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A comparative study of the biochemical and functional properties of camel and cattle meat during frozen storage

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ABSTRACT

The quality of camel meat has received little attention. It is nutritionally as good as that of the major sources of red or white meats. The purpose of this study was to compare the biochemical and functional properties of fresh and frozen camel meat with cattle meat. Twenty four slaughtered animals (camel and cattle) of different ages and sexes were randomly sampled. Samples from biceps femoris, triceps brachii, longissimus dorsi, and heart muscles were removed and external fat and epimysial connective tissues separated. Measurement of gross composition, pH, water holding capacity (WHC), total volatile nitrogen (TVN), peroxide value, acid value, tensile strength analysis and myofibrillar protein electrophoresis was done on meat samples. Meat samples were frozen for 1, 4 and 8 weeks at -18 °C. After defrosting, WHC, dripping loss, TVN, peroxide value, acid value and kreis test were determined at each storage time. Results indicated that for most of the factors studied, fresh camel and cattle meat were similar, except for ash and fat contents which were lower in camel meat ($P<0.05$). In the frozen state, camel and cattle meat were similar in all parameters except TVN, acid value, WHC and dripping loss. The latter was higher and others were lower in camel meat ($P<0.05$). In conclusion, the quality of camel meat is comparable with cattle meat. It may even have an edge over beef or lamb due to its low intramuscular fat and cholesterol contents. However, since animals are usually slaughtered at the end of their productive life, camel meat is usually tough. In view of the above it is possible that camel meat could make a greater contribution to the growing need for meat in developing countries.

Key words: camel, cattle, biochemical, functional, freezing, storage

Introduction

Camels belong to the family *Camelidae* and genera *Camelus* and *Lama* with two and four species in each genus respectively. The camel species are *Camelus bacterianum* and *Camelus dromedarius.*

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The world population of the dromedary and bacterianus camels is estimated to be 17 million. Dromedary camels constitute about 91% of this figure and are mainly concentrated in the Arab world, particularly in the Arabian countries of Africa. In addition the ability of the Arabian camel (dromedary camel) to withstand the hot and harsh environmental conditions is not matched by any other red meat animal species. It is capable of converting the cover of these regions into animal products suitable for human consumption. At an age of 7 years a fattened camel can produce a carcass of about 260 kg with a meat: bone ratio of 3:1. This offers considerable scope for utilization of camel meat to alleviate animal protein shortage, particularly in semi-arid zones. In spite of its potential, the contribution of camel meat to the per capita meat consumption in the Arab world is not impressive. This can be attributed to the fact that camel meat is the least studied type of meat and is wrongly believed to be of lower nutritive value and quality than other types of red meat (BABIKER and YOUSIF, 1990; ELGASIM and ALKANHAL, 1992).

Generally, the meat of young camels (below three years) is comparable in taste and texture to beef. In some areas, camels are slaughtered at an advanced age, when they have reached the end of their useful working life as draught or milk-producing animals. This age factor probably accounts for the general opinion that camel meat is unacceptably tough. In addition, freezing and the frozen stage can produce profound effects on the structure and chemical properties of meat including changes in muscle fibers, lipids and proteins, all of which have the potential for influencing the quality attributes of meat (DAWOOD, 1995b). The objective of this study was to investigate the changes in various physicochemical properties of camel meat during freezing as compared with those of beef.

Materials and methods

Animals and muscle samples. Twelve one-humped Iranian breed camels and twelve Holstein cattle were randomly selected from a local slaughter house. Animals of each species were divided into four groups, 6 male and female adults (~5 years) and 6 male and female young (one year). Carcasses were allowed to chill for 24 hours at +3 ºC for completion of rigor mortis. Samples for biceps femoris, triceps brachii, longissmus dorsi and heart muscles were removed and external fat and epimysial connective tissues separated. Measurements of gross composition, pH, WHC, TVN, peroxide value, acid value, tensile strength analysis and myofibrilar protein electrophoresis were conducted on meat samples. Meat samples were frozen for 1, 4 and 8 weeks at -18 °C. After defrosting, WHC, dripping loss, TVN, peroxide value, acid value, kreis test were calculated at each storage time.

pH. 20 g of ground meat was blended with 20 mL distilled water for 1 min using an Ultra Turrax T-25 (Janke & Kunkel IKA-Labortechnik, Staufen, Germany). A CG822 pH meter was used to determine the pH at 20 °C.

Gross composition. Moisture, protein (N × 6.25), fat and ash were determined according to the ANONYM. (1997) methods.

Water holding capacity (WHC). The method of HUNG and ZAYAS (1992) was used for determination of WHC. A Whatman No.2 filter paper was soaked in saturated KCl and then dried under vacuum. The meat (0.3 g) was placed on the paper and 2 plastic plates with dimensions of 6 × 6 × 0.8 inches were placed above and below the paper. A 1-kg weight was placed on the top plate. After 20 min, the area of the pressed meat and the total area of the moistened paper was measured using area measurement system (Delta-T Devices Ltd, London, England). WHC was calculated from the following equation:

$$WHC = [1- (B-A)/A] \times 100$$

where B is the area of the moistened filter paper and A is the area of the pressed meat.

Texture evaluation. Tensile strength was calculated from the maximum load during a tension test carried to rupture the specimen (HONIKEL, 1998) by using an Instron Universal testing machine (Instron Co, Model 1140, California, USA). Muscles were cut perpendicular to the muscle fiber orientation to produce 1 cm thick slices. Slices were hooked to the testing machine and the resistance to tearing (tensile stress) was determined at tensile velocity of 2 cm/min.

Isolation of myofibrils. A modification of the method of CLAEYS et al. (1995) was used. About 2.5 g minced meat was homogenized in 25 mL of a buffer solution (pH=7.6, 3 °C) containing 0.25 M sucrose, 0.05 M Tris and 1mM EDTA using an Ultra Turrax. After centrifugation (1000 × g for 10 min) the supernatant was decanted and myofibrils resuspended in 25 mL of 0.05 M Tris-1mM EDTA (pH=7.6 at 3 °C) and again centrifuged (1000 × g for 10 min). After decanting the supernatant, the treatment was repeated with 25 mL 0.15 M KCl solution (3 °C).

Sample preparation for electrophoresis. About 2.4 g of the isolated myofibrils were dissolved overnight at room temperature in 30 mL sample buffer pH 7.0 containing 0.01 M imidazole, 2% SDS and 2% 2- mercaptoethanol. Solutions were filtered to remove connective tissue. After determination of protein concentration (LOWRY et al., 1951), solutions were diluted to obtain 4.0 mg crude protein/mL. Solutions were frozen and preserved at -18 ºC until electrophoresis.

Electrophoresis. 10 g of minced meat sample was mixed with 10 mL 3% NaCl and the mixture was homogenized in a Silverstone laboratory homogenizer (Buckinghamshire, England) set at 10000 × g for one min. The supernatant was used for SDS-PAGE study. Slabs

for SDS-PAGE were formed according to the discontinuous buffer system of LAEMMLI (1970). Protein samples were added to the loading buffer to give final concentration of 1 mg/mL protein, 0.01 M Tris-HCl, pH 6.8, 0.4% SDS, 10% glycerol, and 0.004% bromophenol blue. The running gel was made of 5-20% (w/v) gradient polyacrylamide gel in 1.2 M Tris-HCl, pH 8.8 and 0.3% SDS. The stacking gel contained 3.0% acrylamide in 0.25 M Tris-HCl, pH 6.8 and 0.2% SDS. The electrode buffer compromised 0.025 M Tris-HCl, 0.192 M glycine, and 0.15% SDS at pH 8.16. Electrophoresis was performed at constant 25 mA and gels were stained with 0.25% Coommassie Brilliant blue R-250 in 50% acetic acid/25% methanol and destained with a 10% acetic acid/7.0% methanol. Molecular mass markers (Fermentas, Burlington, Ontario, Canada) were used for comparing the size of proteins.

