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Evaluation of Functional Properties and Fatty Acid Profiles of One-Hump and Crossbred (*Dromedarius and Bactrianus*) Mamel Meat

Research Article

Z. Ebadi[1*] and F. Sarhaddi[2]

[1] Department of Animal Production Processing, Animal Science Research Institute of Iran (ASRI), Agricultural Research Education and Extension Organization (AREEO), Karaj, Iran
[2] Department of Animal Production Management, Animal Science Research Institute of Iran (ASRI), Agricultural Research Education and Extension Organization (AREEO), Karaj, Iran

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*Correspondence E-mail: z_ebadi@asri.ir

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ABSTRACT

In this study twenty-four male and female one-humped and crossbred (*Camelus dromedarius* and *Camelus bactrianus*) camel meat were evaluated during two fattening periods (6 and 9 months). The characteristics of camel meat and fatty acid profile in different parts of body (leg, shoulder, loin and neck) were measured. The results indicated that the pH ultimate of crossbred camel meat was lower than one-humped sample and the males had higher level than the females ($P<0.05$). The genetic groups of crossbred and one-humped had significantly different percentage of cooking loss, water binding capacity (WBC) and meat pigment concentrations. The fatty acid (FA) composition of camel meat was affected by crossbreeding and fattening periods especially in neck, loin and shoulder cuts. High level of unsaturated FA percentage and the ratio of mono and polyunsaturated FA (MUFA+PUFA) to saturated FA (SFA) were found in crossbred meat samples. Fattening period from 6 to 9 months increased the level of MUFA + PUFA/SFA ratio and health index of crossbred camel meat.

KEY WORDS camel meat, crossbred, fatty acid, one-humped, quality.

INTRODUCTION

Camel is an animal that has adapted in harsh arid regions and plays an important role in the lives of millions of human serving as a source of milk, meat and etc. There are two species of camel within the genus *Camelus*. The dromedary one-humped camel (*Camelus dromedaries*) is most widely distributed in the hot arid areas of the Middle East and Africa, whereas the bactrian two-humped camel (*Camelus bacterianus*) is found in parts of central Asia and China (Dorman, 1986). Camel meat is a good source of red meat that has much nutritional value and the world consumption is recently increasing (Kadim *et al*. 2015; Kadim *et al*. 2006; 2008; Faye and Bonnet, 2012; Kurtu, 2004; Babiker and Yousif, 1990). Camel meat has high quality of protein and it contains low levels of intramuscular fat and relatively high proportion of polyunsaturated fatty acids compared to meat from other animals, which provide more food for growing human population (Kadim *et al*. 2008; Kadim *et al*. 2013; Kadim *et al*. 2015). Kadim *et al*. (2015) reported that considering the similarity of camel meat to cattle meat for several quality attributes and the increasing acceptability of camel meat, there are huge opportunities for development of the camel meat sector. Increasing global requirement and the ever-changing consumer demand for sustainable, economically viable, high quality, and healthier meat demands to look for an alternative meat source to feed the ever growing population. An efficient marketing system for camel meat requires more information on meat quality characteristics of various muscles from different regions for

quality classification purposes. Moreover, marketing camel muscles in this way allows producing more attractive cuts with greater quality characteristics (Kadim *et al*. 2013).

Breeding and crossbreeding camel for meat producing animal has been attended in recent years, which can increase the quantity and quality of camel meat (Ebadi *et al*. 2010; Ebadi, 2015). The plan of camels' crossbreeding in Iran showed that crossbreeding (*C. dromedaries*×*C. bactrianus*) can improve the performance and carcass characteristics (Sarhaddi, 2009; Ebadi *et al*. 2010; Ebadi, 2015). Ebadi (2015) reported that high levels of nutritional values were obtained by camel crossbreeding, hence the high level of protein and low level of fat contents were assessed in crossbred camel meat and main mineral contents of camel meat (Zn and Fe) increased by growing periods. The effect of three fattening periods (6, 9 and 12 months) on performance of crossbred camel had been studied by Sarhaddi (2009). In regions of the world that have wide spread desert regions, limited rangeland and low annual rainfall such as Iran, camel crossbreeding projects have been performed to improve meat characteristics.

Fatty acid composition in meat producing animals has received considerable interest in view of its implications for human health and for meat quality characteristics (Wood and Enser, 1997; Wood *et al*. 1999; De Smet *et al*. 2004; Osorio *et al*. 2007). Meat fatty acid composition depends on several factors such as dietary, environmental and genetic factors (De Smet *et al*. 2004; Osorio *et al*. 2007). However, genetic factors have been investigated far less, although several studies have reported breed differences for fatty acid composition in different farm animal species, and a few have reported estimates of genetic parameters (De Smet *et al*. 2004). Information on fatty acid composition of crossbred camel meat in different cuts of carcass can be used for development of value added products. Nevertheless, limited studies have been conducted on the breeding and crossbreeding regarding camel meat, therefore having knowledge of its quantity and quality is necessary.

Therefore, the objective of present study was to characterize the functional properties and fatty acid profile of the dromedary and its crosses with bactrian camel meat, during different fattening periods.

MATERIALS AND METHODS

Functional properties of meat such as pH ultimate, cooking loss percentage, texture value (raw and cooked), percentage of water binding capacity (WBC), the optical density (OD) of meat pigment concentrations and fatty acid profile were determined in four commercial cuts of carcasses (leg, shoulder, loin and neck).

Gluteo biceps femoris, infraspinatus, longissimus thoracis et lumborum (LTL) and neck muscles from leg, shoulder, loin and neck cuts were removed respectively.

