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Effect Age and Cooking on Quality Characteristics and Nutritive Value of Camel (*Camelus Dromedaries*) *Longissimus Thoraces* Muscle

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Abstract
The aim of this study was to determine the effect of age and cooking temperature on quality and nutritional values of dromedary camel Longissimus thoraces muscle (between the 10th and the 13th of the left side). Longissimus thoraces muscle samples were randomly collected from 30 dromedary male camels of three different age groups (2-4, 6-9, 12-15 year-old). Sampled were chilled (1-3ºC) for 48 hrs. Moisture, protein, fat and ash were determined on freeze dried ground muscle samples. Mineral contents were determined using an Inductively Coupled Plasma Emission Spectrometer. Meat quality (ultimate pH, Warner-Bratzler shear force, sarcomere length, Myofibrillar Fragmentation Index, expressed juice, cooking loss and colour) and nutritive value (fatty acid composition and amino acid profile) were measured using standard procedures. Muscle samples were divided into two equal portions. The first portion was kept raw while the second one was cooked at 70°C for 90 minutes. Longissimus thoraces from 2-4 year old camels had significantly lower shear force value, expressed juice and lighter colour than those from 12-15 year-old. The muscle protein% decreased and fat% increased with increasing age of camels. Values of middle age camels (group 2) were in between. Cooked samples had significantly higher dry matter, protein and fat, but lower ash than the raw ones. Cooking had significantly decreased total and heme iron contents. This study confirmed that the camels' meat is healthy and nutritious as it contains low fat as well as minerals. Age and cooking temperatures are important factors in determining meat quality and composition of the dromedary camel.

Introduction

The one-humped camel is the most useful animal in the arid and semi arid regions, which produce good quality meat at comparatively low cost under extremely harsh environments (Kadim et al., 2008). The camel, therefore, can be economically raised for meat production in these ecologically constrained dry and semi-dried areas. There is evidence of a great demand for fresh camel meat due to lower fat and cholesterol and relatively high polyunsaturated fatty acids compared to beef (Kadim et al., 2008). These characteristics are

important for reducing cardiovascular diseases risk related to high saturated fat consumption (Giese, 1992). There is also reluctance towards consuming camel meat in general as it is thought to be tough, coarse and watery. This is mainly because camel meat usually comes from old animals that have served other functions in their life or predominantly at the time their performance and milk yield declines (Wilson, 1998). Moreover, camels are regularly slaughtered for social and religious occasions as an essential source of protein, energy, vitamins and minerals for human nutrition. An approval to increase post mortem muscle metabolism and hasten the onset of rigor mortis might improve the quality characteristics of camel meat. Additionally, a more rapid pH decline could potentially improve quality parameters. Although, cooking of meat is essential for palatable and safe products, heat treatment can lead to undesirable modifications, such decrease in the nutritional value, mainly vitamin and mineral loss and changes in the fatty acid composition (Rodriguez-Estrada *et al*., 1997). There is little information on proximate composition, amino acid, fatty acid and mineral contents of camel meat. The objectives were to investigate the effect of different age groups and cooking on biochemical, composition and meat quality characteristics of the *Longissimus thoracis* muscle of the one-humped dromedary camel.

Materials and Methods

Meat sample

Left side *Longissimus thoraces* samples (10-13 ribs) from 30 camels representing 3 groups: 2-4, 6-9 and 12-15 year-old were kept in a chiller (2-4^{o}C) for 48 hrs before analysis.

Right side *Longissimus thoraces* samples were randomly collected from 10 one-humped camels (2-4 year-old) and kept in a chiller (2-3^{o}C) for 48 hrs. The *Longissimus thoracis* samples were divided into two equal portions. The first portion was kept fresh while the second one was prepared for cooking. Each portion was cut into four 20 mm thick slices and each slice was trimmed to approximately 15 x 15 mm in such a way that all outside surfaces of the muscle were removed. The cooked samples were placed in plastic bags (150 x 250 mm) in preparation for cooking by immersion in a water bath at 70^{0}C for 90 minutes.