Dripping loss. Meat samples were cut from the frozen muscles and immediately weighed. The samples weights were 40-50 g. The samples were placed within the container on the supporting mesh and sealed. After a storage period (usually 24hr) at chill temperatures (1 to 5 °C), samples were again weighed. Drip loss is expressed as a percentage of the initial weight (HONIKEL, 1998).

Total volatile nitrogen (TVN). TVN was determined by Kjeldahl distillation (Buchi 339, Switzerland) of 5 g sample in the presence of MgO for 25 min. Sulfuric acid and methyl red were added to the distillate, and the excess sulfuric acid was titrated with 0.1N NaOH (SILVA and GLORIA, 2002).

Peroxide value. Peroxide value was determined according to ANONYM. (1997). The sample (25 g) was weighed in a 250 mL glass erlenmeyer flask, extracted its fat by chloroform and determined fat ratio in solution. The sample was filtered through Whatman filter paper to remove meat particles. Then 30 mL of acetic acid and 1 mL of saturated potassium iodide solution was added to the filtrate (20 mL). After one minute, 30 mL of distilled water was added and the solution was titrated against a standard solution of sodium thiosulfate (25 g/L). Peroxide value was calculated and expressed as milliequivalent peroxide per kg of sample: Peroxide value = S×N/W ×1000

where S is the volume of titration (mL), N the normality of sodium thiosulfate solution (N = 0.01), and W the sample weight (kg).

Kreis test. Kreis test was determined according to ANONYM. (1997). Epihydrin aldehyde (a product of fat oxidation) reacts with phloroglocinol solution and produces red color. After fat extraction of sample and filtration, 5 mL of filtrate was added to 5 mL of hydrochloric acid (37.5%) in a stoppered tube. High agitation was carried out for 30 seconds. Then 5 mL of 0.1% phloroglocinol solution in ether was added and agitated for another 30 seconds. After 10 minutes, red color in the acid layer indicated epihydrin aldehyde.

Acid value. Acid value was determined according to ANONYM. (1997). The acid value is the number of milligrams of sodium (or potassium) hydroxide necessary to neutralize the free acids in 1 gram of sample. The sample (25 g) was weighed in a 250 mL glass erlenmeyer flask, extracted the fat by chloroform and determined fat ratio in the solution. The sample was filtered through Whatman filter paper to remove meat particles. Then 25 mL of neutralized ethanol with 0.5 mL of 1% phenolphthalein solution was added to the filtrate (25 mL). After complete agitation, the sample was titrated against a standard solution of sodium hydroxide. Acid value was calculated by this formula:

Acid value = S×N×56.1/W

where S is the volume of titration (mL), N the normality of sodium hydroxide solution, and W the sample weight (g).

Statistical analysis. All data were statistically analyzed by SPSS/PC software (version 11.5). Repeated measures of ANOVA, One way ANOVA, independent and paired T test, Duncan's multiple range test were used. $P<0.05$ was considered as the significance level for all tests.

Results

Gross composition and pH in different muscles of camel and cattle are shown in Table 1. Cattle meat had higher ash and fat than camel meat ($P<0.05$). pH, protein and moisture content did not differ in camel and cattle meat ($P>0.05$). TVN values are shown in Table 2. They showed a non significant increase during storage time ($P>0.05$). Acid values are shown in Table 3. Acid values increased with storage time and showed a significant difference after week 4. Cattle meat often showed a higher acid value than camel meat ($P<0.05$). All peroxide values were zero and all kries tests were negative in the two animal species and each storage time. Dripping loss values of camel and cattle meat are shown in Table 4. They increased significantly during storage time ($P<0.05$). Table 5 shows water holding capacity values. WHC values decreased significantly over storage time ($P<0.05$). Cattle meat often showed higher WHC in comparison with camel meat. Shear forces data are shown in Table 6. Significant differences ($P<0.05$) were observed between different muscles, in two species. Values were seen in decreasing order in triceps brachii, biceps femoris, longissimus dorsi and heart muscles. Camel and cattle were not significantly different in this respect. The sex of the camel did not have a significant effect on shear force and, except in the biceps femoris and heart muscles of female camels, adults exhibited higher shear forces ($P<0.05$). No significant difference in the electrophoretic pattern of camel and cattle meat was observed (figures 1 and 2).

Table1. Gross composition percent and pH (Mean ± SD) of camel and cattle muscles in different age and sex

