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REGULAR ARTICLE

Fatty acid profile comparison and hygienic quality of cow and camel (*Camelus dromedarius*) milk in Algeria

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ABSTRACT

The objective of this work was to investigate the fatty acid composition and assess hygienic quality of the Algerian camel milk from Targui breed, then to compare obtained results with cow milk in local rearing conditions. Sampling was performed over three months at a rate of one sample per month. The physicochemical analyzes carried out revealed that the Targui camel milk had averages values of 6.33 ± 0.15 for the pH, acidity equal to 18.50 ± 0.02 °D, and 1030.40 ± 1.08 for density. The total dry extract and the fat levels were lower than those of cow milk. In addition, results of fatty acid profile analysis from camel milk revealed a relatively low level of saturated fatty acids (SFAs) compared to cow milk, palmitic acid (C16:0) being the predominant fatty acid in both milks. The content of unsaturated fatty acids (UFAs) was significantly higher in camel milk fat compared with cow milk, with higher total monounsaturated fatty acids (MUFAs) rate in camel milk. Oleic acid (C18:1 n9) was in the same proportions, and the most abundant unsaturated fatty acid in both species. However, no significantly difference was observed between PUFAs levels of camel and cow milk. Linoleic acid (C18:2 n6) was the most represented polyunsaturated fatty acid in both milks with similar proportions. In contrast, the content of α-linolenic acid (C18:3 n3) was significantly ($p < 0.001$) higher in cow milk than in camel one.

Keywords: *Camelus dromedaries*; Cow; Fatty acid profile; Hygienic quality; Milk

INTRODUCTION

Cow milk account for more than 80 % of the world dairy production (Faye and Konuspayeva, 2012). It's the widest used raw material in the processing industry.

Its composition has largely been studied worldwide and thousand references have been available for more than 70 years.

Studies concerning the milk composition of other animal species such as dromedaries are scarcer despite their evident economic and dietary interest (Karray et al., 2005; Konuspayeva et al., 2009; Merin et al., 2001; Sawaya et al., 1984).

Camel milk possesses interesting medicinal and dietetic properties which had been widely studied (Magjeed, 2005; Mal et al., 2006; Kaskous, 2016; Hamad et al., 2011; Konuspayeva and Faye, 2011; Habib et al., 2013) and exploited (Mal et al., 2006) over the last 20 years. For example, a high unsaturated fatty acids content contributes to its overall dietetic grade (Kaskous, 2016; Konuspayeva et al., 2008; Karray et al., 2005). Moreover, it holds a high concentration of vitamin C (Haddadin et al., 2008; Barlowska et al., 2011; Konuspayeva et al., 2011). camelcow).

In Algeria, most of the studies carried out on the camel milk were focused on its weak clotting capacity (Boudjenah-Haroun et al., 2012;) or about the technological properties of lactic acid bacteria isolated from camel milk (Belkheir et al., 2016; Bendimerad et al., 2012; Drici et al., 2010).

In this context, the composition of the Algerian camel milk should be more deeply studied in order to achieve a better characterization by breed or area.

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Therefore, the objective of this work was to investigate the fatty acid composition and assess hygienic quality of the Algerian camel milk from Targui breed, then to compare the results with cow milk sampled in Algerian dairy farms.

MATERIALS AND METHODS

Collection of milk

The studied camel milk (CM) was a mixture of milk from several females belonging to a dromedary herd (*Camelus dromadarius*) in extensive farming system. Camels grazed in arid natural pasture of Biskra (South-East of Algeria) along Oued Souf where the vegetation was composed of dry grasses such as *Artemisia sp*. and *Cladium sp.* All these animals (diagnosed healthy by veterinary control**)** were Targui breed at first lactation. According to Ben Aïssa (1989), the Targui breed was originated from Touaregs of the North and mainly present in the Hoggar and Central Sahara.

The cow milk (CwM) studied was a mixture of milk from the Montbeliard cow morning milking and reserved for cheese processing in Algiers region.