Chemical analysis

The muscle samples were dried in a Thermo freeze dryer (Modulyo-230) for 5 days under 100-mbar pressures at –50ºC. They were then ground to a homogenous mass in a grinder then used for chemical analyses. The chemical composition of the muscle tissue was determined according to standard methods of AOAC (2000). Mineral concentration in meat was carried out after complete digestion using a microwave laboratory system type Milestone 1200 MDR, with a maximum temperature of 200^{o}C in closed polytetrafluoroethylene (PTFE) vessel. An Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) type Perkin Elmer Model 3300, equipped with a low- flow Gem Cone nebulizer in addition to an ultrasonic nebulizer for the detection of very low concentrations was used for chemical analyses. Total iron was determined by the spectrophotmetric method explained by Sadettin et al. (2004). Heme iron was determined, using the acidified acetone extraction explained by Hornsey (1956). The non-heme iron levels were determined using 500 mg of ground, freeze-dried meat samples by mixing with 3 ml of citrate phosphate buffer and 1 ml of ascorbic acid solution. The samples were mixed thoroughly then incubated at room temperature (25^{o}C) for 15 min. Two ml of TCA was added, and the mixture was centrifuged at 3000 g for 10 min. The supernatant was collected and filtered through a glass microfiber filter (Whatman filter paper GF/A), then 2 ml of clear supernatant was mixed with 0.8 ml of ammonium acetate and 2 ml of ferrozine reagent. The absorbance was measured at 562 nm against a reagent blank.

Amino acid contents of duplicate meat samples were determined using a Waters ion-exchange HPLC system, utilizing post-column ninhydrin derivatisation and fluorescence detection,

following hydrolysis in 6M glass-distilled hydrochloric acid containing 0.1% phenol for 24 h at 110±2°C in evacuated sealed tubes. Lysozyme was used as an external standard for the amino acid analysis. Performic acid oxidization was not used in the study and cysteine in the samples was not determined. Values for glycine in the excreta are not presented because uric acid is not quantitatively converted to glycine during acid hydrolysis.

The lipids from muscle were extracted by Soxhlet of the dry samples, using petroleum ether (AOAC, 2000). Fat samples (0.5 g) were mixed thoroughly with 1*N* KOH and 5 ml of internal standard [Tricosnoic acid (C23)] was added. The mixture was heated for 30 min at 150°C, cooled at room temperature and then separated with an additional 150 ml distilled water followed by 0.1% methyl orange which was added drop-wise until the color changed to yellow. The pH of the sample was adjusted with 5N HCl until the color turned to light pink, which was partitioned vigorously for 5 min with 100 ml of diethyl ether. The diethyl ether layer was collected and the colored aqueous phase was re-extracted with another portion of 100 ml of diethyl ether. Diethyl ether extracts were pooled and washed four times with 40 ml of distilled and passed over anhydrous Na_2SO_4 and concentrated to 2 ml in a rotary vacuum evaporator at 30°C. The sample was transferred to a screw cap test tube and 2 ml of BF_3 (14%) was added. The test tube was heated at 100°C for 15 min, cooled at room temperature, 3 ml of hexane and 5 ml of saturated NaCl was added and the mixture was shaken vigorously for 5 min. The hexane layer was carefully transferred into vial and stored at –20 °C until analysed by Gas Chromatograph (GC). Fatty acids were analyzed with Hewlett Packard 5890 ser II Plus GC coupled with HP5989B mass engine. FA separated with a 30 m × 0.25 mm Omegawax ™ capillary column (Supeclo Inc., USA). The GC temperature program consisted of 70 °C for 1 min then 5 °C/min until 260°, which was maintained for 5 min. The temperatures of injector and detector were set at 250° and 270°C, respectively. GC conditions consisted of optics autotuned at 69, 219 and 502using DFTPP. GC scan range was set from 40 to 550 amu at 30 thresholds. Fatty acids were identified by comparison of retention time with their reference compound purchased from Supelco, Inc., USA. Concentration of individual fatty acids was calculated by using tricosanoic acid (C23) as internal standard.

