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FATTY ACIDS PROFILE OF THE DROMEDARY HUMP FAT IN ALGERIA

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ABSTRACT

The fatty acid composition of hump fat stemming from 43 Algerian camels (*Camelus dromedarius*), 1 to 13 years old, both sexes, belonging to Sahraoui and Tergui breeds, was determined. Saturated fatty acids (SFA) represented 64.4% (weight basis) of total fatty acids, while the monounsaturated (MFA) and polyunsaturated (PUFA) fractions accounted for 33.1 and 2.5%, respectively. The main saturated fatty acids, namely palmitic and stearic acids represented 49.6% and 38.8 % of SFA (31.5% and 25.5% of total fatty acids). Unsaturated fatty acids (UFA) were mainly represented by oleic acid, 78.1% of MFA (25.9% of total fatty acids), linoleic acid which accounted for 88.5% of omega 6 (1.17% of total fatty acids) and linolenic acid accounting for 63.9% of ω_3 (0.42% out of total fatty acids). SFA/PUFA was 0.039 and ω_6/ω_3, 2.81. The levels of fatty acids, SFA and MFA were significantly higher in females, while the contents in ω_6, ω_3, CLA, PUFA, as well as the PUFA / SFA and ω_6/ω_3 ratio were comparable in relation to both sexes. When reported to the breeds, the contents in MFA, PUFA and ω_6 was higher in Sahraoui, as the ω_6/ω_3 ratio was. The percentage of SFA, however, was higher in Tergui.

Key words: Breed, camel, fatty acid, hump

Camels store energy as fat deposits accumulated in various parts of the body, mainly hump and abdomen (Kadim *et al,* 2002). The hump contains most of the subcutaneous fat, while the internal fat is mainly located around the kidneys (15 % of the fat storage) and inside the mesentery (5%) (Kamili *et al,* 2006). As a whole, a dromedary weighing 750 kg contains more than 150 kg of body lipids. Changes in body fat are very little known in the dromedary. On an average, the weight of lipids in the hump is estimated between 10 and 20 kg, but with a large variability associated to the physical activity and the nutritional and physiological status, age and sex of the animal (Wilson, 1984). For example, the size of the hump increases during the rainy season, when the animal restores its fat deposits (Chilliard, 1989).

The lipid metabolism underlying fat store in dromedary has been reported (Mirgani, 1977). Its indicators are similar to other species, i.e. cholesterol, triglycerides, free fatty acids at serum levels, and fatty acids at the hump (Chilliard, 1989; Kadim *et al,* 2002).

In Algeria, dromedary is generally kept on natural pasture. Their diet includes foliage and desert vegetation like *Acacia* sp. and *Artiplex* sp. The aim of this study was to assess the fatty acid profile of hump fat from dromedary raised on natural pastures in Algeria.

Materials and Methods

Animals and sampling:

This study was performed on 43 camels slaughtered at the Ouargla abattoir (800 km South-Eastern from Algiers-Algeria). These induded 7 females and 36 males aged 1 to 13 years old, belonging to 2 breeds, i.e. Sahraoui and Tergui.

Samples of 50 g fat were obtained from the centre of each hump immediately after slaughter and were taken in on to the ice to the laboratory and stored at -20°C in sealed plastic bags until analysis.

The fatty acids were analysed based on gas chromatography with electronic pressure control Hewlett Packard type (HP 6890 series), equipped with a capillary column HP-5 (30 m x 0.25 mm) displaying a film thickness of 0.25 µm, an FID detector set at 260°C and fed with a H_2 / Air mixture and a split/ splitless injector set at 275°C. Injection by split method

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split ratio: 1/50. The nitrogen gas was used with a flow rate of 1.7 ml min^{-1}. The column temperature was set to 50 to 25°C at 4°C min^{-1}. The unit was controlled by a computer system "HP ChemStation" type, managing the operation of the device and enabling monitoring of the progress of the chromatographic analysis.

Statistical analysis:

The analysis was performed on Statistica 10.0, (Statsoft Inc., Tulsa, USA) and IBM SPSS 20 (IBM Corp).

Fatty acids [saturated fatty acid (SFA), monounsaturated fatty acid (MFA), polyunsaturated (PUFA)] were expressed as g/100 g of hump fat and mg/100g fatty acid. The normality of the values distribution and the homogeneity of variances were evaluated by the Kolmogorov-Smirnov and Levene tests, respectively. The fatty acid content and percentage were then compared according to gender and breed, based on Students 't' test. The Mann-Whitney test was used whenever significant deviations observed was from the normality and homogeneity of variances.

