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Differences in sheep and goats milk fatty acid profile between conventional and organic farming systems

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The objective of this study was to investigate whether there is a difference in chemical composition and particularly in fatty acid (FA) profile, with emphasis on *cis*-9, *trans*-11 CLA, of milk obtained from conventional and organic dairy sheep and goats farms under the farming conditions practiced in Greece. Four dairy sheep and four dairy goat farms, representing common conventional production systems and another four dairy sheep and four dairy goat farms, organically certified, representing organic production and feeding systems were selected from all over Greece. One hundred and sixty two individual milk samples were collected from those farms in January–February 2009, about three months after parturition. The milk samples were analyzed for their main chemical constituents and their FA profile. The results showed that the production system affected milk chemical composition: in particular fat content was lower in the organic sheep and goats milk compared with the corresponding conventional. Milk from organic sheep had higher content in MUFA, PUFA, α-LNA, *cis*-9, *trans*-11 CLA, and ω-3 FA, whereas in milk from organic goats α-LNA and ω-3 FA content was higher than that in conventional one. These differences are, mainly, attributed to different feeding practices used by the two production systems. The results of this study show that the organic milk produced under the farming conditions practiced in Greece has higher nutritional value, due to its FA profile, compared with the respective conventional milk.

Keywords: organic, sheep, goats, milk, fatty acids.

Abbreviation key: **CLA** = conjugated linoleic acid, **FA** = fatty acids, **VA** = trans-vaccenic acid, **SCFA** = rated Fatty Acids, **MCFA** = Medium Chain Saturated Fatty Acids, **MUFA** = Mono-Unsaturated Fatty Acids, **PUFA** = Poly-Unsaturated Fatty Acids, **LCFA** = Long Chain Saturated Fatty Acids, **S/ U** = Saturated/Unsaturated ratio, **α-LNA** = α- linolenic, **LA** = linoleic acid

The demand for organically produced food is increasing. This growth could be attributed to the increased consumer interest in organic products. There are two major motives for buying organic products: health aspects for the consumers themselves and environmental concern (Haward & Green, 2003; Green, 2004). In addition, but not less important, there are ethical issues, a major one being concern for animal welfare. So, there is no doubt that a large proportion of consumers relate organic production to healthier food, less harm to the environment and better animal welfare. In general, it seems that health aspect have become more important during the 1990s (Wier & Calverly, 1999). Looking at the health aspect, it is important to realize that the consumers are not primarily focusing on the ''traditional'' nutritive value of the food, but on the increase of some nutrients, which have beneficial effects on human health.

Ruminant milk contains a large number of fatty acids (FA) some of which are very important for human health including polyunsaturated fatty acids (PUFA) within the ω-3 (omega-3) FA group, vaccenic acid (VA) and conjugated linoleic acid (CLA). The ω-3 FA have been linked to improved neurological function (Contreras & Rapoport, 2002), protection against coronary heart diseases (Albert et al. 2005; Djousé et al. 2005) and prevention of some forms of cancer (Saadatian-Elahi et al. 2004). Biomedical studies with animal models have demonstrated a variety of effects from CLA, including anticarcinogenic, antiatherogenic, antiobesity, immune system enhancement and antidiabetic (Corl et al. 2003; Larsson et al. 2005). The *cis*-9, *trans*-11 CLA in milk fat is the major isomer and it represents about 78–89% of the total CLA in sheep milk fat (Antogiovanni et al. 2004).

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Table 1. Detailed data concerning the sheep and goats farms used in the experimental period.

Farm data	Sheep		Goats	
	Conventional (CS)	Organic (CS)	Conventional (CG)	Organic (CG)
Animal breed	Karagouniko	Karagouniko	Local native	Local native
Average body weight (Kg)	60	60	50	50
Average milk yield (Kg/day)	1·1	0·8	1·3	0·9
Body condition score	2·7	2·7	2·5	2·5
Supplementary feeding (Kg/day)				
Alfalfa hay	0·8	0·8	0·9	0·9
Wheat straw	0·4	—	—	—
Concentrate	1·2	—	1·0	—
Maize grain	—	0·9	—	0·8
Grazing[1]				
Grass (Kg/day)	+[8]	0·5	—	—
Grass +Shrubs(Kg/day)	—	—	1·5	2·0
Animal average requirements [2]				
Energy (MJ/NE_l[3]/day)	12	10·5	11·3	9
Protein (g CP[4]/day)	250	188	225	142
Calculated values[5]				
Supplementary feeding				
Energy (MJ/NE_l[3]/day)	12	10	9·8	7·1
Protein (g CP[4]/day)	260	163	235	86
Grazing				
Energy (MJ/NE_l[3]/day)	+	0·5	1·5	1·9
Protein (g CP[4]/day)	+	15	50	67
Total regimen[6]				
Energy	12+	10·5	11·3	9
Protein	260+	181	285	153
F/C[7]	50/50	50/50	63/37	62/38
NDF (% DM)	38·7	30·7	35·0	22·0
ADF (%DM)	30·0	20·0	23·5	12·6