Meat quality evaluation

The *Longissimus thoracis* muscles were evaluated for a range of quality characteristics including ultimate pH, expressed juice, cooking loss%, Warner-Bratzler shear force value, sarcomere length, myofibrillar fragmentation index and colour (*L*, a*, b*).* The ultimate pH was assessed in homogenates at 20-22°C (using a Ultra Turrax T25 homogenizer) of duplicate 1.5-2 g of muscle tissue in 10 ml of neutralized 5-mM sodium iodoacetate and the pH of the slurry measured using a Metrohm pH meter (Model No. 744) with a glass electrode. Chilled muscle samples (13 mm x 13 mm cross section) for the assessment of shear force by a digital Dillon Warner-Bratzler shear machine were prepared from muscle samples cooked in a water bath at 70°C (±0.5°C) for 90 min. sarcomere length by laser diffraction was determined using a procedure described by Cross et al., (1980/1981). Express juice was assessed by a filter paper method, as the total wetted area less the meat area (cm^2) relatively to the weight of the sample (g). Approximately 60 min after exposing the fresh surface, CIE *L*, a*, b** light reflectance coordinates of the muscle surface were measured at room temperature (25±2°C) using a Minolta Chroma Meter CR-300 (Minolta Co., Ltd., Japan). Myofibrillar fragmentation index was measured using a modification of the method of Johnson et al., (1990). This measured the proportion of muscle fragments that passed through a 231-µm filter after the sample had been subjected to a standard homogenization treatment. A 5 g (±0.5 g) samples of diced muscle (6 mm^3 pieces) was added to 50 ml of cold physiological saline (85% NaCl) plus five drops of antifoam A emulsion

(Sigma Chemical A5758) in a 50 ml graduated cylinder, and homogenized at ¼ speed using an 18 mm diameter shaft on an Ultra-Turrax homogenizer for 30-second periods separated by a 30 second rest period. The homogenate was poured into a weighed filter (231 x 231 µm holes). The filter typically ceased dripping after 2-3 h, at which time they were dried at 26-28^{o}C in an incubator for 40 h before being reweighed. The myofibrillar fragmentation index values presented herein were calculated as 100 minus the percentage of the initial meat sample weight that remained on the filter.

Statistical Analysis

The general liner model (GLM) ANOVA procedure within SAS (1993) was used to compare the effect of age, and cooking on composition, amino acid, fatty acid and mineral composition of *Longissimus thoracis* muscles in one-humped camels. Significant differences between means were assessed using the least-significant-difference procedure

Results and Discussion

Table 1 show that the values for moisture, protein, fat and ash were within the range reported for camel meat (Pérez et al., 2000; Kadim, 2014; Kadim et al., 2006, 2008, 2013, 2014; Ibrahim et al., 2015). The mean fat of 6.8% fat for camel's *Longissimus* muscle was similar to those (6.7%) of Dawood and Alkanhal (1995) but slightly higher than the ranges listed by El-Faer et al. (1991) and Elgasim and Alkanhal (1992) and lower than those reported by Babiker and Yousif (1990). The fat content variability is a general trend for camel meat. However, the high value recorded for fat indicates that fat content of camel meat may increase with age. The mean protein of 21.7% for camel is similar to value reported by Kadim et al. (2006, 2013), higher than value of Elgasim and Alkanhal (1992) and Dawood and Alkanhal (1995) and Ibrahim et al. (2015).

The present study showed that macro- and microelements of camel meat contained higher levels of potassium followed by phosphorus, sodium, magnesium and calcium, respectively in addition to smaller percentages of the other elements (Table 1). These values are in agreement with those reported by Dawood and Alkanhal (1995); El-Faer et al. (1991); Kadim et al., 2006, 2013) and Ibrahim et al. (2015).

Although, the age had no effect on moisture and ash contents of camel meat, 12-15 year-old camels contained significantly (P<0.01) more fat and less protein than 2-4 year-old ones (Table 1). It is well-documented that body deposit more fat with increasing age (kadim et al., 2006). Therefore, younger camel below 3 years old should be targeted for good meat quality. Similar conclusion was found by Ibrahim et al. (2015) in dromedary camels. Table 1 also shows that the mineral contents of camel meat increased significantly (P<0.05) with increasing age for cadmium, nickel, molybdenum, cobalt, beryllium and vanadium. Camel meat (12-15 year-old) had a higher mineral content than 2-4 or 6-9 year-old camels. High levels of cadmium and molybdenum are regarded as contaminants because do not fulfill any specific requirements in the animal body (Ruiter, 1985).