Sampling procedure

In this study twenty-four male and female one-humped (6 males and 6 females) and crossbred (*C. dromedarius*×*C. bactrianus*) (6 males and 6 females) camels were utilized by completely randomized design. 24 yearling camels from each sex representing two genotypes were fattened during six- and nine- months at the research farm in the Animal Science Research Institute of Iran (ASRI) (karaj, Iran). The F1 crossbred camel was the offspring of male bactrian and female dromedary (Ebadi, 2015). Animals were grown in the same diet and environmental conditions for six and nine month periods in feedlot system at ASRI. The diet of all camels was fed *ad libitum* containing; 25% alfalfa, 25% wheat straws and 50% concentrate (55% barely, 20% wheat bran, 8% cottonseed meal, 15% sugar beet pulp and 2% salt). All the animals were on good health conditions. At the end of different growth periods, camels of each breed and sex groups, were slaughtered by Islamic slaughtering method (chest knifing of jugular vein) and kept in the cold storage room at 4 ˚C for 24 hour.

pH ultimate

Minced meat samples were homogenized with distilled water at a ratio of 1:5 for few minutes. The pH of the meat slurry was measured using a pH meter (Schott-Gerate, CG 804, German).

Cooking loss measurement

Meat samples trimmed of external fat, cut to 1 × 2 × 5 cm and initial weight was determined. Samples were cooked at 85 ˚C, to a core temperature of 75 ˚C. Cooked meat was drained, cooled, and dried with filter paper and reweighed (Pena *et al*. 2009).

Cooking loss %= ((initial weight (g)-final weight (g))/(Initial weight (g))) ×100

300WBC= -(11.43×S)

Color measurement:

The optical density (OD) of the concentration of meat pigments was determined using by spectrophotometer. The determination of pigments in meat was done according to Pearson and Gillett (1997). Muscle samples trimmed of external fat, the absorbance of the extract are measured at 555, 540-580, and 505 nm for myoglobin, oxymyoglobin and metmyoglobin, respectively.

Fatty acid analysis

Five grams of minced of samples was extracted (Folch *et al*. 1957). Fatty acid methyl esters (FAME) were prepared using 5 ml of chloroform-methanol extract. The methylation process was assigned based on AOAC (1995). Separation and quantification of the FAME were performed by gas chromatography (GC) using 6890N GC of Agilent Technologies equipped with a flame ionization detector (FID), and a fused silica capillary column DB-1701 (30 m long×0.32 mm inside diameter and 0.25 µm film thickness). 1.0 µL of the sample was injected into the GC at 250 ˚C, in Biochemistry Laboratory at Animal Science Research Institute. Individual fatty acids were identified by comparing their retention times with authenticated standards and quantified as a percentage of total fatty acids identified (Pena *et al*. 2009).

Sensory evaluation

Sensory evaluation was carried out on cooked meat of four parts of carcasses by twelve semi-trained panelists. Meat samples were placed in tightly sealed polyethylene bags and frozen at -18 ˚C for subsequent sensory evaluation. The frozen meat was thawed in a chiller at 5 ˚C for 24 h prior to preparation of the meat pieces. Meat samples were cut into uniform sized pieces (1×2×5 cm) and cooked using the same cooking method. The samples were boiled at 85 ˚C to reach a core temperature of 75 ˚C and served warm for testing. A 5-point hedonic scale was used to asses meat samples (Meilgaard *et al*. 2007). Sensory attributes such as color, tenderness, odor and flavor scores were assigned with 5 being "like extremely and dislike extremely" (AMSA, 1995).

Statistical analysis

A completely randomized design with factorial arrangement and 3 replications was applied in this experiment. The general linear model (GLM) within SAS (1995) was used to compare the differences in characteristics of one-humped and crossbred camel meat. Significant differences between means were assessed by using of the least-significant difference procedure (LSD). A Pearson correlation test was used to assess the significance of the correlation of the meat characteristics *vs*. fatty acid profile. The Kruskal-wallis non-parametric test was used for comparison of means of sensory evaluation.

RESULTS AND DISCUSSION

This paper studies functional properties and fatty acid profiles of i) crossbred and one-hump camel meat characteristics in different parts of carcass, ii) the sex factor that influences these characteristics and iii) the different fattening periods that influence these traits. The results we found are as follows.

Functional properties

The effect of genetic groups, sex and fattening periods on qualitative traits of camel meat are shown in Table 1.

Breed effects

The result showed that the average pH level of crossbred camel meat (5.79) was lower than one-humped (5.88) sample and it was significant in leg and shoulder parts of body (*P*<0.05) (Table 1). The result indicated that ultimate average pH values of the camel samples were within the normal range previously reported for camel meat (Kadim *et al*. 2015; Kadim *et al*. 2013; Kadim *et al*. 2009; Babikerand Yousif, 1990). The pH decline of meat is related to the glycogen content of the muscle at slaughter, where lower glycogen contents may result in decreased rates of glycolysis; hence, a slower accumulation of lactic acid and a slower rate of post- slaughter pH decline (Soltanizadeh *et al*. 2008; Kadim *et al*. 2008). Consequently changes in the pH during the postmortem period influence the characteristics of the meat such as tenderness, juiciness and color (Watanabe *et al*. 1996; Immonen and Puolanne, 2000; Soltanizadeh *et al*. 2008; Kadim *et al*. 2013).