Sampling procedure

The hygienic quality and the chemical composition of these two milks were studied for three months (from April and June 2016) at a rate of one sample per month. The milk samples were collected in sterile, sealed and labeled flasks. They were stored at 4°C as far as the laboratory where a set of physico-chemical and microbial analysis were performed.

Physico-chemical analysis

The milk acidity and density were respectively measured according to the AFNOR standards (NF V04-206, 1969 and NF V04-204, 2004). The total dry extract (TDE) was determined by using an infrared dessiccator. Fat Matter (FM) was determined by the Gerber's method (NF V04-210, 2000).

Antibiotic residue detection, was based on a fast screening with the Betastar® Combo test (Neogen Corporation, Lansing, MI, USA).

Analysis of FAME by GC/MS

Fatty acid methyl esters (FAMEs) were prepared according to the ISO Standards (ISO 12966-2: 2011), after fat extraction (ISO 1211: 2010, IDF 1:2010). They were analyzed by an Agilent GC 6890A gas chromatograph coupled to a MSD 5973 mass-selective detector (Agilent Co. Ltd, USA), using a polyethylene glycol (PEG) fused silica capillary column (HP-Wax, 60 m x 0.25 mm, 0.25 µm film thickness, Agilent Co. Ltd, USA). The injection volume was 1 µL in 1:20 split mode. The injector temperature was maintained at 250°C. The carried gas was helium at flow rate 0.5 mL/min. The initial oven temperature was held at 40°C for 4 min, increased to 140°C at a rate of 10°C/min (held for 1 min), and then increased by 2°C/min to a final temperature of 240°C (held for 2 min). The whole duration of the analysis was 67 min long.

Identification of common FA was performed by comparing their mass spectral data to those performed with NIST '02 [US National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA] mass spectral database.

Microbiological analysis

Microbiological analysis of camel and cow milks was achieved. Total aerobic mesophilic germs (TAMG) were counted on PCA agar, after 72 h of an incubation period at 30°C.

The investigation of total and fecal coliform was carried out on Deoxycholate medium containing bile salts, bright green and bile as selective agents for 24 to 48 h at 37°C.

Staphylococcus aureus detection and enumeration was based on the use of Baird-Parker medium upon egg-yolk after 48 hr at 37°C.

The isolation of sulphite-reducing Clostridia was evaluated upon medium meat-liver agar, supplemented with sodium sulphite and iron alum after 72 h at 37°C under anaerobic conditions.

Statistical analysis

Data were statistically processed by ANOVA one-criterion by analysis of variance using Statistica® version 6.1 (Statsoft, France), in order to study the physicochemical quality and fatty acid profile differences between camel and bovine milk.

When ANOVA's results were significant, Duncan's test was used to compare the mean percentage. For this purpose, only one significant number at 5 % was taken into account.

RESULTS AND DISCUSSION

Microbial analysis

The enumerations of total aerobic mesophilic bacteria (TAMB) in the milk (Table 1) were $2.5*10^2$ CFU/mL in camel milk and $3.0*10^2$ CFU/mL in the cow milk. Both values testified to the good quality of our samples. Calvo and Olano (1992) reported that when the milk is collected under suitable hygienic conditions, the total flora did't exceed 10^3 to 10^4 CFU/mL.

Table 1: Enumeration of microbial groups of hygienic and health significance in milk

Microorganisms (CFU/mL)	TAMB	Total coliforms	Fecal coliforms	Sulphite-reducing clostridia	*Staphylococcus aureus*
Camel milk	$2.5*10^2$	$2.8*10^2$	$2*10^2$	0	0
Cow milk	$3.0*10^2$	$2.9*10^2$	$2*10^2$	0	0

The presence of coliforms, indicative of fecal contaminations, allows to consider the hygienic state of product, even at low levels. These bacteria would show the degraded hygienic conditions during the manual milking or during the milk carriage (Badis et al., 2005). Our results were $2.8*10^2$ CFU/mL coliform and $2*10^2$ CFU/mL fecal coliforms in the camel milk and $2.9*10^2$ CFU/mL coliform and $2*10^2$ CFU/mL fecal coliforms in the cow milk which was relatively low.