Table 2 shows that the meat quality values were within the range reported for camel meat (Babiker and Yousif, 1990; Kadim et al., 2006, 2013, 2014; Ibrahim et al., 2015). The *longissimus* muscle of 12-15 year-old camels had significantly lower (P<0.05) pH value (5.75) than of 2-4 (5.95). According to Kannan et al. (2003), young animals usually produce high meat pH due to lack of glycogen. The high ultimate pH of the samples from 2-4 year-old camels might be due to differences in proportions of muscle fiber types and or lower muscle glycogen stores at the time of slaughter. Fiber types have been shown to differentiate at various stage of development and therefore have different metabolic functions in the body (Ashmore et al., 1972). The proportion of fast twitch muscle fibers increases with animal age, which may cause differ in patterns of muscle metabolism (Swatland, 1982), and ultimate muscle pH. The value for shear force was significantly (P<0.001) higher for 12-15 year-old camels than for 2-4 or 6-9 year old camels.

Similarly, myofibrillar fragmentation index (MFI) shows significant differences between the three age groups of camels (Table 2). Significantly lower MFI and shorter sarcomere lengths for the 12-15 year-old camels are consistent with the tougher meat from that group. A number of studies have substantiated the findings that shear values increase with increase age of the camels (Kadim et al., 2006, Ibrahim et al., 2015). Any differences due to age may be related to histological changes that make place in muscle structure and composition as animals mature, particularly in the connective tissue (Asghar and Pearson, 1980), Meat from 12-15 year-old camels was darker (lower *L**) and redder (higher *a**) than that of 2-4 year-old camels (Table 2). Lawrie (2006) stated that darker meat color is more likely a result of increased myoglobin content as a result of age. The moderately high pH values from 2-4 year-old camels might have led to degradation of more protein, which increases light scattering properties of meat and thereby increase *L*, a** and *b** values (Offer, 1991). Expressed juice was significantly affected by age, with 2-4 year-old camels had higher expressed juice value than 12-15 year-old camels (Table 2). These differences may have been due to variations in fat content. Decrease in the water-holding capacity as fat levels increase due to an increase in the ratio of moisture to protein (Miller et al., 1968). In agreement with the present study, Dawood (1995) and Kadim et al. (2006) reported that young camel meat had significantly ($P<0.05$) higher expressed juice than the meat from old camels. The effect of age on cooking loss is also shown in Table 2. One-two-year old camels had significantly ($P<0.05$) higher values than 12-15 year-old camels. The decreased binding ability of less mature animal meat, higher moisture content and lower degree of marbling may contribute to the variations. Similar results were reported by Dawood (1995); Kadim et al. (2006) and Ibrahim et al. (2015). This experiment showed that the age of camel has an important influence on the composition and meat quality characteristics and should be taken into consideration when slaughtering camels for meat consumption.

Cooking camel meat at 70^{o}C for 90 minutes led to significant changes in meat chemical composition (Table 3), which might be attributed to protein denaturation (Brewer and Novakofski, 1999). Cooked meat samples had significantly higher dry matter, protein, fat and lower ash contents than fresh samples. It has been reported that cooked beef meat contained higher dry matter, fat and protein than fresh samples (Greenwood et al., 1951). Chappell (1986), Sheard *et al*. (1998) and Gerber et al. (2009) reported fat losses for cooking meat samples from various species. During cooking, the loss of cooking juices are composed of water and molecules such as myofibrillar or sarcoplasmic proteins, collagen, lipids, minerals, polyphosphates (Ortigues-Marty *et al*., 2006; Gerber *et al*., 2009).

Total, heme and non-heme iron contents of cooked and raw meat samples are presented in Table 3. The effects of cooking on the total, heme and non-heme iron content of camel *Longissimus thoracis* muscles were significant ($P<0.01$). The effect may be due to moisture losses that occurred upon cooking, which in agreement with (Turhan *et al*., 2004; Purchas *et al*., 2003). The total and heme iron may be lost during cooking and released as cooking juice.