The ultimate pH of camel meat was significantly different between the groups and in different parts of the body. It seems that the effects of the breed, the rate of the glycolysis and the amount of enzymes in glycolytic pathway in two genetic groups were also affected by crossbreeding, which agrees with Suliman *et al*. (2011) and Soltanizadeh *et al*. (2008). Suliman *et al*. (2011) reported that the effect of breeds of camels on the chemical composition and meat quality characteristics were significant between the breed groups and their muscles with respect to the composition and quality of meat. Soltanizadeh *et al*. (2008) compared fresh beef and camel meat proteolysis during cold storage, who reported that camels are gluconeogenesis animals due to its having humps and the amount of enzymes in its glycolytic pathway is, therefore, less than in cattle causing slower glycogen degradation and pH decline. It seems that the body physical changes and massive hump of crossbred camel can be affected on the ultimate pH and other functional properties of camel meat. Similarly Ebadi (2015) reported that F1 hybrid had very long massive hump of bactrian camel and showed that the crossbreeding affected carcass traits.

Cooking loss percentage of crossbred meat was lower than dromedary and this difference was significant in leg cuts (49.2±0.64% and 51.1±0.58% respectively) (P<0.05). The effect of genetic groups on percentage of WBC was significant in loin and neck parts of carcasses (P<0.05).

Table 1 The effect of breed, sex and fattening periods on characteristics of camel meat

Factors[1]			Ultimate pH	Cooking loss (%)	WBC (%)	Texture (kg)	
						Raw	Cooked
Leg	Breeds		*	*	NS	NS	NS
		Crossbred	5.68±0.04	49.2±0.64	47.6±6.40	12.7±3.0	15.5±3.0
		One-humped	5.83±0.04	51.1±0.58	61.1±5.35	17.3±2.5	11.8±2.6
	Sex		**	NS	NS	NS	NS
		Male	5.86±0.04	50.0±0.60	54.2±5.72	16.6±2.6	15.3±2.7
		Female	5.65±0.04	50.3±0.62	54.4±6.07	13.4±2.8	12.0±2.9
	Growth periods		***	***	NS	NS	NS
		6 month	5.90±0.04	48.3±0.62	54.3±2.95	15.0±1.36	13.6±1.41
		9 month	5.61±0.04	51.9±0.60	55.3±2.86	15.4±1.32	13.3±1.37
Shoulder	Breeds		*	NS	NS	NS	NS
		Crossbred	5.68±0.05	50.4±0.87	61.9±7.33	19.8±2.0	14.7±2.3
		One-humped	5.82±0.04	49.4±0.79	68.3±6.14	19.3±1.7	10.8±2.0
	Sex		**	NS	NS	NS	NS
		Male	5.86±0.04	49.1±0.82	65.7±6.56	20.1±1.8	12.7±2.1
		Female	5.64±0.04	50.7±0.84	64.5±6.95	19.0±1.9	12.8±2.2
	Growth periods		***	**	NS	NS	NS
		6 month	5.90±0.04	47.7±0.84	65.1±3.38	19.6±0.93	12.7±1.09
		9 month	5.62±0.04	52.1±0.82	64.0±3.28	19.7±0.91	11.9±1.05
Loin	Breeds		NS	NS	*	*	*
		Crossbred	5.82±0.05	48.2±0.80	50.0±4.32	19.8±1.9	18.0±2.6
		One-humped	5.86±0.05	46.0±0.73	63.1±3.61	14.2±1.6	9.9±2.2
	Sex		NS	NS	NS	NS	**
		Male	5.91±0.05	47.0±0.76	58.1±3.86	16.2±1.7	9.4±2.3
		Female	5.78±0.05	47.1±0.78	55.0±4.09	17.9±1.8	18.5±2.5
	Growth periods		***	**	NS	NS	NS
		6 month	6.02±0.05	45.2±0.78	56.5±1.99	17.0±0.87	14.0±1.19
		9 month	5.67±0.05	49.0±0.76	58.1±1.93	16.7±0.84	13.1±1.16
Neck	Breeds		NS	NS	*	NS	NS
		Crossbred	6.00±0.06	46.0±1.14	69.5±2.51	23.5±0.5	13.7±2.0
		One-humped	6.02±0.06	48.0±1.04	77.8±2.10	23.4±0.4	10.2±1.7
	Sex		*	NS	NS	NS	NS
		Male	6.12±0.06	46.4±1.07	72.3±2.25	23.8±0.4	14.3±1.8
		Female	5.90±0.06	47.6±1.11	75.0±2.38	23.1±0.4	9.6±1.9
	Growth periods		****	NS	NS	NS	NS
		6 month	6.29±0.06	46.5±1.11	73.7±1.16	23.4±0.23	11.9±0.94
		9 month	5.72±0.06	47.5±1.07	73.3±1.12	23.6±0.22	11.9±0.91

WBC: water binding capacity.
* (P<0.05); *** (P<0.001) and **** (P<0.0001).
NS: non significant.

The result showed that WBC (%) of crossbred was lower than one-humped (P<0.05) in loin (50.0±4.32% *vs*. 63.1±3.61%) and neck (69.5±2.51% *vs*. 77.8±2.10%) cuts of carcasses.

The result showed that the breed factor had not affected texture (raw and cooked) values (Table 1), nevertheless shear force value of raw and cooked meat samples was significant in loin cuts of bodies (P<0.05). The result indicated that shear force values (kg) of dromedary sample were lower than crossbred ones. The results showed that only loin cuts of crossbred carcasses had a significant increase in meat toughness and a reduction in the WBC, that it could be related to changes in muscle structure and composition by crossbreeding in the hump region.