Results

Proportions of fatty acids:

Weight proportions of individual fatty acids in the hump of the 43 camels and their proportion in fat hump are shown in table 1.

SFA represented for more than 60g/100g hump palmitic acid was the most important (31.5 g/100g), followed by stearic acid (25.5 g/100 g). The 2 FA represented more than half of the fat hump (57%) and C14:0 represented a low value of 5% of total FA.

As MFA concerns, oleic acid predominated (25.9 g/100 g). The C16:1(9) was found far behind with 2.33 g/100 g. Two intermediate chain of fatty acid- C18:1 trans 11 and C18:1 cis 11 showed closed levels and accounted for about 2.63 and 1.74%, respectively.

The PUFA, linoleic acid was predominant with 1.17 g/100 g (88.5% of the total ω_6), linolenic acid with 0.42 g/100 g (63.9% of the total ω_3). The cis - 9, trans – 11 CLA averaged 0.50 mg/100 g. In much smaller quantities followed C22: 5n-3 (0.19 g/100 g) and C20: 4n-6 (0.056 g/100 g).

Finally cis-9, trans-11 CLA (0.50%) was found in small quantities. Other fatty acids were found in very small quantities. However, PUFA/SFA was 0.039±0.003 and ω_6/ω_3 was 2.81±0.33.

The effect of gender on fatty acids profile showed that females hump fat was richer in total FA than males (77.5 *vs* 61.4 g/100g) and contained more SFA and MFA (49, 8 and 25,9 vs 39.7 and 20.3 g/100g, respectively) (Table 2). The PUFA levels, as for them, were similar (1.8 and 1.5 g/100g), as was the case for ω_6, ω_3 and CLA levels (988, 366, 418 mg/100g and 797, 402, 302 mg/100g, respectively).

Effect of breed:

The content in fatty acids in the hump fat for the 2 breeds is presented in table 3. When considering the proportions of FA in hump fat, results indicate that the Tergui breed had higher SFA proportions than the Sahraoui breed, in contrast to MFA and PUFA effects (significantly for the first and a trend for the second ones). The gain in PUFA in the Sahraoui breed was mainly explained by differences in ω_6 levels, inter-breed ω_3 levels being not different. As a consequence, the ratios of PUFA/SFA and ω_6/ω_3 were significantly different between breeds, in favour of the Sahraoui animals. Similar effects were observed for CLA.

When considering the interaction breed to gender, results showed few significant differences concerned ω_6 levels, in males. In males Tergui presented a fat richer in SFA (66.53±0.78 *vs* 62.42±1.08) but poorer in MFA (31.31±0.77 *vs* 34.71±0.96). Fat from Tergui males had a largely lower levels in ω_6 than Sahraoui males (1.05±0.08 *vs* 1.60±0.12). Sahraoui

Table 1. Fatty acids composition (g/100 g) of hump fat in Algerian dromedaries.

SFA		MFA		PUFA			
				ω_6		ω_3	
C14:0	4.90±0.21	C16:1cis9	2.33±0.18	C18:2n-6	1.17±0.07	C18:3n-3	0.42±0.05
C15:0	0.83±0.04	C17:1cis10	0.48±0.02	C20:2n-6	0.032±0.004	C20:5n-3	0.035±0.003
C16:0	31.5±0.7	C18:1trans11	2.63±0.26	C20:3n-6	0.025±0.005	C22:5n-3	0.19±0.02
C17:0	1.34±0.05	C18:1cis9	25.9±0.5	C20:4n-6	0.056±0.003	C22:6n-3	0.015±0.001
C18:0	25.5±1.0	C18:1cis11	1.74±0.06	C22:4n-6	0.043±0.003	Total ω_3	0.66±0.06
C20:0	0.28±0.02	C20:1cis11	0.009±0.001	Total ω_6	1.33±0.08		
Total SFA	64.4±0.7	Total MFA	33.1±0.6				

males had a higher percentage of ω_3 and PUFA than Tergui.

Discussion

According to Faye *et al* (2012) the dromedary hump stores on average 44% of the fatty reserves of the animal. It is the most representative organ in terms of importance of fatty reserves, before the perirenal and perivisceral regions. The fatty tissue is also deposited in different parts of the carcass like shoulder, sternum, flank, ribs, thigh and neck, subcutaneous and inter- or intramuscular tissues. In fatty animals, the tissue accumulates equally in the ano-genital area (Ollier *et al*, 1995; Faye *et al,* 2002).