Age and sex	Muscles	pH		Proteine %		Moisture %		Ash %		Fat %	
		Camel	Cattle	Camel	Cattle	Camel	Cattle	Camel	Cattle	Camel	Cattle
Young male	Biceps femoris	5.66 ± 0.07	5.99 ± 0.05^{a}	22.8 ± 1.01^{a}	22.57 ± 0.71^{a}	73.00 ± 2.00^{b}	73.33 ± 1.53^{ac}	0.75 ± 0.08	1.10 ± 0.07	1.01 ± 0.06^{b}	2.47 ± 0.42
	Triceps brachii	5.69 ± 0.04	5.72 ± 0.08^{c}	21.58 ± 1.14^{b}	21.43 ± 0.7^{ab}	71.67 ± 2.52^{a}	71.33 ± 1.53^{a}	0.78 ± 0.07	1.14 ± 0.07	1.19 ± 0.05^{c}	2.99 ± 0.39
	Longissimus dorsi	5.62 ± 0.15	5.85 ± 0.07^{b}	21.66 ± 1.18^{b}	21.87 ± 0.65^{a}	67.33 ± 2.08^{b}	70.67 ± 2.08^{a}	0.67 ± 0.09	1.02 ± 0.06	1.48 ± 0.13^{b}	3.20 ± 0.40
	Heart	5.61 ± 0.08	5.61 ± 0.05^{c}	18.55 ± 0.49^{b}	20.4 ± 0.90^{b}	74.67 ± 1.53^{a}	75.33 ± 1.53^{c}	0.71 ± 0.08	1.06 ± 0.07	1.10 ± 0.04^{ac}	2.81 ± 0.35
Young female	Biceps femoris	5.67 ± 0.12	5.95 ± 0.13^{a}	22.98 ± 1.37^{b}	22.77 ± 0.85	73.00 ± 1.0^{ac}	73.33 ± 2.08^{ac}	0.81 ± 0.07	1.11 ± 0.09	1.11 ± 0.14^{a}	2.94 ± 0.39
	Triceps brachii	5.71 ± 0.21	5.74 ± 0.09^{ab}	20.99 ± 1.22^{a}	21.5 ± 0.85	72.33 ± 1.53^{a}	71.00 ± 2.65^{bc}	0.85 ± 0.07	1.16 ± 0.10	1.52 ± 0.15^{bc}	3.29 ± 0.44
	Longissimus dorsi	5.66 ± 0.09	5.89 ± 0.12^{a}	21.37 ± 1.10^{b}	21.83 ± 0.81	69.33 ± 1.53^{b}	68.67 ± 1.53^{b}	0.70 ± 0.08	1.03 ± 0.06	1.71 ± 0.15^{b}	3.29 ± 0.47
	Heart	5.66 ± 0.07	5.59 ± 0.14^{b}	18.49 ± 0.53^{b}	20.57 ± 0.83	75.00 ± 1.00^{c}	75.67 ± 2.52^{a}	0.74 ± 0.08	1.07 ± 0.08	1.30 ± 0.17^{ac}	3.14 ± 0.45
Adult male	Biceps femoris	5.67 ± 0.11	5.78 ± 0.08^{a}	20.93 ± 0.60^{b}	22.07 ± 0.45^{a}	70.67 ± 1.53	70.67 ± 0.58^{a}	0.97 ± 0.04^{ac}	1.23 ± 0.05^{ac}	1.16 ± 0.12^{a}	3.82 ± 0.15^{a}
	Triceps brachii	5.94 ± 0.44	5.69 ± 0.01^{a}	20.34 ± 0.55^{a}	20.5 ± 0.75^{c}	69.67 ± 3.21	68.33 ± 1.15^{a}	1.05 ± 0.07^{c}	1.29 ± 0.04^{c}	2.14 ± 0.21^{c}	4.32 ± 0.22^{b}
	Longissimus dorsi	5.77 ± 0.14	5.67 ± 0.07^{ab}	20.55 ± 0.57^{a}	21.5 ± 0.30^{a}	66.67 ± 3.21	66.67 ± 1.53^{b}	0.84 ± 0.06^{b}	1.09 ± 0.08^{b}	2.51 ± 0.26^{b}	4.5 ± 0.24^{b}
	Heart	5.76 ± 0.10	5.56 ± 0.07^{b}	17.98 ± 0.79^{b}	19.27 ± 0.42^{b}	72.67 ± 1.53	73.00 ± 1.00^{c}	0.91 ± 0.06^{ab}	1.15 ± 0.07^{ab}	1.81 ± 0.14^{c}	4.13 ± 0.17^{ab}
Adult female	Biceps femoris	5.75 ± 0.15	5.88 ± 0.09^{a}	20.78 ± 0.89^{a}	22.3 ± 0.82	72.00 ± 1.00^{b}	71.67 ± 1.53^{a}	0.99 ± 0.09	1.26 ± 0.06	1.96 ± 0.38^{b}	4.07 ± 0.13^{a}
	Triceps brachii	5.96 ± 0.38	5.63 ± 0.05^{b}	20.14 ± 0.92^{a}	21.57 ± 0.97	71.33 ± 0.58^{b}	69.33 ± 0.58^{ab}	1.07 ± 0.10	1.34 ± 0.08	2.73 ± 0.4^{ab}	4.67 ± 0.17^{bc}
	Longissimus dorsi	5.84 ± 0.13	5.75 ± 0.09^{b}	20.49 ± 0.91^{a}	21.87 ± 0.97	69.00 ± 1.00^{b}	67.33 ± 1.53^{b}	0.88 ± 0.05	1.12 ± 0.08	3.04 ± 0.36^{b}	4.97 ± 0.24^{b}
	Heart	5.72 ± 0.13	5.49 ± 0.04^{c}	18.08 ± 0.29^{b}	20.43 ± 1.46	73.00 ± 1.00^{b}	74.33 ± 1.53^{c}	0.93 ± 0.06	1.17 ± 0.09	2.35 ± 0.47^{ab}	4.44 ± 0.13^{c}

Means in the same age and sex stage with different superscripts are significantly different (P<0.05)

Table 2. Mean ± SD of TVN values (mg/100 g) in different muscles of camel and cattle during freezing storage time (-18 ± 3 °C)

Age and sex	Muscles	Camel				Cattle			
		Day 0	Week 1	Week 4	Week 8	Day 0	Week 1	Week 4	Week 8
Young male	Biceps femoris	$10.36 \pm 1.16^{a,A}$	$11.85 \pm 0.29^{a,A}$	$14.84 \pm 0.4^{ab,B}$	$17.03 \pm 0.63^{a,C}$	$13.44 \pm 0.64^{a,A}$	$14.89 \pm 0.9^{b,B}$	$15.87 \pm 0.72^{a,B}$	$16.28 \pm 0.72^{a,B}$
	Triceps brachii	$9.57 \pm 0.82^{a,A}$	$11.20 \pm 0.50^{a,B}$	$13.90 \pm 0.44^{a,C}$	$15.68 \pm 0.64^{b,D}$	$12.13 \pm 0.21^{a,A}$	$13.49 \pm 0.63^{a,B}$	$14.7 \pm 0.85^{a,BC}$	$15.35 \pm 0.80^{a,C}$
	Longissimus dorsi	$8.91 \pm 0.53^{a,A}$	$10.97 \pm 0.49^{a,B}$	$13.72 \pm 0.28^{a,C}$	$15.73 \pm 0.43^{b,D}$	$12.27 \pm 0.77^{a,A}$	$13.77 \pm 1.1^{a,AB}$	$15.35 \pm 0.8^{a,BC}$	$15.77 \pm 0.66^{a,C}$
	Heart	$12.55 \pm 0.63^{b,A}$	$13.91 \pm 0.53^{b,A}$	$15.96 \pm 1.11^{b,B}$	$18.34 \pm 0.64^{a,C}$	$15.26 \pm 0.98^{b,A}$	$16.33 \pm 0.8^{b,AB}$	$17.78 \pm 0.6^{b,BC}$	$18.43 \pm 0.66^{b,C}$
Young female	Biceps femoris	$11.53 \pm 0.99^{a,A}$	$13.02 \pm 1.1^{a,AB}$	14.61 ± 0.91^{BC}	16.66 ± 1.59^{C}	$13.67 \pm 1.1^{ab,A}$	14.98 ± 0.92^{AB}	16.15 ± 0.19^{B}	$16.71 \pm 0.91^{a,B}$
	Triceps brachii	$10.64 \pm 1.06^{a,A}$	$12.32 \pm 0.78^{a,A}$	14.51 ± 1.21^{B}	16.33 ± 0.77^{B}	$12.09 \pm 0.63^{c,A}$	14.09 ± 1.17^{B}	15.17 ± 1.13^{B}	$15.82 \pm 1.00^{a,B}$
	Longissimus dorsi	$10.55 \pm 0.63^{a,A}$	$11.85 \pm 1.05^{a,A}$	13.77 ± 1.09^{B}	15.49 ± 1.17^{B}	$12.69 \pm 0.7^{ac,A}$	14.09 ± 0.84^{AB}	15.45 ± 0.95^{BC}	$16.29 \pm 0.91^{a,C}$
	Heart	$13.58 \pm 0.50^{b,A}$	$15.31 \pm 0.82^{b,B}$	16.38 ± 0.78^{B}	18.84 ± 0.98^{C}	$15.03 \pm 0.43^{b,A}$	16.29 ± 1.13^{AB}	17.69 ± 1.06^{BC}	$18.62 \pm 0.92^{b,C}$
Adult male	Biceps femoris	$9.10 \pm 0.42^{a,A}$	$10.31 \pm 0.84^{a,B}$	$12.97 \pm 0.21^{a,C}$	$15.54 \pm 0.51^{a,D}$	$10.92 \pm 0.98^{a,A}$	$11.90 \pm 1.1^{a,AB}$	$13.02 \pm 0.98^{a,B}$	$13.72 \pm 0.92^{a,B}$
	Triceps brachii	$8.87 \pm 0.35^{a,A}$	$9.80 \pm 0.28^{a,B}$	$12.37 \pm 0.57^{a,C}$	$14.84 \pm 0.42^{a,D}$	10.27 ± 1.21^{a}	11.11 ± 1.21^{a}	12.23 ± 1.05^{a}	12.80 ± 1.07^{a}
	Longissimus dorsi	$8.82 \pm 0.37^{a,A}$	$9.85 \pm 0.57^{a,B}$	$12.55 \pm 0.21^{a,C}$	$15.07 \pm 0.29^{a,D}$	$10.31 \pm 1.09^{a,A}$	$11.34 \pm 1.1^{a,AB}$	$12.6 \pm 0.84^{a,BC}$	$13.35 \pm 0.91^{a,C}$
	Heart	$11.20 \pm 0.70^{b,A}$	$12.79 \pm 1.27^{b,B}$	$14.98 \pm 0.24^{a,C}$	$16.66 \pm 0.70^{b,D}$	$13.21 \pm 0.49^{b,A}$	$14.14 \pm 0.74^{b,B}$	$15.21 \pm 0.21^{b,C}$	$15.96 \pm 0.37^{b,C}$
Adult female	Biceps femoris	$10.13 \pm 0.71^{a,A}$	$11.53 \pm 0.84^{a,A}$	13.44 ± 1.20^{B}	15.26 ± 1.11^{B}	$11.62 \pm 0.78^{a,A}$	$12.6 \pm 0.61^{a,AB}$	$13.81 \pm 0.7^{a,BC}$	$14.61 \pm 0.63^{a,C}$
	Triceps brachii	$9.80 \pm 0.56^{a,A}$	$10.87 \pm 0.71^{a,A}$	13.58 ± 1.34^{B}	14.98 ± 0.64^{B}	$10.45 \pm 0.29^{a,A}$	$11.67 \pm 0.43^{a,B}$	$12.74 \pm 0.5^{a,BC}$	$13.72 \pm 0.61^{a,D}$
	Longissimus dorsi	$9.52 \pm 0.56^{a,A}$	$10.78 \pm 1.11^{a,A}$	13.35 ± 1.21^{B}	14.79 ± 0.80^{B}	$11.11 \pm 0.63^{a,A}$	$12.04 \pm 0.50^{a,A}$	$13.16 \pm 0.37^{a,B}$	$14.19 \pm 0.63^{a,C}$
	Heart	$12.27 \pm 0.70^{b,A}$	$13.86 \pm 1.1^{b,AB}$	15.54 ± 1.61^{B}	17.13 ± 1.27^{C}	$13.30 \pm 0.85^{b,A}$	$14.51 \pm 1.1^{b,AB}$	$15.31 \pm 0.98^{b,B}$	$16.29 \pm 0.77^{b,B}$