The meat pigment concentrations (OD) of crossed and native camel meat were shown in Figure 1. The result indicated that the meat pigment concentrations (OD) of crossbred samples were higher than one-humped one, even though this difference was not significant with exception of neck part. Myoglobin (OD_{555}) and oxy-myoglobin (OD_{540}) concentrations of crossbred neck were more reddish than dromedary groups (0.19 and 0.22 *vs*. 0.15 and 0.17 respectively) (P<0.05).

Consequently, the results showed that breed had significantly affected the functional properties of camel meat. Meat quality of crossbred was different especially in loin, shoulder and neck parts of carcasses compared with dromedary camels.

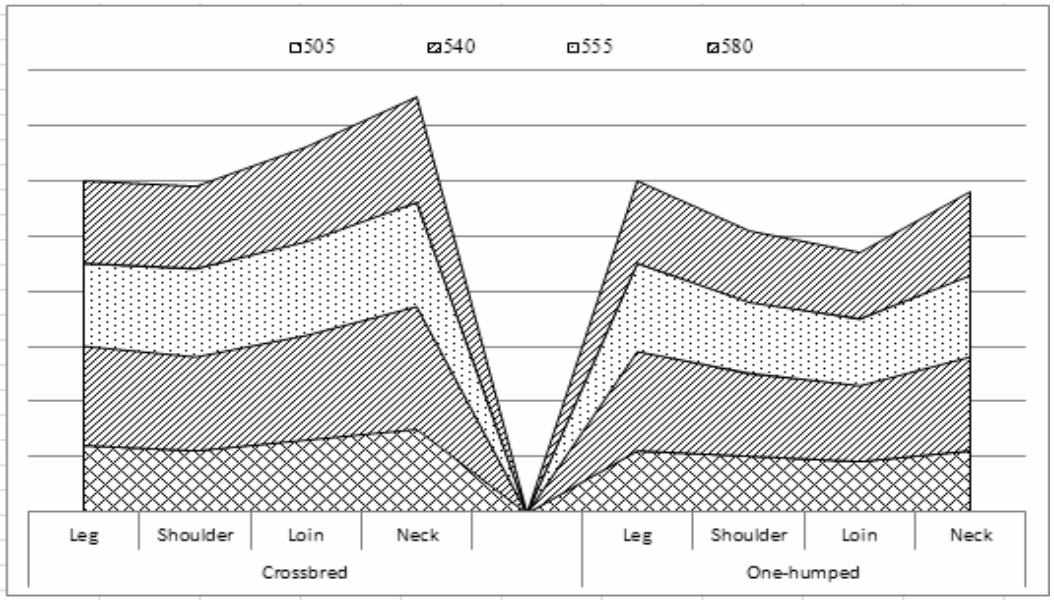

Figure 1 The optical density (OD) of meat pigments in different parts of one-humped and crossbred carcasses

The identification of camel muscles that can be marketed might increase the demand for camel products by improving the consistency of the products and allowing processing technologies to be targeted toward maximum effectiveness of camel carcass value (Kadim *et al*. 2013).

Sex effects

The effects of sex groups on quality characteristics of camel meat are shown in Table 1. The results indicated that, except pH, there was no difference for sex groups on quality characteristics of meat. Also Ebadi (2015), showed that the sex was not an important factor in chemical composition (dry matter, protein and ash) of camel meat. These results are in agreement with those reported for llamas (*Lama glama*) (Perez *et al*. 2000). Perez *et al*. (2000) indicated that the sex had no effects on carcass characteristics and the chemical composition of llamas (*Lama glama*) meat. The evaluation of this study showed that the average pH level of male camel meat was higher (5.94) than the female (5.74) and these differences were observed in four parts of the carcasses (P<0.05) (Table 1).

Percentage of cooking loss, WBC, texture values and color had no difference for sex groups; nevertheless shear force of male cooked loin was significantly (P≤0.05) different from female samples, so the meat texture of male loin cut was softer than that was observed in female one.

Growth effects

The results showed that there was no significantly difference on WBC, texture values (raw and cooked) and pigment concentrations of camel meat during fattening periods, while increasing fattening periods from 6 to 9 months had significantly (P<0.01) affected on pH ultimate and cooking loss percentage (Table 1). The pH level was decreased from 6 to 9 months in fattened camels (6.03 *vs*. 5.65) in four parts of body (P<0.001). The percentage of cooking loss was increased with fattening period in four parts of carcasses (P<0.01). Also similar result was observed in six parts of body (leg, shoulders, breast, loin, flank and neck) (Ebadi *et al*. 2010). The effects of pH degradation on protease activity and meat texture had been studied by Soltanizadeh *et al*. (2008), Kadim *et al*. (2008) and Kadim *et al*. (2009). Soltanizadeh *et al*. (2008) indicated that factors that may contribute to tenderization, include pH decline (glycolysis), temperature and their effect on muscle protease activity.

Increasing the cooking loss percentage of camel meat during the fattening period from 6 to 9 months, was probably due to variations in the ratio of moisture to protein and fat content and binding ability of meat (Kadim *et al*. 2008).

Kadim *et al*. (2008) reported that the dromedary camel meat contains higher expressed juice than other camelidae such as the llama and alpaca probably because of the lower fat content. Dawood (1995) reported that young camel meat (8 month of age) had significantly higher expressed juice than the meat from 26 month-old camels.

Totally these results indicated that not only the sex but also the age had no significant effect on functional properties of camel meat, except pH and cooking loss %, and it is in agreement with Perez *et al*. (2000).

Perez *et al*. (2000) reported that age and sex seemed to have no effects on the body and carcass characteristics studied nor on the chemical composition of llamas (*Lama glama*) meat.