[1] Grazing = Calculated by difference (energy and protein requirements based on maintenance and produced milk minus energy and CP covered by supplementary feeding)
[2] Requirements of small ruminants (Zervas, 2007)
[3] NE_l = Net Energy of lactation
[4] CP = Crude Protein
[5] Calculated values = Calculated values from Tables: Zervas, (2007)
[6] Total regimen = Calculated energy, CP, etc coming from supplementary feeding+grazing in total
[7] F/C = Forage /Concentrate ratio on a dry matter basis
[8] + = According to balance calculations the grass intake by the conventional sheep should be very low as the animals covered their energy and CP requirements by the supplementary feeding

Milk and dairy products from certified organic dairy production systems have been reported to contain higher concentrations of *cis*-9, *trans*-11 CLA, α-linolenic (α-LNA) acid (the main ω-3 FA in milk) (Jahreis et al. 1996; Bergamo et al. 2003; Butler et al. 2008; Prandini et al. 2009; Slots et al. 2009) and α-tocopherol and β-carotene (Bergamo et al. 2003; Butler et al. 2008) than high-input conventional production systems. However some other studies have reported no differences in *cis*-9, *trans*-11 CLA milk fat content between organic and conventional or extensive production systems (Toledo et al. 2002; Ellis et al. 2006). The contradictory results of these studies are probably related to different feeding strategies among these different production systems.

Although there are a number of studies on dairy cows, which have investigated the differences in milk FA profile between organic and conventional production systems, to our knowledge there is only one study on dairy goats (Tudisco et al. 2010). Further to that Zervas et al. (2000) and Pirisi et al. (2002) have reported comparison of milk yield and composition from organic and conventional dairy sheep under controlled feeding regimen. In the absence of data on compositional differences, the aim of this study was to determine whether there is a difference in chemical composition of milk, particularly in FA profile, with emphasis on *cis*-9, *trans*-11 CLA, between conventional and organic dairy sheep and goat farms in Greece.

Materials and Methods

One hundred and sixty two individual milk samples were collected from sixteen dairy sheep and goats farms all over Greece in January–February 2009 about three months after parturition. The milk samples were taken as percentage (10%) of the milked female animals of each flock/herd.

Four dairy sheep (CS) and four dairy goat (CG) farms were selected representing common conventional production and feeding systems in Greece. Another four dairy sheep (OS) and four dairy goat (OG) farms organically certified were selected representing organic production and feeding systems in Greece. Those organic farms produced milk according to the legislation concerning organic farming by the Greek Ministry of Rural Development and Food. The average flock/ herd size was around 100 females.

The CS and CG farms were selected from those using concentrates from the same feed mill company in order to minimize the dietary effects. Then, in those areas OS and OG farms, with comparable size and management to the conventional ones, were also selected for this trial.

The nutrition of the CS and CG farms was based mainly on supplements, apart from the limiting grazing, during the winter months up to March–April. The CS supplement consisted of alfalfa hay, wheat straw and concentrates and that of CG of alfalfa hay and concentrates. The goats were grazing wooded pastures dominated by shrubs and trees, consisted of species such as *Quercus coccifera, Pyrus amugdaliformis, Arbutus unedo, Spartum junceum, Phlomis fruticosa* and *Olea european*.

The OS and OG animals were fed during the winter months with a mixed ration consisting of alfalfa hay and corn grain, grazing organic certified grasslands at the same time as the conventional.

The average concentrate composition was: maize grain (60%), barley grain (10%), soybean meal (15%), wheat middlings (10%), calcium phosphate and mineral and vitamins (5%).

All the detailed data concerning the sheep and goats farms used in this trial during the experimental period are presented in Table 1. The energy and crude protein (CP) intake from grazing (grass in the case of sheep or grass and shrubs in the case of goats) was calculated based on the assumption that those animals had certain energy and CP requirements for maintenance and milk production (Table 1), which were partly met by the supplementary feeding offered to them indoors, and partly by the grazed forage. Since the body condition score of the animals was rather constant (2·7 for the sheep and 2·5 for the goats in a scale from 1 to 5) during the experimental period, the estimated requirements met by grazing are based on the difference between actual total energy and CP requirements and those covered by supplementary feeding.