Means in the same column with different lowercase superscripts are significantly different ($P<0.05$). Means in the same row with different uppercase superscripts are significantly different ($P<0.05$).

Table 3. Mean ± SD of acid values in different muscles of camel and cattle during freezing storage time (-18 ± 3 °C)

Age and sex	Muscles	Camel				Cattle			
		Day 0	Week 1	Week 4	Week 8	Day 0	Week 1	Week 4	Week 8
Young male	Biceps femoris	$0.028 \pm 0.01^{a,A}$	$0.044 \pm 0.01^{a,A}$	0.097 ± 0.011^{B}	$0.228 \pm 0.02^{a,C}$	$0.039 \pm 0.01^{a,A}$	$0.056 \pm 0.01^{a,A}$	$0.106 \pm 0.01^{a,B}$	$0.256 \pm 0.02^{a,C}$
	Triceps brachii	$0.048 \pm 0.01^{ab,A}$	$0.071 \pm 0.01^{bc,A}$	0.117 ± 0.015^{A}	$0.324 \pm 0.08^{c,B}$	$0.056 \pm 0.01^{ab,A}$	$0.08 \pm 0.01^{bc,A}$	$0.127 \pm 0.01^{ab,A}$	$0.368 \pm 0.08^{c,B}$
	Longissimus dorsi	$0.058 \pm 0.01^{b,A}$	$0.084 \pm 0.01^{b,A}$	0.127 ± 0.012^{B}	$0.437 \pm 0.04^{b,C}$	$0.065 \pm 0.01^{b,A}$	$0.095 \pm 0.01^{b,AB}$	$0.138 \pm 0.01^{b,B}$	$0.473 \pm 0.04^{b,C}$
	Heart	$0.039 \pm 0.01^{ab,A}$	$0.054 \pm 0.01^{ac,A}$	0.104 ± 0.009^{B}	$0.262 \pm 0.02^{ac,C}$	$0.044 \pm 0.01^{a,A}$	$0.063 \pm 0.01^{ac,A}$	$0.115 \pm 0.01^{a,B}$	$0.289 \pm 0.02^{ac,C}$
Young female	Biceps femoris	0.043 ± 0.012^{A}	$0.059 \pm 0.01^{a,A}$	$0.112 \pm 0.01^{a,B}$	$0.25 \pm 0.051^{a,C}$	0.048 ± 0.012^{A}	$0.071 \pm 0.01^{a,A}$	$0.121 \pm 0.003^{a,B}$	$0.302 \pm 0.04^{a,C}$
	Triceps brachii	0.059 ± 0.017^{A}	$0.087 \pm 0.01^{bc,A}$	$0.157 \pm 0.01^{d,B}$	$0.405 \pm 0.07^{bc,C}$	0.071 ± 0.017^{A}	$0.095 \pm 0.01^{b,A}$	$0.164 \pm 0.01^{d,A}$	$0.467 \pm 0.09^{bc,B}$
	Longissimus dorsi	0.074 ± 0.014^{A}	$0.093 \pm 0.01^{b,A}$	$0.179 \pm 0.01^{b,B}$	$0.456 \pm 0.07^{b,C}$	0.080 ± 0.014^{A}	$0.102 \pm 0.01^{b,A}$	$0.188 \pm 0.01^{b,B}$	$0.538 \pm 0.07^{b,C}$
	Heart	0.052 ± 0.014^{A}	$0.074 \pm 0.01^{ac,A}$	$0.136 \pm 0.01^{c,B}$	$0.334 \pm 0.06^{ac,C}$	0.059 ± 0.017^{A}	$0.082 \pm 0.01^{ab,A}$	$0.145 \pm 0.01^{c,B}$	$0.371 \pm 0.05^{ac,C}$
Adult male	Biceps femoris	$0.054 \pm 0.01^{a,A}$	$0.076 \pm 0.01^{a,B}$	$0.110 \pm 0.01^{a,C}$	$0.312 \pm 0.02^{a,D}$	0.065 ± 0.012^{A}	$0.086 \pm 0.01^{a,A}$	$0.119 \pm 0.01^{a,B}$	$0.336 \pm 0.02^{a,C}$
	Triceps brachii	$0.073 \pm 0.01^{bc,A}$	$0.110 \pm 0.01^{bc,B}$	$0.218 \pm 0.02^{b,C}$	$0.521 \pm 0.03^{b,D}$	0.084 ± 0.010^{A}	$0.119 \pm 0.01^{bc,A}$	$0.229 \pm 0.02^{b,B}$	$0.702 \pm 0.04^{b,C}$
	Longissimus dorsi	$0.086 \pm 0.01^{b,A}$	$0.121 \pm 0.01^{b,A}$	$0.248 \pm 0.02^{b,B}$	$0.571 \pm 0.08^{b,C}$	0.095 ± 0.011^{A}	$0.130 \pm 0.01^{b,A}$	$0.261 \pm 0.02^{b,B}$	$0.781 \pm 0.09^{b,C}$
	Heart	$0.061 \pm 0.01^{ac,A}$	$0.097 \pm 0.01^{c,A}$	$0.171 \pm 0.03^{c,B}$	$0.488 \pm 0.02^{b,C}$	0.074 ± 0.014^{A}	$0.104 \pm 0.01^{ac,A}$	$0.183 \pm 0.03^{a,B}$	$0.533 \pm 0.02^{c,C}$
Adult female	Biceps femoris	$0.074 \pm 0.01^{a,A}$	0.108 ± 0.020^{A}	$0.175 \pm 0.03^{a,B}$	$0.476 \pm 0.06^{a,C}$	$0.082 \pm 0.01^{a,A}$	0.117 ± 0.023^{A}	$0.185 \pm 0.03^{a,A}$	$0.555 \pm 0.12^{a,B}$
	Triceps brachii	$0.102 \pm 0.01^{b,A}$	0.140 ± 0.025^{A}	$0.284 \pm 0.05^{b,B}$	$0.623 \pm 0.08^{bc,C}$	$0.113 \pm 0.02^{ab,A}$	0.155 ± 0.025^{A}	$0.297 \pm 0.05^{b,B}$	$0.840 \pm 0.10^{bc,C}$
	Longissimus dorsi	$0.116 \pm 0.01^{b,A}$	0.155 ± 0.031^{A}	$0.327 \pm 0.06^{b,B}$	$0.722 \pm 0.10^{b,C}$	$0.127 \pm 0.02^{b,A}$	0.166 ± 0.031^{A}	$0.344 \pm 0.06^{b,B}$	$0.940 \pm 0.13^{b,C}$
	Heart	$0.095 \pm 0.02^{ab,A}$	0.119 ± 0.02^{A}	$0.242 \pm 0.06^{b,B}$	$0.529 \pm 0.05^{a,C}$	$0.100 \pm 0.02^{ab,A}$	0.130 ± 0.018^{A}	$0.252 \pm 0.06^{ab,B}$	$0.707 \pm 0.05^{ac,C}$