The dromedary hump represents almost 13% of the carcass weight (Yousif and Babiker, 1989) and its tissue could contain 84% fat (Abu Tarboush and Dawoud, 1993). In this species, half of the sirloin cut may be fat since hump is currently part of this cut (Yousif and Babiker, 1989). Its importance on a human dietary point of view could not be neglected.

Results showed that the fat found in the dromedary hump is characterised by a high content, at about two third, in saturated fatty acids. The monounsaturated acids, practically representing one third and the PUFA a level as low as 2%. More than half of the PUFA were from ω_6 family, a bit more than a quarter was represented by the ω_3 family, and the 5th was represented by cis-9, trans-11 CLA.

With regard to SFA in the hump prevailed palmitic (31.5%), oleic (25.9%), stearic (25.5%) and in a lower amount, myristic acids (4.9%). The same observation, in similar orders of importance, was reported by Mirgani (1977) and Kadim *et al* (2002). Mirgani (1977) observed a slightly higher proportion in miristic acid (12%). Rawdah *et al* (1994) reported that the main fatty acids present in the fat stored in the dromedary hump were palmitic acid (34.4%), followed by oleic (28.2%), myristic (10.3%) and stearic acids (10.0%).

Comparing the saturated fatty acids present in the dromedary hump with those acids present in the milk shows very similar values. The findings of Gorban and Izzeldin (2001) showed that the camel milk is also rich in saturated fatty acids (66.1%) and monounsaturated fatty acids (30.5%). Accordingly, the dominating saturated fatty acids are palmitic acid (34. 9%), myristic acid (14.5%) and stearic acid (9.7%).

It is remarkable to note that these 4 FA generally stem from a lipogenetic metabolism (Maier *et al,* 2006) or, in ruminants, from saturation of dietary

Table 2. Effect of gender on fatty acids level in hump and on fatty acid composition of hump fat, in Algerian dromedaries.

	Total FA	SFA g/100g hump	MFA	PUFA	ω_6 mg/100g hump	ω_3	CLA	SFA	MFA	PUFA g/100 hump fat	ω_6	ω_3	CLA	PUFA/ SFA	ω_6/ω_3
Male (36)	61.43±2.20	39.67±1.57	20.25±0.79	1.50±0.08	797.1±52.7	401.08±33.3	302.4±22.2	64.47±0.74	33.01±0.67	2.52±0.15	1.33±0.09	0,69±0.07	0.50±0.03	0.040±0.003	2.58±0.35
Female (7)	77.52±3.81	49.82±2.59	25.93±1.82	1.77±0.30	988.2±164.2	365.9±120.1	417.9±61.6	64.30±1.47	33.34±1.20	2.36±0.47	1.31±0.26	0.51±0.18	0.54±0.07	0.038±0.008	4.00±0.86
p	0.004	0.006	0.020	0.411	0.304	0.782	0.117	0.918	0.815	0.758	0.953	0.373	0.617	0.803	0.162

Table 3. Effect of breed on fatty acids level in hump and on fatty acid composition of hump fat, in Algerian dromedaries.

	Total FA	SFA g/100g hump	MFA	PUFA	ω_6 mg/100g hump	ω_3	CLA	SFA	MFA	PUFA g/100 hump fat	ω_6	ω_3	CLA	PUFA/ SFA	ω_6/ω_3
Sahraoui (23)	65.47±3.11	41.24±2.22	22.48±1.11	1.75±0.14	1004.4±76.2	407.7±58.7	341.4±34.7	62.80±0.95	34.40±0.82	2.80±0.24	1.57±0.12	0.70±0.11	0.53±0.05	0.046±0.004	3.59±0.50
Tergui (20)	62.41±2.91	41.43±1.99	19.68±1.04	1.31±0.06	625.6±31.0	382.5±26.3	298.0±24.5	66.34±0.73	31.52±0.72	2.14±0.09	1.04±0.07	0.63±0.04	0.47±0.02	0.032±0.001	1.90±0.30
p	0.48	0.95	0.07	0.018	0.0001	0.49	0.31	0.010	0.010	0.07	0.0002	0.86	0.23	0.06	0.0001

fatty acids in the pre-stomachs (Kouba and Mourot, 2011). Owing to the fact that the diet from dromedary maintained on pasture is, as a rule, very poor in fat, it can be concluded that the very large proportion of the fat found in the hump derived from the lipogenesis in the animal.