Veiseth *et al*. (2004) reported that several studies have investigated the effect of animal age on meat tenderness, and produced contradicting conclusions, while some groups reported a decrease in meat tenderness with increasing animal age.

Fatty acid composition

Fatty acid (FA) composition of camel meat in different cuts of carcasses is shown in Tables 2-5.

Breed effects

The results indicated that crossbred samples had high percentages of C8:0 and C14:0 in neck and loin cuts of body respectively (Table 2) (P≤0.05). The percentages of C16:0 and C18:0 in shoulder and leg parts of crossbred carcasses were lower than dromedary samples (P≤0.05). Linolenic acid (C18:3) was higher in neck and shoulder parts of dromedary samples (P<0.05), while the amount of C20:4 was higher (P<0.05) in leg crossbred samples than dromedary ones (1.3±0.23 *vs*. 0.8±0.10).

Almost one-third of the total fatty acids in camel meat of genetic groups was the monounsaturated fatty acids and dominated by oleic followed by palmitoleic acid and it was similarly those of that have been studied previously (Rawdah *et al*. 1994; Kadim *et al*. 2008). It seems that the body physical changes of crossbred camel had affected on FA profiles. The results showed that the average percentage of PUFA between groups was from 5.7 to 8.7, in crossbred loin and dromedary leg meat respectively, and falls near those reported for the meat of beef (8.8%) (Sinclair *et al*. 1982). A recommended value is 0.45 for UFA/SFA (Wood and Enser, 1997), and the present study showed that the high level of UFA/SFA (0.80-0.81) was observed in leg parts of carcasses (Table 5). Sinclair *et al*. (1982) and Kadim *et al*. (2008) reported that the ratio of PUFA/SFA of camel meat is 0.36 as compared with 0.22, 0.26 and 0.36 in beef, mutton and goat meat, respectively. The ratio of n-6/n-3 in crossbred camel meat and dromedary ones was 18.14 and 16.42 respectively and was much higher than the ratio found in the meat of cattle, sheep and goat (2.0, 2.4 and 2.8, respectively) reported by Sinclair *et al*. (1982). The results showed that the percentage of the PUFA, the ratio of UFA/SFA, n-6/n-3 and HI in camel meat were noticeable in comparison with the other red meat animals. Total meat UFA and MUFA + PUFA/SFA ratio in crossbred and dromedary camel were 38.32, 0.70 and 37.92, 0.66; respectively. Meat health index (HI) of camel crossbred compared with one-hump was significant (0.62 *vs*. 0.60). Health index in leg and shoulder parts of cross carcasses was higher than dromedary samples (Table 5). The results showed that high level of UFA and UFA to SFA were found in crossbred meat samples. Consequently, the results indicated that FA profiles of camel meat had been affected by crossbreeding and it could improve the nutritional values of camel meat.

Sex effects

The results showed that the sex groups had most significant (P<0.05) variable of fatty acids profiles in loin cuts of body (Table 3). The female camels had the most of C12:0, C14:0, C16:0, C16:1, C18:2 and C20:4 among other fatty acids (P<0.05). The neck meat of female body had more C8:0 than male one, while the neck meat of male body had more C18:1 than female one (P<0.05). The sex factors had no affected on fatty acids profile of leg and shoulder parts, only amount of C10:0 in male ones was high in shoulder parts (P<0.05). The results showed that the maximum of UFA/SFA ratio and HI was obtained in male neck meat and minimum of UFA/SFA ratio and HI was obtained in female loin samples (Table 5). The results of this study showed that male camel meat had the more ratios of UFA/SFA and HI in compared with female one.

Growth effects

FA composition of camel meat in different cuts of carcasses during two fattening periods is shown in Table 4. The results of this experiment showed that low chain triglyceride (C8:0) decreased in different parts of body during fattening periods and it was significantly (P<0.001) different in loin cut, nevertheless medium chain triglyceride (C12:0) significantly (P<0.01) increased in loin cut. The composition of C16:0 in loin and leg parts of body was significantly difference (P<0.05), it was increased in loin cut from 6 to 9 months of fattening time, while decreased in leg cut of carcasses. The amount of C18:0 was decreased in shoulder parts of body in fattened camels. The results showed that the most variation was observed in loin cuts of body so C12:0, C16:0 and C18:2 increased, while C8:0 and C20:4 decreased significantly during fattening periods (P<0.05) (Table 4). During two fattening periods, C18:3 and C20:4 decreased and they were significantly different (P<0.05) in neck and loin cuts.

Comparison of fatty acid profile of camel meat showed that during fattening period, increased the level of UFA/SFA ratio and the highest ratio (0.81) was obtained in leg parts of carcasses (Table 5). At the beginning and at the end of fattening period, the average ratio of n-6/n-3 was 15.89 and 20.04, respectively. Meat health index (HI) of camel increased from 6 to 9 months fattening periods (0.59 *vs*. 0.62) (Table 5). Totally the results indicated that a nutrition value of camel meat was increased by fattening times. The evaluation of fatty acid profiles of camel meat showed that the factors of genetic groups, sex and fattening periods affected the UFA, UFA/SFA and HI ratios of meat (Table 5).