Means in the same column of each age and sex stage with different lowercase superscripts are significantly different ($P<0.05$). Means in the same row of each age and sex stage with different uppercase superscripts are significantly different ($P<0.05$).

Table 4. Mean ± SD of dripping loss percent in different muscles of camel and cattle during freezing storage time (-18 ± 3 ºC)

Age and sex	Muscles	Camel			Cattle		
		Week1	Week4	Week8	Week1	Week4	Week8
Young male	Biceps femoris	13.64 ± 1.65^{A}	15.83 ± 1.01^{A}	18.72 ± 1.28^{B}	13.44 ± 0.76^{a,A}	15.44 ± 0.84^{ac,AB}	17.57 ± 1.51^{a,B}
	Triceps brachii	12.97 ± 1.38^{A}	15.05 ± 1.08^{A}	18.05 ± 1.13^{B}	12.52 ± 0.97^{a,A}	14.12 ± 0.73^{a,A}	16.26 ± 0.99^{ab,B}
	Longissimus dorsi	12.75 ± 1.23^{A}	14.87 ± 0.80^{B}	17.11 ± 0.95^{C}	10.72 ± 0.48^{b,A}	12.47 ± 0.39^{b,B}	14.63 ± 0.40^{b,C}
	Heart	13.25 ± 1.40^{A}	15.36 ± 0.87^{A}	18.57 ± 1.32^{B}	13.63 ± 0.89^{a,A}	15.97 ± 0.94^{c,B}	18.24 ± 1.39^{a,C}
Young female	Biceps femoris	14.57 ± 1.09^{A}	16.03 ± 1.39^{AB}	18.99 ± 1.92^{B}	12.98 ± 0.52^{a,A}	15.10 ± 0.86^{a,B}	17.96 ± 0.56^{ac,C}
	Triceps brachii	13.90 ± 0.92^{A}	15.41 ± 1.14^{A}	18.48 ± 1.59^{B}	12.30 ± 0.49^{ab,A}	14.39 ± 1.06^{ab,B}	17.04 ± 0.59^{a,C}
	Longissimus dorsi	13.45 ± 0.92^{A}	15.00 ± 1.26^{A}	17.80 ± 1.70^{B}	11.23 ± 0.46^{b,A}	12.81 ± 0.59^{b,B}	14.39 ± 0.77^{b,C}
	Heart	14.12 ± 0.98^{A}	15.78 ± 1.27^{A}	18.65 ± 1.63^{B}	13.42 ± 0.98^{a,A}	15.91 ± 0.90^{a,B}	18.69 ± 0.85^{c,C}
Adult male	Biceps femoris	11.77 ± 1.45^{A}	13.41 ± 1.20^{AB}	15.81 ± 0.98^{B}	9.50 ± 0.83^{A}	12.05 ± 0.77^{B}	15.42 ± 0.76^{a,C}
	Triceps brachii	11.24 ± 1.42^{A}	12.80 ± 0.99^{A}	15.28 ± 0.94^{B}	9.00 ± 0.81^{A}	11.16 ± 0.28^{B}	14.41 ± 0.59^{ab,C}
	Longissimus dorsi	10.52 ± 1.04^{A}	11.98 ± 0.99^{A}	14.51 ± 0.64^{B}	8.18 ± 0.18^{A}	10.87 ± 0.56^{B}	13.04 ± 0.53^{b,C}
	Heart	11.58 ± 1.35^{A}	13.21 ± 1.14^{AB}	15.48 ± 1.01^{B}	9.60 ± 0.90^{A}	12.83 ± 1.27^{B}	15.73 ± 1.28^{a,C}
Adult female	Biceps femoris	10.98 ± 1.55^{A}	12.69 ± 1.55^{A}	15.57 ± 0.92^{B}	10.48 ± 0.95^{A}	13.01 ± 0.73^{B}	15.50 ± 0.25^{ac,C}
	Triceps brachii	10.53 ± 1.45^{A}	12.36 ± 1.67^{AB}	15.04 ± 1.08^{B}	9.98 ± 1.19^{A}	11.64 ± 1.18^{B}	14.35 ± 0.91^{bc,B}
	Longissimus dorsi	10.00 ± 1.47^{A}	11.79 ± 1.46^{AB}	14.27 ± 0.84^{B}	8.96 ± 1.06^{A}	11.34 ± 1.00^{B}	13.44 ± 0.67^{b,C}
	Heart	10.76 ± 1.58^{A}	12.65 ± 1.85^{AB}	15.26 ± 0.95^{B}	10.62 ± 1.07^{A}	12.98 ± 1.58^{B}	16.04 ± 0.72^{a,C}

Means in the same row of each age and sex stage with different uppercase superscripts are significantly different (P<0.05).