Moreover, the absence of sulphite-reducing clostridia and *Staphylococcus aureus* in both camel and cow milk reflected a satisfactory microbiological quality of these milk samples.

Antibiotic residues

The bad use of antibiotics by the veterinary practitioners and farmers and the non-respect of the withdrawal period after the animals' treatment lead to the attendance of milk antibiotic residues (Aning, 2007) which prevents the milk clotting and limits the range of the products offered by the dairies.

The antibiotic test shows an entire absence of antibiotic residues in our camel and cow milk samples, which means that the milk was healthy and suitable for the human consumption and processing.

Comparison of camel and cow milks in relation to fat composition

Unlike cow milk which is yellowish, camel milk is generally white opaque. It has a sweet and sharp taste but can sometimes be salty (Farah, 2011). The taste generally depends on the type of fodder and drinking water availability (Farah, 2011; Farah, 1993). According to Sheraz et al. (2013), the yellowish color of cow milk is related to carotene (liposoluble component) missing in the other species. Besides, the apparent viscosity is a function of fat content. Dromedary milk cream presents a higher obvious viscosity than that of bovine milk cream. This difference markedly increased as fat content raised (Attia et al., 2000). camelcow Except density, all parameters were significantly different between camel and cow milk (table 2).

Fat content of camel milk appeared significantly lower than cow milk while acidity was higher (table 1).

CamelcowThe result regarding acidity is confirmed by several authors who studied camel milk: 6.41 (Sboui et al., 2009); 6.31 ± 0.15 (Siboukeur, 2007) and 6.49 (Abu-tarbouch et al., 1998; Sawaya et al., 1984). Other works about camel milk provided higher pH values: 6.61 ± 0.02 in Egypt (Mehaia et al., 1995); 6.55 ± 0.04 in Saudi Arabia (Abu-Lehia, 1994) and 6.51 ± 0.12 in Tunisia (Kamoun, 1995).

Camel milk pH ranges from 6.2 to 6.5 and its density from 1.026 to 1.035. Both density and pH are lower than those of cow milk (Farah, 2011). Compared to cow milk, camel milk sours very slowly and can be kept longer without refrigeration.

Saley (1993) considered that the rather high content of vitamin C in camel milk could be the cause of this lower pH. In 1985, Yagil attributed the low pH value of camel milk to the strong concentration of volatile fatty acids.

The acidity values were obviously correlated to pH of both milks (dromadery and cow). Camel milk acidity (18.5 ± 0.02°D) was markedly higher than in cow milk (16.0 ± 0.25°D). This acidity was closer to the one reported by Siboukeur (2007): 18.2 ± 2.93°D. Nevertheless, many authors, gave higher or equal to 15°D values such as Sboui et al. (2009) and Kamoun (1995) in Tunisia with respectively 17.2°D and 15.6 ± 1.4°D and Abu-Lehia (1994) in Saudi Arabia (15 ± 4°D).

Natural milk acidity is due to the presence of caseins, mineral substances, traces of organic acids. The increase of milk acidity is caused by lactic acid and other acids resulting from the microbial degradation of lactose contained in spoilt milk (Vignola, 2002; Mahaut et al., 2000). cowFM in camel milk (24.0 ± 2.5 g/L) was markedly lower ($p < 0.001$) than in cow milk (33.0 ± 0.9 g/L). These results are in perfect accordance with those given in other works (Abu-Lehia, 1989; Kamoun and Fourati, 1989; Barbour et al., 1984).