Table 2 Means and standard errors for fatty acid profile of crossbred and one-humped camel meat in different cuts of carcass

Fatty acid	Neck			Loin			Shoulder			Leg		
	Cross-bred	Drome-dary	Sig.	Cross-bred	Drome-dary	Sig.	Cross-bred	Drome-dary	Sig.	Cross-bred	Drome-dary	Sig.
C8:0	0.8±0.01	0.6±0.01	****	0.7±0.02	0.7±0.02	NS	0.8±0.10	0.9±0.10	NS	0.7±0.14	1.0±0.11	NS
C10:0	0.4±0.13	0.6±0.13	NS	0.3±0.12	0.4±0.10	NS	0.3±0.12	0.4±0.01	NS	0.3±0.03	0.4±0.05	NS
C12:0	0.4±0.01	0.5±0.01	NS	0.5±0.02	0.5±0.01	NS	0.4±0.02	0.5±0.02	NS	0.5±0.06	0.5±0.05	NS
C14:0	8.5±0.24	8.2±0.23	NS	8.6±0.19	8.1±0.17	*	8.3±0.25	8.2±0.21	NS	7.6±0.27	8.2±0.22	NS
C16:0	27.5±0.71	26.6±0.69	NS	31.8±0.69	31.5±0.63	NS	25.8±0.67	28.4±0.58	**	25.9±0.71	27.9±0.58	*
C16:1	3.8±0.19	4.2±0.18	NS	3.3±0.19	3.7±0.17	NS	4.0±0.16	4.4±0.14	NS	4.0±0.22	4.5±0.18	NS
C18:0	18.6±0.59	17.4±0.57	NS	23.1±0.63	22.9±0.58	NS	15.9±0.65	17.8±0.57	*	15.2±0.90	16.5±0.73	NS
C18:1	29.6±0.92	28.0±0.89	NS	24.7±0.71	22.9±0.65	NS	28.7±1.25	28.2±1.09	NS	27.7±1.05	27.8±0.85	NS
C18:2	5.7±0.22	5.9±0.22	NS	5.1±0.18	5.6±0.16	NS	5.8±0.27	6.2±0.23	NS	6.9±0.49	6.7±0.40	NS
C18:3	0.3±0.02	0.4±0.03	*	0.3±0.03	0.3±0.03	NS	0.3±0.02	0.4±0.02	*	0.4±0.03	0.4±0.02	NS
C20:0	0.2±0.01	0.2±0.01	NS	0.2±0.01	0.2±0.01	NS	0.2±0.01	0.2±0.02	NS	0.2±0.01	0.2±0.03	NS
C20:4	0.5±0.02	0.5±0.02	NS	0.4±0.07	0.3±0.04	NS	0.5±0.10	0.5±0.10	NS	1.3±0.23	0.8±0.10	*

* (P<0.05); *** (P<0.001) and **** (P<0.0001).
NS: non significant.

Table 3 Means and standard errors for fatty acid profile of male and female camel meat in different cuts of carcass

Fatty acid	Neck			Loin			Shoulder			Leg		
	Male	Female	Sig.	Male	Female	Sig.	Male	Female	Sig.	Male	Female	Sig.
C8:0	0.6±0.02	0.8±0.01	****	0.7±0.02	0.7±0.02	NS	0.8±0.10	0.8±0.10	NS	1.0±0.11	0.7±0.14	NS
C10:0	0.5±0.10	0.9±0.10	NS	0.3±0.12	0.4±0.10	NS	0.5±0.15	0.3±0.01	*	0.3±0.07	0.4±0.05	NS
C12:0	0.4±0.01	0.5±0.01	NS	0.4±0.01	0.5±0.01	*	0.4±0.02	0.4±0.02	NS	0.5±0.05	0.5±0.06	NS
C14:0	8.1±0.24	8.6±0.23	NS	7.9±0.18	8.8±0.18	**	8.3±0.22	8.2±0.24	NS	7.8±0.22	8.0±0.27	NS
C16:0	26.1±0.71	28.0±0.69	NS	30.6±0.65	32.7±0.67	*	27.1±0.60	27.1±0.65	NS	26.4±0.58	27.4±0.71	NS
C16:1	3.9±0.19	4.2±0.18	NS	3.1±0.18	4.0±0.18	**	4.1±0.15	4.4±0.16	NS	4.0±0.18	4.5±0.22	NS
C18:0	17.6±0.59	18.4±0.57	NS	23.0±0.60	23.0±0.61	NS	16.9±0.58	16.8±0.64	NS	15.8±0.73	15.9±0.90	NS
C18:1	30.4±0.92	27.2±0.89	*	23.1±0.67	24.5±0.69	NS	28.2±1.12	28.7±1.22	NS	27.6±0.85	27.8±1.05	NS
C18:2	6.0±0.22	5.7±0.22	NS	5.1±0.17	5.7±0.17	*	5.8±0.24	6.2±0.26	NS	6.8±0.40	6.7±0.50	NS
C18:3	0.4±0.03	0.3±0.02	NS	0.3±0.03	0.4±0.03	*	0.3±0.02	0.4±0.02	NS	0.3±0.02	0.4±0.03	NS
C20:0	0.2±0.01	0.2±0.01	NS	0.2±0.01	0.2±0.01	NS	0.2±0.01	0.2±0.02	NS	0.2±0.02	0.2±0.03	NS
C20:4	0.5±0.05	0.5±0.02	NS	0.3±0.03	0.4±0.07	*	0.5±0.10	0.4±0.10	NS	0.9±0.20	0.9±0.10	NS

* (P<0.05); *** (P<0.001) and **** (P<0.0001).
NS: non significant.