In man, the saturated fatty acids consumed in excess increase plasma cholesterol, LDL and HDL levels (Mensink *et al,* 2003). However, not all saturated fatty acids bear the same cardio-vascular risk: the medium chain fatty acids such as myristic or palmitic acid have more deleterious effects than the long chain fatty acids such as stearic acid (Dubois *et al,* 2012). In our results, medium and long-chain FA accounted for similar amounts, and the mono-unsaturated fatty acids practically represented one-third of the total fatty acids (33.1%), with emphasis on oleic acid, representing the very large part of the monounsaturated acids and also the 2nd most frequently encountered FA after palmitic acid, i.e., more than a quarter of the total FA. Similar values have been reported by Mirgani (1977), Emmanuel and Nahapetian (1980) and Kadim (2002). In lower quantities, but consistent when put in relation to the monounsaturated acids, trans-vaccenic, palmitoleic and vaccenic acids totalised close to 7% of total FA. Monounsaturated fatty acids are considered as beneficial for health owing to the fact it decreases the total cholesterol and LDL and, in the same time, increases the HDL blood levels (Hu *et al,* 1997).

Short chain PUFA levels were quite low in the present study. Besides similar features as ours for SFA and MFA, Emmanuel and Nahapetian (1980), as well as Kadim (2002) also reported low levels of C18:2 ω_6 and C18:3 ω_3 in hump fat. Polyunsaturated fat are protective against cardiac arrhythmias. A study of post-menopauseal women with a relatively low fat intake showed that polyunsaturated fat exert a protection against the progression of coronary atherosclerosis, in contrast to monounsaturated fat (Mozaffarian *et al,* 2004). However, it is known that polyunsaturated fats are sensitive to lipid peroxidation. Vitamin E has been shown to be protective against this phenomenon (Leibovitz *et al,* 1990), as well as selenium (Se), whose levels in meat from dromedary are rather high (Sahraoui *et al,* 2013). The unsaturated/saturated fatty acids ratio was 0.039 and that of ω_6/ω_3 was 2.81. These ratios could be judged small because the current recommendations for a healthy diet are in favour of ratios close to 1 and 5, respectively (Renaud and de Lorgeril, 1989; ANC, 2011).

In relation to gender, our results revealed sex differences in the concentrations of SFA and MFA. The contents were significantly higher in the females, despite that the SFA/FA and MFA/FA ratios remained comparable. This could be explained by the fact that the FA levels were higher in females probably, owing to management associated to gender or age of the animals. Indeed, slaughtering of females is generally forbidden in dromedary breeders, but when females should be culled for advanced age (Ministry of Agriculture and Rural Development, 2012). Moreover, there are indications that basal fat oxidation is lower in females as compared to males, thereby contributing to a higher fat storage in females, may be as a result of lower basal metabolism (Blaak, 2001).

Asadi *et al* (2009) reported that females store more triglyceride values, as opposed to males. They showed the impact of gender on the increased blood concentration of free fatty acids. In addition, the liver triglycerides in female camels were higher than in male camels.

Females had a higher percentage of MFA and PUFA than males, similar to results for heifers and steers of Marchello *et al* (1967) and Waldman *et al* (1968). Opposite results have been reported by Malau-Aduli *et al* (1998) with heifers and steers. Sex differences in fatty acid composition in the literature have been inconsistent.

In foals, Sarriès *et al* (2006) noted differences in the fatty acid profile of subcutaneous adipose tissue between the 2 sexes. This could be a consequence of greater lipogenic enzyme activity in females compared to males, as has been observed previously in beef (Eguinoa *et al,* 2003).

Breed effects were observed only on the main totals, but not on individual FA, with higher levels of unsaturated FA, especially PUFA, and within this category, ω_6 family. Sahraoui breed has been reported as fairly slim, with a bump height of the male averaging 2 m (Ezzahiri, 1988). Benyoucef and Bouzegag (2006) also reported that this breed is large and robust, with a good dairy and fattening capacity.

Conclusion

This study showed that hump of 2 breeds of dromedary (Sahraoui and Tergui) raised on natural pasture in Algeria is especially rich in saturated fatty acids, followed by monounsaturated ones, with modest levels of polyunsaturated ones. The gender appears to affect this composition, but not that of the

fat hump. The fat of Sahraoui breed appears to be richer in unsaturated faty acids. Hump fat may be considered as a significant source of unsaturated fatty acids for nomadic populations.

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