This component varied according to lactation stage, species (Guliye et al., 2000) and feeding as well (Moges et al., 2016). It varied between 12 and 64 g/L in accordance with the meta-analysis of Konuspayeva et al. (2009) which includes 82 references. In Tunisia, this amount varies between 29 and 54 in camel milk (Farah, 2011). In Egypt, the mean value was 32.0 ± 2.0 g/L (Ibrahim and Khalifa, 2015) and in Saudi Arabia, 33.5 ± 8.1 g/L (Faye et al., 2013).

The mean composition of camel milk according to literature data was 38.2 ± 10.8 g/L for the FM and 124.7

± 15.3 for TDE (Konuspayeva et al., 2009). TDE content of 108.61±2.50 g/L in our camel milk samples was significantly ($p < 0.05$) lower than the cow milk (118.48 ± 2.75 g/L).

In the meta-analysis of Konuspayeva et al. (2009), it was reported that, except for ash, all the milk components were in significant higher concentration in Bactrian double-humped camel milk from Asia. Regarding references involving only the dromedary, data from East Africa showed a higher content in fat matter compared to other areas. The differences between camel breeds could play a certain role.

Fatty acids profiles

Fatty acids (FAs) composition of camel milk fat varied according to the countries where camels are living (Cardak et al., 2003; Gorban and Izzeldin, 2001; Abu-Lehia, 1989; Farah et al., 1989; Sawaya et al., 1984; Orlov and Servetnik-Chalaya, 1981).

Camel milk lipid composition is influenced by environmental and physiological factors such as diet, stage of lactation and genetic differences within the species (Dreiucker and Vetter, 2011; Sboui et al., 2009; Karray et al., 2005; Palmquist et al., 1993; Farah et al., 1989).

Regarding FAMEs of camel milk samples (Table 3, Fig. 1 and Fig. 2), a rather lower proportion (46.41 ± 0.25 %) of saturated fatty acids (SFAs) was observed with mainly palmitic acid C16:0 (24.54 ± 0.03 %) and myristic acid C14:0 (14.51 ± 0.01 %). In contrast, cow milk showed a high content of SFA (60.76 ± 0.43 %) with palmitic acid percentage of 29.17 ± 0.13 % whereas myristic acid was 9.69 ±0.10 %.

The comparison of the palmitic acid amount in camel and bovine milk fats is still discussed by authors: Abu-Lehia (1989) found that it is present in similar amounts in camel and bovine milk fats. However, Dreiucker and Vetter (2011) and Attia et al. (2000) found that the proportion of C16:0 was lower in dromedary milk fat and Farah et al. (1989), found that this fatty acid was present in higher quantities in camel milk originating from Kenya.

Stearic acid showed a smaller value (2.95±0.12 %) in camel milk compared to cow milk (12.92 ± 0.08 %), results already recorded by Jensen (2002). However, several studies (Dreiucker and Vetter, 2011; Khalil et al., 2011; Haddad et al., 2010; Attia et al., 2000; Abu-Lehia, 1989) reported higher stearic acid contents in camel milk (within the range 6.96-15.20%).

The results also revealed the very low presence of butyric (0.01±0.00 %) and caproic (0.07±0.01 %) acids in the Algerian camel milk in accordance with the results of Ibrahim and Khalifa (2015) and with Khalil et al. (2011) In other studies (Dreiucker and Vetter, 2011; Shibani et al., 2011; Haddad et al., 2010; Karray et al., 2005), it waseven noted that camel milk was C4:0 and C6:0 free. The range reported by Karray et al. (2005) indicating the notably smaller amounts of these FAs in camel milk was similar to

Table 2 : Physico-chemical analysis results of the camel and cow milk samples

Parameters	Camel milk	Cow milk	*P* value
pH	6.33±0.03	6.68±0.10	<0.01
Acidity (°D)	18.5±0.02	16.0±0.25	<0.001
Density	1030.4±0.30	1030.0±0.70	NS
FM (g/L)	24.0±2.50	31.0±0.90	<0.001
TDE (g/L)	108.61±2.50	118.48±2.75	<0.05

(P) Probability; (NS) not significant.