The minerals concentrations of the camel *Longissimus thoracis* are presented in Table 3. The cooked meat samples had significantly lower mineral content than the fresh meat samples, which in agreement with that of Gerber et al. (2009). The cooking temperature used affected mineral content the most. The nutritional implications of the availability of minerals in cooked meat are difficult to determine because variable amounts of macro- and micro-elements do leach into broth (Zenoble and Bowers, 1977) Significant differences between cooked and fresh samples for calcium, phosphorus, magnesium, sodium and potassium, were detected. The most abundant essential amino acid in camel meat is lysine, leucine and arginine, respectively (Table 4), which are similar between the two treatments. These results are in agreement with Greenwood,

et al. (1951) and Schweigert et al., (1949). The effect of cooking on fatty acid composition of meat has been reported with contradictory results due to different animal species, meat cuts, cooking methods and temperatures (Scheeder et al., 2001, Sarries et al., 2009, Gerber et al., 2009). According to Rhee (2000), the effect of cooking is dependent on meat type and fat content. Cooking exerted no significant effect on fatty acid composition (Table 5), which in agreement with Sarries *et al.* (2009). Ono et al. (1985) stated that unsaturated fatty acids are less affected by cooking since they are part of the membrane structure. However, Gerber et al. (2009) found that the total saturated, unsaturated and polyunsaturated fatty acids of muscles decreased significantly by grilling. Table 5 shows that oleic acid is the most abundant monounsaturated fatty acid found in camel meat followed by palmetic acid and stearic acid.

Table 1. Mean± standard deviation of chemical composition for the one-humped camel meat slaughtered at three different age groups.

Component	Age (year)		
	2-4	6-9	12-15
Moisture%	70.6±1.05	70.5±1.19	69.8±1.17
Protein%	23.6^{b}±0.62	21.1^{a}±0.60	20.5^{a}±0.65
Fat%	4.6^{a}±1.12	7.2^{b}±1.14	8.5^{b}±1.05
Ash%	1.2±0.05	1.2±0.04	1.2±0.06
Calcium (mg/100g)	14^{a}±3.9	19^{ab}±1.5	29^{b}±2.9
Magnesium (mg/100g)	36±2.2	40±2.4	43±2.5
Sodium (mg/100g)	157±17	163±16	162±18
Potassium (mg/100g)	713±56	778±58	827±61
Phosphorus (mg/100g)	383±39	447±39	499±42
Cadmium (mg/100g)	0.01±0.002	0.01±0.002	0.012±0.002
Chromium (mg/100g)	0.04±0.019	0.04±0.029	0.06±0.042
Nickell (mg/100g)	0.06^{a}±0.017	0.10^{ab}±0.019	0.11^{b}±0.017
Lead (mg/100g)	0.06^{a}±0.013	0.10^{b}±0.019	0.13^{c}±0.017
Cobalt (mg/100g)	0.01^{a}±0.001	0.01^{ab}±0.001	0.01^{ab}±0.001
Molybdenum (mg/100g)	0.11±0.047	0.13±0.047	0.15±0.050
Beryllium (mg/100g)	0.01^{a}±0.002	0.02^{b}±0.002	0.02^{c} ±0.002
Vanadium (mg/100g)	0.06^{a}±0.012	0.07^{ab}±0.021	0.11^{b}±0.019

Means within each component (at the same column between the three age groups) with different letters were significantly different (P<0.05).

Table 2 Means ± standard errors for some meat quality characteristics of the one-humped Arabian camel *M. Longissimus thoracis* slaughtered at three different age groups.

Measurement	Age (Year)		
	2-4	6-9	12-15
Ultimate pH	5.95^{b}±0.14	5.75^{a}±0.14	5.75^{a}±0.19
Shear value (kg)	6.7^{a}±0.81	9.1^{b}±0.75	14.5^{c}±0.82
Sarcomere length (µm)	1.9^{c}±0.01	1.3^{b}±0.01	1.2^{a}±0.01
Myofibrillar fragmentation Index%	78.9^{c}±1.89	71.3^{b}±1.07	60.5^{a}±0.59
Expressed juice (cm^2/g)	30.6^{b}±1.12	28.4^{b}±1.18	22.3^{a}±1.25
Cooking loss %	27.1^{b}±1.16	24.7^{ab}±2.31	23.4^{a}±1.34
Colour parameters			
*L** (lightness	36.7^{c}±1.51	33.0^{b}±1.36	30.7^{a}±1.51
*a** (redness)	14.4^{a}±1.02	14.8^{a}±1.02	17.2^{b}±1.02
*b** (yellowness)	8.1±0.48	8.8±0.48	9.3±0.49

Means with the same row with different letters were significant different (P<0.05)

Table 3 Proximate composition, mineral, total iron, heme and non-heme contents of fresh and cooked camel *Longissimus thoracis* muscle.

