
| C18:1n9c | 25.9 | 25.4 | 25.2 | 23.4 | 24.3 |
| C20:1 | 0.79 | 0.77 | 0.79 | 0.95 | 0.55 |
| Polyunsaturated fatty acids (PUFAs) | | | | | |
| C18:2n6c | 12.7 | 12.9 | 14.2 | 13.9 | 14.0 |
| C18:3n6c | 1.22 | 1.13 | 1.11 | 1.22 | 1.64 |
| C20:3n3c | 0.95 | 0.93 | 1.03 | 0.97 | 0.95 |
| TSFA | 48.9 | 48.4 | 48.6 | 50.0 | 50.7 |
| MUFA | 35.7 | 36.4 | 34.8 | 33.2 | 33.2 |
| PUFA | 15.4 | 15.2 | 16.6 | 16.4 | 15.9 |
| TFA | 51.1 | 51.6 | 51.4 | 50.0 | 50.0 |
| TFA:TSFA | 1.04 | 1.07 | 1.06 | 1.00 | 1.04 |

SEM: Standard error of mean, fatty acid: C14: myristic acid, C15: pentadecanoic acid, C16: palmitic acid, C17: margaric acid, C18: stearic acid, C20: arachidic acid, C22: behenic acid, C14:1: myristoleic acid, C16:1: palmitoleic acid, C17:1: heptadecenoic acid, C18:1n9: oleic acid, C18:2n6: linoleic acid, C18:3n3: α-linolenic acid, C20:2: eicosadenoic acid, C20:3n6: TSFA: total saturated fatty acids, MUFA: total mono-unsaturated fatty acids, PUFA: total polyunsaturated fatty acids.
different camel muscles were reported (Bekhit & Farouk 2013). The amount of camel meat required to supply the daily requirements of essential amino acids for an adult (70 kg body weight) is similar to that for lamb but is less than the amount required from beef meat.

Glutamic (16.1–16.9% of protein) and aspartic (9.91–10.1% of protein) acids were the major non-essential amino acids in camel meat (Table 3). Non-essential amino acid contents slightly varied between the muscles. Age had no effect on concentrations of non-essential amino acids in the current study. However, Dawood and Alkanhal (1995) reported that aspartic acid was the only non-essential amino acid affected by camel age. Camel meat is similar or maybe a better source of non-essential amino acids compared with beef, lamb, goat and ostrich (Bekhit & Farouk 2013). Elgasim and Alkanhal (1992) found a low alanine content in dromedary camel meats relative to other red meats. However, the present study and other studies (Dawood & Alkanhal 1995; Al-Shabib & Abu-Tarboush 2004; Kadim et al. 2011) did not find low concentrations of alanine in dromedary camel meats relative to other red meats.

### 3.5. Mineral composition

The mineral compositions of four muscles and two age groups of Sudanese dromedary camel are grouped into macro- and micro-mineral contents in Table 5. There were no significant differences in concentrations of macro- and micro-elements between BF, ST SM and LT muscles. Similarly, Kadim et al. (2013) reported no differences in mineral concentrations between the six dromedary camel muscles. No significant variations in mineral contents were reported between different dromedary meat cuts (Kadim et al. 2008). There was a general trend of mineral content of camel meat increasing with age (Table 5). This effect was significant (P < .05) for Ca and Pb contents. Sudanese camel muscles from the older group (6–7 years old) had higher macro- and micro-minerals’ content than the younger group (3–4 years old). Heavy metals such as Pb and Cd are natural constituents of meat but are regarded as contaminants if found in high levels. They are toxic and have a tendency to accumulate in animal body (Ruiter 1985). The maximum levels of Pb (0.0185 mg/100 g fresh tissue) and Cd (0.15 mg/100 g fresh tissue) are much higher than the levels allowed in muscle tissue (0.3 and 0.05 mg/kg for Pb and Cd, respectively (Bekhit & Farouk 2013). In the current study, K was the most abundant macro-mineral in Sudanese camel muscles followed by P, Na, Mg and then Ca. Similar trends of macro-minerals in the dromedary camel LT muscle were reported by Kadim et al. (2006) and El-Faer et al. (1991). Sodium expressed on fresh tissue in camel meat increased with increased age in the four different muscles, LT (149–159 mg/100 g) followed by BF (141–159 mg/100 g), SM (141–155 mg/100 g) and ST (139–157 mg/100 g). In contrast, Elgasim and Alkanhal (1992);
Rashed (2002) and Kadim, et al. (2006) found that the dromedary camel LT muscle contained the lowest Na than other muscles. In the present study, Mg concentration increased with increased camel age from 4–4 to 6–7 years old in LT by 10.6%, ST by 21.4%, SM by 18.7% and BF by 10.7%. Similar values were reported by Kadim et al. (2006) for two different age groups of dromedary camel. In accordance with the current study, Kadim et al. (2006) found that K is the most abundant mineral in the dromedary camel LT muscle (193.4–379.1 mg/100 g). Phosphorus is the second most abundant element in camel meat (352–425 mg/100 g fresh tissue) and 6–7-year-old camel muscle had slightly higher P than 3–4-year-old camel muscles by 14.6%, 14.5%, 7.8% and 7.8% for LT, ST, SM and BF muscles, respectively. The 6–7-year-old camel muscles had significantly (P < 0.05) higher Ca by 43.9% in LT, 41.3% in ST, 40.5% in SM and 42.9% in BF muscles than muscles from 3– to 4-year-old camels. Similarly, Kadim et al. (2006) reported that the concentrations of Ca content in dromedary camel muscles ranged from 13.7 to 29.6 mg/100 g. Red meat is an important source of zinc. Sudanese camel meat muscles contained 4.98–5.89 mg/100 g fresh tissue) and 5.11 mg/100 g, which is slightly lower than beef (0.5 mg/100 g), veal (0.11 mg/100 g), horse and leg muscles (0.8 mg/100 g) (Lombardi-Boccia et al. 2005). The thiamine concentration in dromedary camel muscles varied in quantities from a few micrograms to several milligrams per 100 g fresh meat sample. There were no significant differences in thiamine (B1) concentration (0.08–0.11 mg/100 g) between individual muscles or two different age groups. In beef there were significant differences (P < 0.05) in thiamine content between the loin muscles (0.2 mg/100 g) and leg muscles (0.8 mg/100 g) (Lombardi-Boccia et al. 2005). The thiamine concentration in dromedary camel muscles (0.09 mg/100 g) was higher than lamb (0.06 mg/100 g), and lower than beef (0.5 mg/100 g), veal (0.11 mg/100 g), horse