Table 3: Fatty acid composition of camel milk fat (%)

Fatty acids (FAMEs)		Camel milk (%)	Cow milk (%)	*P* value
Common name	Formula			
Butyric	C4:0	0.01±0.00	1.09±0.14	<0.001
Caproic	C6:0	0.07±0.01	0.89±0.09	<0.001
Caprylic	C8:0	0.11±0.01	0.65±0.05	<0.001
Capric	C10:0	0.21±0.01	1.76±0.10	<0.001
Hendecanoic	C11:0	0.02±0.00	0.03±0.00	<0.001
Lauric	C12:0	1.07±0.02	2.53±0.06	<0.001
Tridecanoic	C13:0	0.11±0.00	0.07±0.00	<0.001
Myristic	C14:0	14.51±0.01	9.69±0.10	<0.001
Pentadecanoic	C15:0	1.99±0.04	1.09±0.01	<0.001
Palmitic	C16:0	24.54±0.03	29.17±0.13	<0.001
Margaric	C17:0	0.68±0.04	0.65±0.01	NS
Stearic	C18:0	2.95±0.12	12.92±0.08	<0.001
Arachidic	C20:0	0.13±0.03	0.21±0.02	<0.05
SFAs		46.41±0.25	60.76±0.43	<0.001
Myristoleic	C14:1	1.99±0.03	0.64±0.01	<0.001
Palmitoleic	C16:1	13.55±0.19	1.53±0.02	<0.001
Heptadecenoic	C17:1	0.93±0.06	0.31±0.01	<0.001
Oleic	C18:1 n9	32.68±0.45	32.22±0.35	NS
Eicosenoic	C20:1	0.16±0.01	0.18±0.03	NS
MUFAs		49.33±0.34	34.88±0.40	<0.001
Linoleic	C18:2 n6	3.46±0.05	3.43±0.02	NS
γ-Linolenic	C18:3 n6	0.07±0.00	0.07±0.02	NS
α-Linolenic	C18:3 n3	0.20±0.00	0.58±0.00	<0.001
Eicosadienoic	C20:2	0.27±0.04	0.02±0.00	<0.001
Eicosatrienoic	C20:3n3	0.20±0.01	0.17±0.01	NS
Arachidonic	C20:4	0.01±0.00	0.01±0.00	NS
Others		0.05±0.02	0.08±0.01	NS
PUFAs		4.26±0.09	4.36±0.06	NS
UFAs		53.59±0.28	39.24±0.50	<0.001

(SFAs) Saturated fatty acids; (UFAs) Unsaturated fatty acids; (MUFAs) Mono unsaturated fatty acids; (UFAs) Poly unsaturated fatty acids; (P) Probability; (NS) not significant