Table 4 Means and standard errors for fatty acid profile of camel meat in different cuts of carcass during two fattening periods

Fatty acid	Neck			Loin			Shoulder			Leg		
	6 month	9 month	Sig.	6 month	9 month	Sig.	6 month	9 month	Sig.	6 month	9 month	Sig.
C8:0	0.7±0.02	0.7±0.01	NS	0.8±0.02	0.7±0.02	***	0.9±0.10	0.7±0.10	NS	1.0±0.14	0.7±0.11	NS
C10:0	0.5±0.10	0.6±0.10	NS	0.4±0.12	0.3±0.04	NS	0.5±0.01	0.3±0.01	NS	0.4±0.04	0.3±0.05	NS
C12:0	0.4±0.01	0.4±0.01	NS	0.4±0.02	0.5±0.01	**	0.4±0.02	0.4±0.02	NS	0.5±0.06	0.4±0.05	NS
C14:0	8.3±0.25	8.3±0.23	NS	8.4±0.18	8.3±0.18	NS	8.4±0.22	8.1±0.24	NS	8.1±0.27	7.7±0.22	NS
C16:0	27.0±0.73	27.1±0.67	NS	30.5±0.67	32.9±0.65	*	27.9±0.61	26.3±0.63	NS	27.9±0.71	25.9±0.58	*
C16:1	4.0±0.19	4.1±0.17	NS	3.5±0.18	3.4±0.18	NS	4.2±0.15	4.3±0.16	NS	4.2±0.22	4.3±0.18	NS
C18:0	18.1±0.60	17.9±0.55	NS	22.4±0.61	23.6±0.60	NS	18.0±0.60	15.6±0.62	*	17.1±0.90	14.7±0.73	NS
C18:1	28.7±0.94	28.9±0.86	NS	24.3±0.69	23.3±0.67	NS	28.1±1.17	28.8±1.19	NS	27.81±1.05	27.6±0.86	NS
C18:2	5.3±0.23	6.4±0.21	**	5.1±0.17	5.6±0.17	*	5.5±0.25	6.5±0.25	*	6.0±0.49	7.4±0.40	*
C18:3	0.4±0.03	0.3±0.02	*	0.3±0.03	0.3±0.03	NS	0.3±0.02	0.3±0.02	NS	0.4±0.03	0.4±0.02	NS
C20:0	0.2±0.01	0.2±0.01	NS	0.2±0.01	0.2±0.01	NS	0.2±0.01	0.2±0.01	NS	0.2±0.02	0.2±0.03	NS
C20:4	0.5±0.04	0.5±0.07	NS	0.4±0.06	0.3±0.02	*	0.5±0.12	0.5±0.07	NS	0.9±0.18	0.9±0.16	NS

* (P<0.05); *** (P<0.001) and **** (P<0.0001).
NS: non significant.

These differences were noticeable in the neck, loin and shoulder cuts of body and the health aspect of camel meat was improved.

Trait correlation

The correlation of meat traits was shown in Table 6. The results showed that pH had significant positive correlation with WBC, the shear force value of fresh meat, OD_s (+0.31 to +0.43; P<0.05) and negative correlation with cooking loss percentage (-0.50); (P<0.0001). Also WBC had significant negative correlation with texture (cooked meat) (-0.29; (P<0.05). It may be related to the ratio of fat and protein and the changes of meat composition during heating. This is in agreement with the results of Aaslyng *et al*. (2003).

Pigment concentrations had high level of positive correlation with each other (+0.84 to +0.96; P<0.0001) and it also has a significant correlation with raw meat shear force values (+0.23 to +0.47; P<0.05).

Table 5 Comparison of fatty acid profile of camel meat in different cuts of carcass

Breeds	Neck		Loin		Shoulder		Leg	
	Crossbred	Drome-dary	Crossbred	Drome-dary	Crossbred	Drome-dary	Crossbred	Drome-dary
Fatty acid[1]								
SFA	56.4	54.1	65.2	64.4	51.7	56.4	50.4	54.7
UFA	39.9	39	33.8	32.8	39.3	39.7	40.3	40.2
Total fattty Acid	**96.3**	**93.1**	**99**	**97.2**	**91**	**96.1**	**90.7**	**94.9**
MUFA	33.4	32.2	28	26.6	32.7	32.6	31.7	32.3
PUFA	6.5	6.8	5.8	6.2	6.6	7.1	8.6	7.9
MUFA / SFA ratio	0.59	0.59	0.43	0.41	0.63	0.58	0.63	0.59
PUFA / SFA ratio	0.11	0.12	0.09	0.10	0.12	0.12	0.17	0.14
MUFA + PUFA (UFA) / SFA ratio	0.71	0.72	0.52	0.51	0.76	0.70	0.80	0.73
n-6 FA	5.7	5.9	5.1	5.6	5.8	6.2	6.9	6.7
n-3 FA	0.3	0.4	0.3	0.3	0.3	0.4	0.4	0.4
n-6 / n-3	19	14.75	17	18.67	19.33	15.5	17.25	16.75
Health index	0.64	0.64	0.50	0.50	0.65	0.63	0.69	0.64
Sex	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
SFA	53.5	57.4	63.1	66.3	54.2	53.8	52.0	53.1
UFA	41.2	37.9	31.9	31.4	38.9	40.1	39.6	40.3
Total fattty Acid	**94.7**	**95.3**	**95**	**97.7**	**93.1**	**93.9**	**91.6**	**93.4**
MUFA	34.3	31.4	26.2	24.9	32.3	33.1	31.6	32.3
PUFA	6.9	6.5	5.7	6.5	6.6	7.0	8.0	8.0
MUFA / SFA ratio	0.64	0.55	0.41	0.37	0.60	0.61	0.61	0.61
PUFA / SFA ratio	0.13	0.11	0.09	0.10	0.12	0.13	0.15	0.15
MUFA + PUFA / SFA ratio	0.77	0.66	0.50	0.47	0.71	0.74	0.76	0.76
n-6 FA	6.0	5.7	5.1	5.7	5.8	6.2	6.8	6.7
n-3 FA	0.4	0.3	0.3	0.4	0.3	0.4	0.3	0.4
n-6 / n-3	15	19	17	14.25	19.33	15.5	22.67	16.75
Health index	0.69	0.59	0.50	0.50	0.63	0.66	0.67	0.66
Fattening periods	**6 month**	**9 month**	**6 month**	**9 month**	**6 month**	**9 month**	**6 month**	**9 month**
SFA	55.2	55.2	63.1	66.5	56.3	51.6	55.2	49.9
UFA	38.9	40.2	33.6	32.9	38.6	40.4	39.31	40.6
Total fattty Acid	**94.1**	**95.4**	**96.7**	**99.4**	**94.9**	**92**	**94.51**	**90.5**
MUFA	32.7	33	27.8	26.7	32.3	33.1	32.01	31.9
PUFA	6.2	7.2	5.8	6.2	6.3	7.3	7.3	8.7
MUFA / SFA ratio	0.59	0.60	0.44	0.40	0.57	0.64	0.58	0.64
PUFA / SFA ratio	0.11	0.13	0.09	0.09	0.11	0.14	0.13	0.17
MUFA + PUFA / SFA ratio	0.70	0.73	0.53	0.49	0.69	0.78	0.71	0.81
n-6 FA	5.3	6.4	5.1	5.6	5.5	6.5	6.0	7.4
n-3 FA	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4
n-6 / n-3	13.25	21.33	17	18.67	18.33	21.67	15	18.5
Health index[2]	0.63	0.65	0.51	0.49	0.61	0.67	0.63	0.69