Parameter	Fresh	Cooked	SEM[2]	Significance[1]
Dry matter%	26.9	35.8	0.34	***
Protein%	20.5	29.3	0.59	***
Fat%	3.1	3.7	0.12	**
Ash%	1.4	1.3	0.03	*
Total iron (mg/kg DM)	66.5	63.6	2.01	**
Heme iron (mg/kg DM)	52.4	47.8	1.94	**
Non-heme iron (mg/kg DM)	27.1	25.9	1.39	**
Calcium (mg/100g DM)	5.5	3.3	0.32	***
Phosphorus (mg/100g DM)	598	499	10.6	***
Magnesium (mg/100g DM)	71.9	35.8	2.10	***
Sodium (mg/100g DM)	308	144	3.80	***
Potassium (mg/100g DM)	1550	920	29.5	***
Sulfur (mg/100g DM)	559	517	9.6	*
Zinc (mg/100g DM)	13.9	12.2	0.23	NS
Barium (mg/100g DM)	5.3	4.4	0.23	**
Boron (mg/100g DM)	3.5	3.0	0.11	*
Aluminum (mg/100g DM)	2.2	2.1	0.34	NS
Copper (mg/100g DM)	0.31	0.26	0.30	NS

[1] Significance: NS not significant; * P<0.05, ** P<0.01*** P<0.001, [2] Standard error of the means.

Table 4. Amino acid composition (mg/100g DM) of fresh and cooked camel *Longissimus thoracis* muscle.

	Fresh	Cooked	SEM[2]	Significance[1]
Leucine	6.42	6.40	0.09	NS
Valine	4.26	4.30	0.08	NS
Isoleucine	3.60	3.60	0.08	NS
Threnonine	3.34	3.56	0.11	NS
Arginine	5.06	5.23	0.08	NS
Histidine	3.30	3.00	0.10	NS
Lysine	7.17	7.41	0.12	NS
Methionine	2.04	2.10	0.8	NS
Glycine	3.11	3.41	0.10	NS
Alanine	4.93	5.03	0.13	NS
Proline	2.94	3.16	0.11	NS
Phenylalanine	3.24	3.30	0.08	NS
Serine	2.63	2.74	0.07	NS
Gultamic A.	10.8	10.5	0.13	NS
Aspartic A.	7.29	7.47	0.14	NS
Tyrosine	2.61	2.71	0.11	NS

[1]Significance: NS not-significant, [2] Standard error of the means.

Table 5 Least square mean percentages of fatty acid composition of fresh and cooked camel *Longissimus thoracis* muscle.

Fatty acid%	Fresh	Cooked	SEM[2]	Signficance[1]
Myristic (C14:0)	2.9	3.0	0.36	NS
Pentadecanoic (C15:0)	2.8	2.2	0.27	NS
Palmitic (C16:0)	22.8	24.0	2.99	NS
Stearic (C18:0)	20.5	20.6	2.59	NS
Myristoleic (C14:1)	2.9	2.7	0.18	NS
Palmitoleic (C16:1)	5.8	5.4	0.84	NS
Oleic (C18:1)	35.6	35.5	0.91	NS
Linoleic (C18:2)	3.8	3.7	0.21	NS
Linolenic (C18:3)	1.4	1.4	0.74	NS
Arachidonic (C20:4)	1.5	1.5	0.53	NS
Total saturated fatty acids	49.0	49.8	10.21	NS
Total mono-unsaturated fatty acids	44.3	43.6	4.82	NS
Total poly-unsaturated fatty acids	6.7	6.6	0.67	NS

[1] Significance: NS not-significant, [2] Standard error of the means; Values are on dry-basis

Conclusions

Camel meat is rich in minerals, amino acids, fatty acids and heme iron. Cooking resulted in a greater increase in dry matter, protein and fat contents and significant changes in the proportions of macro- and micro-minerals occurred. Amino acids and fatty acids were not significantly affected by cooking.

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