Table 5. Mean ± SD of water holding capacity (WHC) percent in different muscles of camel and cattle during freezing storage time (-18 ± 3 °C)

Age and sex	Muscles	Camel				Cattle			
		Day 0	Week 1	Week 4	Week 8	Day 0	Week 1	Week 4	Week 8
Young male	Biceps femoris	44.91 ± 2.10^{A}	43.69 ± 1.79^{A}	41.73 ± 1.88^{AB}	$38.52 \pm 1.5^{ab,B}$	51.43 ± 2.17^{A}	47.43 ± 1.95^{AB}	44.20 ± 2.30^{BC}	42.42 ± 2.54^{C}
	Triceps brachii	43.82 ± 1.85^{A}	42.07 ± 1.64^{AB}	39.96 ± 1.47^{BC}	$37.23 \pm 1.12^{a,C}$	48.79 ± 2.19^{A}	45.58 ± 1.47^{AB}	42.98 ± 2.51^{BC}	41.19 ± 2.14^{C}
	Longissimus dorsi	41.77 ± 1.72^{A}	40.87 ± 1.8^{AB}	38.55 ± 1.02^{B}	$35.70 \pm 1.18^{a,C}$	48.46 ± 2.31^{A}	45.86 ± 2.60^{AB}	42.50 ± 2.12^{BC}	40.76 ± 2.59^{C}
	Heart	46.25 ± 2.02	45.03 ± 2.14	43.16 ± 2.76	40.48 ± 2.29^{b}	52.48 ± 3.39^{A}	48.82 ± 2.82^{AB}	45.87 ± 2.12^{B}	44.05 ± 2.59^{B}
Young female	Biceps femoris	45.64 ± 1.05^{A}	43.96 ± 1.4^{AB}	42.39 ± 1.60^{B}	40.19 ± 1.99^{C}	54.62 ± 2.25^{A}	50.56 ± 2.71^{AB}	46.98 ± 2.91^{BC}	45.19 ± 2.70^{C}
	Triceps brachii	45.17 ± 1.13^{A}	43.93 ± 0.83^{AB}	42.25 ± 1.56^{BC}	39.29 ± 1.40^{C}	52.47 ± 1.10^{A}	48.90 ± 1.57^{B}	45.51 ± 1.43^{C}	43.25 ± 1.67^{C}
	Longissimus dorsi	44.13 ± 1.36^{A}	42.60 ± 1.37^{AB}	40.51 ± 1.10^{BC}	38.19 ± 1.71^{C}	51.74 ± 1.23^{A}	48.52 ± 1.27^{B}	45.26 ± 1.47^{C}	43.37 ± 1.95^{C}
	Heart	45.96 ± 1.10^{A}	44.78 ± 1.5^{AB}	43.33 ± 1.20^{BC}	41.28 ± 1.18^{C}	54.89 ± 2.39^{A}	50.49 ± 2.53^{AB}	47.08 ± 2.56^{B}	45.69 ± 2.69^{B}
Adult male	Biceps femoris	46.97 ± 1.31^{A}	$45.50 \pm 1.36^{a,A}$	$42.87 \pm 0.14^{ac,B}$	$40.55 \pm 0.65^{ac,C}$	50.47 ± 1.21^{A}	46.15 ± 1.47^{B}	42.89 ± 1.39^{C}	41.26 ± 1.33^{C}
	Triceps brachii	46.72 ± 1.36^{A}	$44.61 \pm 0.4^{ab,B}$	$41.84 \pm 0.5^{bc,C}$	$39.84 \pm 0.89^{a,D}$	49.45 ± 1.08^{A}	45.53 ± 1.46^{B}	41.79 ± 2.16^{C}	39.94 ± 1.70^{C}
	Longissimus dorsi	45.75 ± 1.22^{A}	$43.09 \pm 1.01^{b,B}$	$40.80 \pm 1.17^{b,C}$	$38.30 \pm 0.46^{b,D}$	49.18 ± 0.79^{A}	45.54 ± 0.48^{B}	41.66 ± 1.10^{C}	40.07 ± 1.36^{C}
	Heart	47.50 ± 1.08^{A}	$46.21 \pm 0.98^{a,A}$	$43.57 \pm 0.37^{a,B}$	$41.14 \pm 0.32^{e,C}$	51.57 ± 1.61^{A}	47.79 ± 2.45^{AB}	44.09 ± 1.91^{BC}	42.15 ± 2.19^{C}
Adult female	Biceps femoris	47.17 ± 2.44^{A}	45.66 ± 1.48^{AB}	42.81 ± 1.59^{BC}	40.21 ± 2.17^{C}	51.66 ± 1.43^{A}	47.77 ± 1.65^{B}	43.98 ± 2.15^{C}	42.59 ± 1.95^{C}
	Triceps brachii	46.73 ± 2.05^{A}	44.92 ± 2.31^{A}	42.40 ± 3.09^{AB}	39.84 ± 2.47^{B}	50.95 ± 1.79^{A}	46.74 ± 1.99^{B}	43.08 ± 2.05^{BC}	41.47 ± 2.04^{C}
	Longissimus dorsi	45.20 ± 2.29^{A}	43.70 ± 2.57^{A}	41.12 ± 1.73^{AB}	37.69 ± 1.64^{B}	49.46 ± 2.10^{A}	45.53 ± 2.48^{AB}	42.22 ± 2.31^{BC}	41.02 ± 2.23^{C}
	Heart	47.54 ± 2.47^{A}	46.03 ± 2.56^{A}	44.14 ± 2.15^{AB}	41.39 ± 1.45^{B}	52.36 ± 1.69^{A}	47.96 ± 1.47^{B}	44.51 ± 2.28^{BC}	43.21 ± 1.81^{C}

Means in the same column of each age and sex stage with different lowercase superscripts are significantly different ($P<0.05$).Means in the same row of each age and sex stage with different uppercase superscripts are significantly different ($P<0.05$).

Table 6. Mean ± SD of tensile strengths (kgF) in different muscles of camel and cattle

Age and sex	Muscles	Camel	Cattle
Young male	Biceps femoris	8.10 ± 0.20 $^{ab, B}$	5.90 ± 0.26 $^{ac, A}$
	Triceps brachii	7.90 ± 0.17 $^{a, B}$	6.23 ± 0.30 $^{c, A}$
	Longissimus dorsi	7.67 ± 0.15 $^{bc, B}$	5.23 ± 0.50 $^{a, A}$
	Heart	7.37 ± 0.23 $^{c, B}$	4.53 ± 0.32 $^{b, A}$
Young female	Biceps femoris	7.83 ± 0.32	6.20 ± 0.53 ^{ab}
	Triceps brachii	7.57 ± 0.30	6.67 ± 0.45 ^{a}
	Longissimus dorsi	7.37 ± 0.38	5.53 ± 0.63 ^{bc}
	Heart	7.03 ± 0.32 ^{B}	4.93 ± 0.38 $^{c, A}$
Adult male	Biceps femoris	9.17 ± 0.35 ^{a}	8.13 ± 0.76 ^{ab}
	Triceps brachii	8.87 ± 0.32 ^{ab}	8.63 ± 0.61 ^{a}
	Longissimus dorsi	8.50 ± 0.20 ^{b}	7.20 ± 0.61 ^{bc}
	Heart	7.90 ± 0.20 ^{c}	6.57 ± 0.68 ^{c}
Adult female	Biceps femoris	8.73 ± 0.35 ^{a}	8.13 ± 0.76 ^{ab}
	Triceps brachii	8.4 ± 0.46 ^{a}	8.67 ± 0.75 ^{a}
	Longissimus dorsi	8.13 ± 0.35 $^{ab, B}$	7.30 ± 0.66 $^{bc, A}$
	Heart	7.60 ± 0.30 $^{b, B}$	6.37 ± 0.51 $^{c, A}$

Means in the same column of each age and sex stage with different lowercase superscripts are significantly different ($P<0.05$). Means in the same row of each age and sex stage with different uppercase superscripts are significantly different ($P<0.05$).