3.6. Vitamins

Water and fat-soluble vitamins concentration (mg/100 g fresh meat) in Sudanese dromedary camel LT, ST, SM and BF muscles are presented in Table 6. The water-soluble vitamins in meat varied in quantities from a few micrograms to several milligrams per 100 g fresh meat sample. There were no significant differences in thiamine (B1) concentration (0.08–0.11 mg/100 g) between individual muscles or two different age groups. In beef there were significant differences (P < 0.05) in thiamine content between the loin muscles (0.2 mg/100 g) and leg muscles (0.8 mg/100 g) (Lombardi-Boccia et al. 2005). The thiamine concentration in dromedary camel muscles (0.09 mg/100 g) was higher than lamb (0.06 mg/100 g), and lower than beef (0.5 mg/100 g), veal (0.11 mg/100 g), horse

| Muscle | 3–4 | 6–7 | 3–4 | 6–7 | 3–4 | 6–7 | 3–4 | 6–7 |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|
| LD     |     |     |     |     |     |     |     |     |
| ST     |     |     |     |     |     |     |     |     |
| SM     |     |     |     |     |     |     |     |     |
| BF     |     |     |     |     |     |     |     |     |

**SEM:** Standard error of mean.

**Table 5.** Macro- and micro-mineral content of Sudanese dromedary camel LT, ST, SM and BF slaughtered at two different age groups.

| Muscles | LT | ST | SM | BF |
|---------|----|----|----|----|
| Age (year) | 3–4 | 6–7 | 3–4 | 6–7 | 3–4 | 6–7 | 3–4 | 6–7 |
| Macro-mineral (mg/100 g fresh tissue) | | | | | | | | |
| Phosphorus | 352 | 412 | 355 | 415 | 389 | 422 | 393 | 425 |
| Calcium | 13.3 | 23.4 | 14.1 | 24.0 | 14.4 | 24.2 | 13.6 | 23.8 |
| Magnesium | 37.1 | 41.5 | 34.9 | 44.4 | 35.6 | 43.8 | 35.9 | 40.2 |
| Sodium | 149 | 159 | 139 | 157 | 141 | 155 | 141 | 158 |
| Potassium | 797 | 833 | 751 | 845 | 778 | 859 | 759 | 849 |
| Micro-mineral (mg/100 g fresh tissue) | | | | | | | | |
| Iron | 3.25 | 3.95 | 3.55 | 3.89 | 3.32 | 3.79 | 3.54 | 3.95 |
| Zinc | 5.11 | 5.71 | 4.98 | 5.74 | 5.49 | 5.89 | 5.58 | 5.88 |
| Copper | 4.11 | 4.71 | 4.41 | 4.89 | 4.55 | 4.99 | 4.51 | 4.89 |
| Cadmium | 0.012 | 0.015 | 0.011 | 0.016 | 0.010 | 0.013 | 0.011 | 0.014 |
| Cobalt | 0.010 | 0.012 | 0.011 | 0.015 | 0.010 | 0.013 | 0.011 | 0.015 |
| Lead | 0.066 | 0.138 | 0.074 | 0.142 | 0.065 | 0.185 | 0.059 | 0.165 |
| Manganese | 0.15 | 0.19 | 0.14 | 0.18 | 0.13 | 0.16 | 0.14 | 0.18 |