[1] SFA: total saturated fatty acid; MUFA: total mono unsaturated fatty acid; n-6 FA: C18:2; UFA (MUFA+PUFA): total unsaturated fatty acid; PUFA: total poly unsaturated fatty acid and n-3 FA: C18:3.
[2] Health index (HI)= (C16:1+C18:1+C18:2+C18:3) / (C12:0+(4×C14:0)+C16:0) (Khas-Erdene *et al*. 2010).

It is noticeable that the amount and concentration of meat pigments of crossbred samples were higher than dromedaries especially in neck cut.

Ebadi (2015) reported that the body physical changes of crossbred camel could be affected on the meat quality such as ODs of neck meat. Many factors influence the development of muscle color, such as myoglobin concentration, ultimate pH, muscle fiber type, intramuscular fat, postmortem protein degradation, electrical stimulation, and cooling rate (Kadim *et al*. 2009; MacDougall and Rhodes, 1972; Faustman and Cassens, 1990; Liu *et al*. 2012; Offer, 1991).

The results showed that in some of fatty acids had a significant correlation with the characteristics of meat (Table 6). Capric acid was correlated with WBC (+0.87; (P<0.001). The pH ultimate and cooking loss percentage had significant correlation (P<0.01) with linoleic acids (-0.28 and 0.29, respectively).

Significant correlation between oleic acid and meat characteristics (color and texture) was observed (+0.29 to +0.54; P<0.01).

Table 6 Correlation between characteristics of camel meat

Traits	WBC	Co. Loss	OD_{505}	OD_{540}	OD_{555}	OD_{580}	R. meat	C. meat	C8:0	C10:0	C12:0	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0	C20:4
PH	**	****	*	*	*	*	**	-	-	-	-	-	-	-	-	-	**	-	-	-
WBC		-	-	-	-	-	-	*	-	***	-	-	-	-	-	-	-	-	-	-
Co. Loss			-	-	-	-	-	-	-	-	-	-	-	**	***	-	**	-	-	-
OD_{505}				****	****	****	**	-	-	-	-	-	-	-	-	**	-	-	-	-
OD_{540}					****	****	**	-	-	-	-	-	-	-	-	***	-	-	-	-
OD_{555}						****	***	-	-	-	-	*	-	-	-	***	-	-	-	-
OD_{580}							**	-	-	-	-	**	-	-	-	****	-	-	-	-
R. meat								-	-	-	-	-	-	-	-	**	-	-	-	-
C. meat									-	-	-	-	-	-	-	*	-	-	-	-
C8:0										-	-	-	-	-	-	-	-	-	-	-
C10:0											-	-	-	-	-	-	-	-	-	-
C12:0												**	***	-	**	**	-	-	***	-
C14:0													****	*	**	-	**	-	*	**
C16:0														-	****	***	**	-	****	-
C16:1															****	****	****	***	***	-
C18:0																****	****	-	****	****
C18:1																	****	-	***	-
C18:2																		****	**	****
C18:3																			-	-
C20:0																				-

* (P<0.05); *** (P<0.001) and **** (P<0.0001).
NS: non significant.

Sensory evaluation

The results of sensory evaluation showed that no significant difference was observed between groups in commercial cuts of the body such as leg, shoulder, loin and neck.

CONCLUSION

The results revealed significant differences for functional properties and fatty acid profiles of camel meat by crossbreeding. Due to the body physical changes in crossbred (*C. dromedarius*×*C. bactrianus*) camel, especially in loin, shoulder and neck parts of carcass; meat quality was different in comparison with dromedaries. The MUFA + PUFA/SFA ratio and HI of crossbred camel meat had noticeable levels and increased during fattening periods. Improvement is possible for the meat quality by crossbreeding. Many authors have previously reported on the proximate value of dromedary meat, but the scarce study about crossbred camel meat is published. Therefore, further investigations are required to more study on crossbreeding and the crossbred camel meat quality.

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