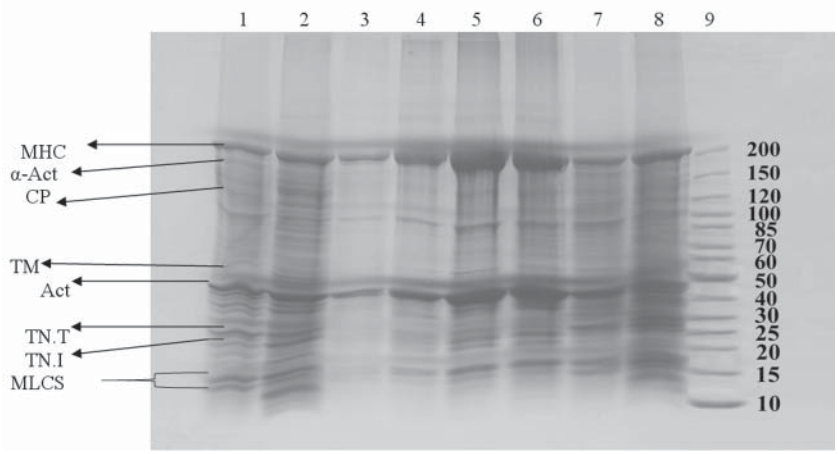

Fig. 1. SDS-PAGE of myofibrillar proteins of adult camel meat. Arrows on the left indicate major myofibrillar proteins: MHC: myosin heavy chain, α-Act: α-Actinin, CP: C protein, TM: tropomyosin, Act: actin, TN.T: troponin T, TN.I: troponin I, MLCS: myosin light chains (band assignments from OUALI, 1990). 1 - biceps femoris muscle, female; 2 - triceps brachii muscle, female; 3 - heart muscle, female; 4 - longissimus dorsi muscle, female; 5l- biceps femoris muscle, male; 6 - triceps brachii muscle, male; 7 - heart muscle, male; 8 - longissimus dorsi muscle, male; 9 - molecular mass markers

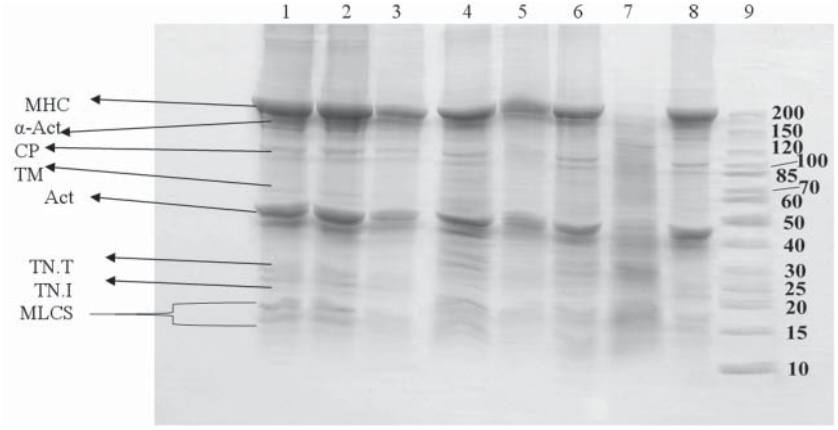

Fig. 2. SDS-PAGE of myofibrillar proteins of adult cattle meat. Arrows on the left indicate major myofriliar proteins: MHC: myosine heavy chain, α-Act: α-Actinin, CP: C protein, TM: tropomyosin, Act: actin, TN.T: troponin T, TN.I: troponin I, MLCS: myosin light chains (band assignments from OUALI, 1990). 1 - biceps femoris muscle, female; 2 - triceps brachii muscle, female; 3 - heart muscle, female; 4 - longissimus dorsi muscle, female; 5 - biceps femoris muscle, male; 6 - triceps brachii muscle, male; 7 - heart muscle, male; 8 - longissimus dorsi muscle, male; 9 - molecular mass markers.

Discussion

Camel meat is nutritionally as good as that of the major sources of red or white meats. It may even have an edge over beef or lamb due to its low intramuscular fat and cholesterol contents. However, its high Na content may represent a risk factor for some people. Because of its unique adaptability to the harsh environmental conditions, the value of the dromedary camel as a source of meat should not be underestimated (ELGASIM and ALKANHAL, 1992).

Our study showed that camel meat had similar protein and moisture percentage and lower fat and ash percentage than cattle meat. ELGASIM and ALKANHAL (1992) reported that the moisture contents of camel and fish meat are higher than cattle, sheep, goat and chicken meat. The protein content of camel meat was slightly lower than cattle, sheep, goat and chicken meat. Camel meat had lower fat content than cattle, sheep, goat and chicken and higher than fish meat. Camel meat had the lowest ash content among the animals studied. EL-FAER et al. (1991) described camel meat as the same as cattle meat in minerals, protein and ash content. They showed that camel meat has a significantly lower fat and higher moisture content than cattle meat.

The content, composition and quality of camel meat depend upon age, sex and nutrition status. The quality of meat produced by younger animals (less than 3 years) was comparable to beef in taste and texture. However, since animals are usually slaughtered at the end of their productive life, camel meat is usually tough (SHALASH, 1979).

pH is probably the quality attribute most commonly measured in fresh meat, as it affects technological properties, keeping ability and most sensory traits. The pH of muscle tissue may be a very important determinant of the tenderness of the fresh product. The relationship between tenderness and pH is very complex. Ultimate pH, the rate of pH decline and the rate of temperature decline have a major impact on both the final tenderness of meat and on the rate at which the tenderness is attained (SILVA et al., 1999; LONERGAN et al., 2000). Our results often showed no significant differences between pH of camel and cattle meat, 24 hours after slaughtering.

In our study, the water holding capacity of muscles decreased significantly during frozen storage in two animal species. Cattle muscles often had higher WHC than camel muscles. DAWOOD (1995a) reported that freezing, age and cutting type have a significant effect on the WHC of camel meat. In his study, defrosted meat showed a significantly lower WHC than fresh meat ($P<0.05$). FAROUK et al. (2003) indicated that frozen storage of cattle meat decreases the WHC slightly, but after 9 months WHC has a rapid fall. This phenomenon has been attributed to the mechanical loosening of muscle tissue by the formation of ice crystals. Also, decreasing pH due to freezing may account for reduced WHC.

ZIAUDDIN (1993) showed an increase in drip losses of buffalo meat as the freezing storage period increased and the losses were greater in cut than in minced meat. FAROUK et al. (2003) showed that slowly frozen and thawed beef meat has higher amounts of thaw drip loss compared with fast frozen samples. The difference in thaw drip between the two freezing regimes was greater in the early storage period and narrowed during storage time. More drip in slowly frozen meat may have resulted from greater structural damage associated with larger intracellular ice crystals produced during slow freezing. In the present study, drip losses of camel and cattle muscles significantly increased during frozen storage time and the two animal species often had the same drip loss.