**SEM:** Standard error of mean. Means in the same row with different superscripts are significantly different (P < 0.05).
Table 6. Effect of type of muscle and age on water- and fat-soluble vitamins levels of LT, ST, BF, SM muscles of the Sudanese dromedary camel.

| Muscle | LT | ST | SM | BF |
|---|---|---|---|---|
| | 3–4 | 6–7 | 3–4 | 6–7 | 3–4 | 6–7 | SEM* |
| Vitamins | | | | | | | |
| Water-soluble vitamins | | | | | | | |
| Thiamine (B1) (mg/100 g) | 0.11 | 0.10 | 0.08 | 0.10 | 0.08 | 0.10 | 0.08 |
| Pyridoxine (B6) (mg/100 g) | 0.39 | 0.53 | 0.61 | 0.12 | 0.08 | 0.10 | 0.12 |
| Pantothenic acid (B5) (mg/100 g) | 0.09 | 0.08 | 0.08 | 0.10 | 0.08 | 0.10 | 0.08 |
| Cyanocobalamin (B12) (µg/100 g) | 4.64 | 4.14 | 4.77 | 4.29 | 4.68 | 4.13 | 4.69 |
| Riboflavin (B2) (mg/100 g) | 0.23 | 0.21 | 0.22 | 0.20 | 0.26 | 0.24 | 0.26 |
| Fat-soluble vitamins | | | | | | | |
| Retinol (A) (µg/100 g) | 10.5 | 10.9 | 11.2 | 11.9 | 10.1 | 10.9 | 9.99 |
| Alpha-Tocopherol (E) (mg/100 g) | 0.85 | 0.89 | 0.92 | 0.99 | 0.86 | 0.89 | 0.83 |

*SEM: standard error for the mean.

(0.18 mg/100 g) (Lombardi-Boccia et al. 2005). The vitamin B6 concentration in the present study ranged from 0.53 to 0.62 mg/100 g. The current values are higher than those reported by Moss et al. (1983), 0.35 to 0.49 mg/100 g for pork meat. An average serving of Sudanese camel meat (200 g) should provide about 80% of the required daily allowance (RDA) of vitamin B6 for the young adult male. The variations in B5 between the selected muscles or age groups were not significant. There were small variations between dromedary camel muscles for vitamin B12 concentrations, with the range from 4.13 to 4.77 µg/100 g. Fifty grams of dromedary camel meat will contain 2.23 g/100 g vitamin B12, which represents 112% of the RDA for vitamin B12. The camel meat contained more vitamin B12 than sheep (0.25 mg/100 g) and veal meats (0.18 mg/100 g) (Ono et al. 1984, 1986). Vitamin B2 content varied between camel muscles and ages from 0.20 to 0.26 mg/100 g (Table 6). Similarly, (Lombardi-Boccia et al. 2005) reported that among beef cuts, vitamin B2 concentration varied from 0.09 to 0.17 mg/100 g, with fillet showing the highest concentration. Beef (0.13 mg/100 g), veal (0.08 mg/100 g), lamb (0.195 mg/100 g) meats contained lower vitamin B2 concentration than camel meat (Lombardi-Boccia et al. 2005; Purchas et al. 2014).

In the present study, vitamin A and E contents were similar between the individual muscles and two age groups (Table 6). The small variations between muscles for vitamins studied may be due to small differences in muscle fibre types and intramuscular fat content between the muscles studied. Sudanese camel meat is reputed to be healthier than other red meats such as beef or lamb. It is leaner and a good source of protein and vitamins.

4. Conclusions

A comparison of the nutrient content of four muscles (LT, ST, SM and BF) and two ages (3–4 and 6–7 years old) from Sudanese camels revealed that camel meat is rich in a wide range of essential nutrients for humans. The comparison type of muscle had no effect on the concentrations of nutrients. Age had a significant effect on several individual nutrients. Small variations in fatty acid, amino acid, mineral and vitamin contents were found between muscles. The Sudanese dromedary camel meat can compete well with other red meats for the fatty acid profile as it contains high levels of PUFAs with a high UFA:SFA. The Sudanese camel meat is also an important source of several vitamins. In general, the Sudanese dromedary camel meat would be a healthy alternative to traditional red meat and can be competitively marketed alongside meat from cattle, dear, sheep and goat.

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