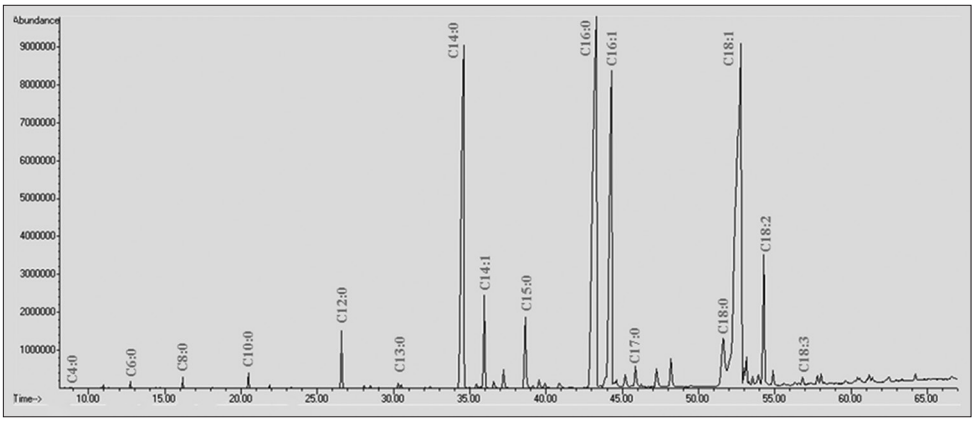

Fig 1. Example of a chromatogram of fatty acids from camel milk

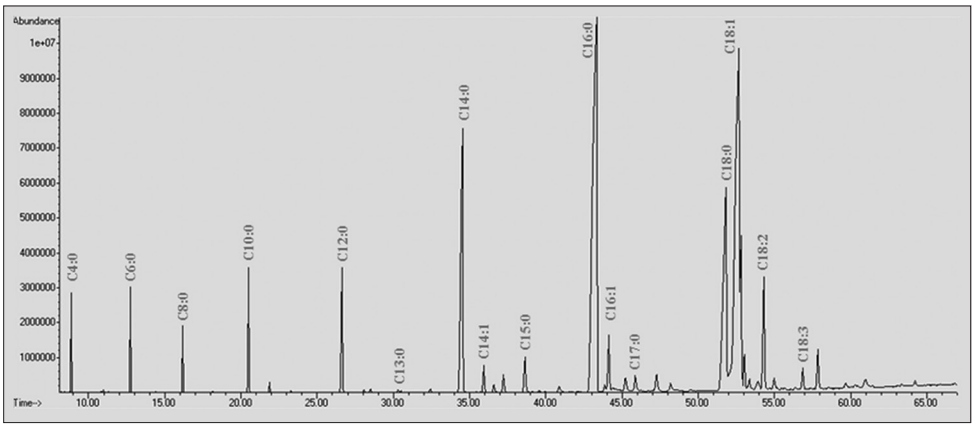

Fig 2. Example of a chromatogram of fatty acids from cow milk

our observations. These two FAs were present in cow milk in markedly higher ($p < 0.001$) contents (respectively 1.09 ±0.14 % and 0.89±0.09 % for C4:0 and C6:0).

Ruminants can produce C4:0-C8:0 fatty acids by cellulose fermentation in the rumen, and thus, camel milk was expected to contain these FAs. Possible explanations for their lower concentration in camel milk could be the rapid metabolizing of these FAs by camel tissues before being excreted in the milk (Karray et al., 2005) or the nature of camel feeding.

Other SFAs such as C8:0, C10:0, C11:0, C12:0 and C20:0 were in higher proportion in cow milk than in camel one, unlike C13:0 and C15:0 proportions which were more abundant in camel milk. Only margaric acid (C17:0) was in similar proportion.

Globally, sShort-chain FAs (C4:0-C12:0) were present in smaller amount in camel milk fat compared to bovine milk fat (Shibani et al*.,* 2011; Cardak et al., 2003; Gorban et Izzeldin, 2001; Attia et al. 2000; Abu-Lehia, 1989; Farah et al., 1989).

Unsaturated fatty acids (UFA) were significantly in higher proportion in camel milk fat (53.59 ± 0.28 %) compared to cow milk (39.24 ± 0.50 %) as stated by Jensen's (2002) but in smaller amounts (37 % in camel milk *vs* 27 % in cow milk). Haddad et al. (2010) pointed out that such result indicated a slower hindgut fermentation system activity in camels or higher FA desaturase activities responsible for monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) biosynthesis in camel milk.

Total MUFAs were higher in camel milk (49.33 ± 0.34 %) than bovine milk (34.88 ± 0.40 %), as already reported by Shibani et al. (2011).

Among the MUFAs, oleic acid C18:1 (32.68 ± 0.45 %) was the most abundant, as in cow milk (32.22 ±0.35 %); followed by palmitoleic acid C16:1 (13.55 ± 0.19 %) with a higher ($p < 0{,}001$) rate than in cow milk (1.53 ± 0.02 %).The other MUFAs (C14:1 and C17:1) were significantly higher in camel milk fat than in bovine milk.