As fresh meat is a rich medium for the growth of microorganisms, it will ultimately spoil as a consequence of such growth unless frozen to temperatures too low for microbial growth to occur. Proteolytic enzymes (internal or microbial source) decompose the structural meat proteins and produce nitrogenous compounds. Therefore, total volatile bases nitrogen (TVN) measurement can help spoilage diagnosis of meat. In the study by BELL and GAROUT (1994), no consistent relationship was seen between the TVN content of surface and deep tissue of lean beef. Averaged over all samples analyzed (n=250), the TVN content on the surface was 0.2 ± 0.5 mg N/100 g higher than in the deep tissue. Once microfloras reached maximal levels (10^7 cells/cm^2) there was a trend for TVN levels to rise to more than 18 mg N/100 g lean, with levels exceeding 24 mg N/100 g when spoilage became organoleptically evident. In the present study, TVN values increased non significantly during frozen storage time. Cattle meat had higher TVN values than camel, except adult female camel. Young animals often had higher TVN values than adults in the two species.

One of the main factors limiting the quality and acceptability of meat and meat products is lipid oxidation. This process leads to discoloration, drip losses, off-odour and off-flavour development, and the production of potentially toxic compounds. Hydroperoxides, the primary initial products of lipid oxidation, are essentially odorless, but will decompose to a variety of volatile and non-volatile secondary products. Aldehydes are major contributors to the loss of desirable flavor in meats because of their rate of formation during lipid oxidation and low flavor threshold. Lipid hydrolysis, another common spoilage type of lipids, take place by tissue's and microbial lipase activities. Free fatty acids are important products of lipid hydrolysis (GRAY et al., 1996). In our study, all peroxide values were zero and all kries tests were negative, therefore freezing is an effective method for prevention of lipid oxidation in meat.

Many factors contribute to the eating quality of meat and the perception of taste, with tenderness being considered as one of the most important attributes (WHEELER et al., 1990; KOOHMARAIE et al., 1991). An objective measure of tenderness is the force required to shear a standardized piece of meat with low shear values being desirable.

The tensile strength test is best suited for structural investigations rather than to predict sensory evaluation of tenderness. It is a useful test in conjunction with other methods. The test can be carried out on raw or cooked meat. Results will be affected by sample size and strain rate, but this latter effect is small. In this study, significant differences ($P<0.05$) were observed between different muscles. Camel and cattle were not significantly different.

Many studies have been conducted to evaluate and quantify myofibrillar proteins of different meat animals by means of SDS-PAGE electrophoresis. These studies have shown many proteins, the most important of which are described below.

The major protein of thick filaments is myosin, which comprises 50-60% of myofibrillar contractile proteins. Myosin contains two identical polypeptide chains and two globular heads. Associated with each globular head section are two light chains, so that four light chains are associated with each myosin molecule. The light chains have a molecular mass of about 16000-25000 daltons. A major protein of the thin filaments is actin, which comprises 15-30% of myofibrillar protein of muscle. Actin probably exists in muscle as a double-helical structure called fibrous actin. Globular actin is the monomeric form of the protein with a molecular mass of 43000-48000 daltons. Tropomyosin is a two-stranded coiled-coil of an α-helix with a molecular mass of 65000-70000 daltons.

Troponin is often isolated with tropomyosin. This protein consists of three subunits designated troponin C (17000-18000 daltons), troponin I (20000-24000 daltons), and troponin T (37000-40000 daltons). C-protein makes up approximately 3% of the thick filament mass. It is a single polypeptide chain of 140000 daltons. α-Actinin is located exclusively in the Z disk. It has a molecular mass of 180000 daltons and consists of two polypeptide subunits of similar mass. β-Actinin is a dimeric protein made up of polypeptides of 37000 and 34000 daltons.

It is well established that the proteolysis of myofibrillar proteins by endogenous proteases during post-mortem aging is primarily responsible for the tenderization of meat. The major proteins associated with myofibrillar contraction, actin, myosin and α-actinin, are not degraded during the aging process. The principal degradative change detectable on examination by SDS polyacrylamide gel electrophoresis of myofibrils is loss of troponin T. Loss of troponin T has been related to meat tenderness but it seems unlikely that degradation of this protein itself causes increased tenderness, since it has no known role in structurally stabilizing myofibrils. This is in agreement with more recent observations showing no relationship or even a negative relationship between troponin T disappearance and meat tenderness.

As myofibrillar protein hydrolysis proceeds, the closely related appearance of proteolytic breakdown components is observed. On SDS polyacrylamide gel electrophoresis, most of them run between tropomyosin and myosin light chain 1 and

exhibit molecular weights (Mr) in the range of 25 K to 34 K (OUALI, 1990; CLAEYS et al., 1995; MCDONAGH, 1999).

Taken together, the one-humped camel as a meat source seems to present a viable alternative to cattle. This is particularly true in desert regions where camel husbandry is much more economical than that of cattle, due to the unique adaptation of the camel to the harsh environmental conditions of arid and semi-arid zones very difficult for all other livestock. Human consumption of camel meat should lead to a reduction in total fat intake and an increase in polyunsaturated fat as compared with other conventional meat sources. Such a diet is highly desirable in view of the established relationship between saturated fat and cardiovascular diseases (RAWDAH, 1994).

In conclusion, the data suggest that the chemical composition of camel meat and the alterations from freezing are comparable to cattle meat. Hence the one-humped camel as a meat source seems to present a viable alternative to cattle. This is particularly true in desert regions where camel husbandry is much more economical than that of cattle due to the unique adaptation of the camel to the harsh environmental conditions of arid and semi-arid zones, which are very difficult for all other livestock.

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SAŽETAK

Malo pozornosti pridaje se kakvoći devina mesa. Hranidbeno je jednako vrijedno kao i ostale vrste crvena mesa. Stoga je cilj ovog istraživanja usporediti biokemijska i funkcionalna svojstva svježega i smrznutoga devina mesa sa svojstvima goveđega mesa. Nasumce su bili uzeti uzorci m. biceps femoris, m. triceps brachii, m. longissimus dorsi i srčanoga mišića od 24 životinje (deva i goveda) različite dobi i spola. Od svakog uzorka odstranjeno je vanjsko masno tkivo i epimizijalno vezivno tkivo. Svakom uzorku elektroforezom je bio određen sastav, pH, sposobnost vezanja vode, ukupni hlapljivi dušik, peroksidni broj, stupanj kiselosti, žilavost i proteinski sastav miofibrila. Uzorci su bili zamrznuti tijekom jedan, četiri i osam tjedana pri temperaturi -18 °C. Nakon odmrzavanja određivana je sposobnost vezanja vode, gubitak vode, ukupni hlapljivi dušik, peroksidni broj, stupanj kiselosti i vrijednosti dobivene Kreisovim testom. Svježe devino i goveđe meso bilo je slično po većini pretraživanih pokazatelja, osim po sadržaju pepela i masti za koje su ustanovljene značajno manje vrijednosti u devinu mesu ($P<0,05$). Smrznuto devino i goveđe meso bilo je slično po svim pretraživanim pokazateljima osim po sadržaju ukupna hlapljiva dušika, stupnju kiselosti, sposobnosti vezanja vode i gubitka vode. Gubitak vode bio je veći, a vrijednosti ostalih pokazatelja bile su manje za devino meso ($P<0,05$). Može se zaključiti da je kakvoća devina mesa usporediva s kakvoćom goveđega mesa, čak i bolja s obzirom na to da sadrži malo mišićne masti i kolesterola. Ipak, budući da se deve kolju pod kraj života, devino meso obično je žilavo. S obzirom na sve rečeno devino meso trebalo bi više upotrebljavati u rastućim potrebama za mesom u zemljama u razvoju.

Ključne riječi: deva, govedo, meso, biokemijska svojstva, smrzavanje, pohrana