There was no significantly difference between PUFAs in camel milk (4.26 ±0.09 %) and cow milk (4.36 ±0.06 %). Among these acids, linoleic acid (C18:2 n6) was the most abundant in both milks, but without any noticeable difference: 3.46 ± 0.05 % in camel and 3.43

± 0.02 % in cow milk. It was 3.67 ± 0.38 % in Egyptian camel milk (Ibrahim and Khalifa, 2015). Linoleic acid proportion in cow milk FAs was commonly between 2 and 3 % (Chilliard et al., 2001).

The α-linolenic acid (C18:3 n3) proportion was significantly higher in cow milk (0.58 ± 0.0 %) than in camel one (0.2 ± 0.0 %). It was higher in Egyptian camel milk (Ibrahim and Khalifa, 2015): 2.17 ± 0.15 %. Besides, small quantities (0.01 ± 0.00 %) of arachidonic acid C20:4 were observed in camel milk. This was an interesting result from the nutritional point of view.

Since a seven countries study (Kromhout et al., 1995), it is considered that an excessive uptake of dietary saturated fat by human could lead to an increase of plasma cholesterol, concentration more particularly low density lipoproteins (LDLs), increasing the possible appearance of atherosclerosis damage (Caggiula and Mustad, 1997; Nicolosi, 1997). Qualitatively, myristic acid first appeared to be the SFA inducing the strongest increase in plasmatic cholesterol (Hayes and Koshla, 1992). However, this was later disproved (Billett et al., 2000; Salter et al., 1998; Temme et al., 1997) in other studies using different FAs concentrations. These studies highlighted that palmitic acid, more abundant FA, was the most hypercholesterolemic (Billett et al., 2000; Salter et al., 1998).

Studies about cardiovascular aspects often depicted some overconsumption which even overstep dietary excesses and led to the distortion of « bad saturated » for which some dogmatists suggested full elimination. Concerning SFAs too, the problem arises from the amount ingested and not from the FA molecule type (Legrand, 2008).

Ever since the studies examined sensible measurements of total SFAs amounts and myristic acid, no significant increase was noticed of LDL-cholesterol in humans when myristic acid increased HDL-cholesterol (Tholstrup et al., 2003; Tholstrup et al., 1994).Then it's important to notice that the relation with harmful effects was recorded only when excessive consumption (Legrand et al., 2001). For these reasons, SFAs cannot be regarded as " bad fatty acids " and cannot be necessarily suppressed them from diet (Legrand, 2008).

Neutrality of oleic acid is an important advantage for cardiovascular system (Legrand, 2008) and it was admitted for long time (Gordon and Kraemer, 1995) that replacing the excess of saturated acids by oleic acid in the diet, reduce cholesterolaemia.

Essential polyunsaturated fatty acids (n-6 and n-3) aren't plentiful present in milk fat matter. However, by improving animal feeding, n-3 fatty acid content can be increased a little more (Legrand, 2008). For example, camel diet enriched in olive cake increased significantly γ-linolenic acid (C18:3ω-6) after 3 months supplementation (Faye et al., 2013). Linoleic and arachidonic acids are basic compounds of phospholipids membrane. They regulate within cellular membranes the activity of many enzymes, transporters, receivers and ionic channels involved in inter- and intracellular signaling (Guesnet et al., 2005).

CONCLUSION

This study was carried out in order to contribute to a better characterization of the Algerian camel milk and to compare it with cow milk reared in the same country.

The physico-chemical analyses carried out on the Targui camel milk, sampled from the Biskra region confirmed the differences observed by many authors. They confirmed also the dietetic interest of camel milk. The fat composition of camel milk is one of the nutritional interest of this product for local population. It is also a commercial argument for the actors of the camel milk sector in Algeria in full development for the last 5 years.

Author's contributions

All authors of the paper contributed equally to the writing of the paper and were involved in the overall planning and supervision of the work.

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