Milk and Feed samples analyses

Each milk sample was divided in two parts, one for chemical analysis and another for FA determination by gas chromatography, as described by Tsiplakou et al. (2006). Milk was analyzed for fat, protein, lactose, total solids (TS), and solids-not-fat (SNF), with IR spectrometry (Milkoscan 133/; Foss Electric, Hllerod, Demark), after appropriate calibration of the instrument according to Gerber (BSI, 1955), Kjeldahl (Inernational Dairy Federation (IDF), 1993) and chloramine-T method, respectively (IDF, 1964).

Feed samples (alfalfa hay, concentrates, corn grain, grass and shrubs) were analyzed for their FA profile (by gas chromatography) and chemical composition, as described by Tsiplakou et al. (2006) and Tsiplakou & Zervas (2008) respectively.

Calculations for milk FA

Short Chain Saturated Fatty Acids (**SCSFA**) $=C_{6:0}+C_{8:0}+C_{10:0}+C_{11:0}$,

Medium Chain Saturated Fatty Acids (**MCSFA**) $=C_{12:0}+C_{13:0}+C_{14:0}+C_{15:0}+C_{16:0}$,

Long Chain Saturated Fatty Acids (**LCSFA**) $=C_{18:0}+C_{20:0}+C_{22:0}+C_{23:0}+C_{24:0}$,

Poly-Unsaturated Fatty Acids (**PUFA**) = *cis*-9, *trans*-11$C_{18:2}$ CLA $+C_{18:2n6c}+C_{18:2n6t}+C_{18:3n3c}+C_{18:3n6c}+C_{20:2}+C_{20:3n3c}+C_{20:3n6c}+C_{20:4}+C_{20:5}+C_{22:2}$,

Mono-Unsaturated Fatty Acids (**MUFA**) $=C_{14:1}+C_{15:1}+C_{16:1}+C_{17:1}+C_{18:1}+VA+C_{20:1}$,

Saturated / Unsaturated ratio = **S**/**U**: (SCSFA+MCSFA+LCSFA)/(PUFA+MUFA) and

VA = *trans*-11$C_{18:1}$. This value is not included in the $C_{18:1}$ content.

The Atherogenicity index (**AI**) was defined as $(C_{12:0}+4\times C_{14:0}+C_{16:0})/(PUFA+MUFA)$ as described by Ulbricht & Southgate (1991).

The Δ^{-9} desaturase activity indexes were calculated by the following four ratios: $C_{14:1}/C_{14:0}$, $C_{16:1}/C_{16:0}$ and $C_{18:1}/C_{18:0}$.

Statistical analysis

The results are presented as least square means ± SEM. Farming system effects (CS vs. OS and CG vs. OG) on milk chemical composition and FA profile in each animal species was test by one-way ANOVA using SPSS statistical package (release 9.0.0). Post-hoc tests were performed using Duncan's multiple range test and significance was set at $P<0·05$.

Results

The data concerning the supplementary feeding of all sheep and goat farms and the calculated quantity of grass/shrubs intake, presented in Table 1, show that CS should have very low grass intake compared with the OS. The CG should also have lower grass and shrubs intake compared with the corresponding OG. However, in any case the grass/shrubs intake by goats was much higher than that of sheep. According to those calculations, which are very close to reality, based on the animal actual requirements and the known quantities of the supplementary feeding, the forage/concentrate (F/C) ratio was very similar between conventional and organic farmed animals for each animal species (Table 1).

Based also on the data of Table 1, the NDF and ADF content (% DM) of total regimen was higher in CS and CG compared with the corresponding OS and OG.

The mean chemical composition of all milk types is presented in Table 3. The CS milk showed higher fat and TS content compared with the OS, while the protein, lactose and SNF did not differ. In goats milk the only difference found was the higher milk fat content of the CG compared with OG.

Milk fatty acid profile, the values of S/U ratio, AI and Δ^{-9} desaturase indices evaluated in conventional and organic sheep and goats' milk fat are also presented in Table 3. The significantly higher values of milk FA between CS vs. OS and CG vs. OG are shown in bold.

Discussion

Different feeding regimens have different impacts on composition and/or functional properties of raw milk (Toledo et al. 2002). There are many sources of feeds like pasture, conserved forages (hay, silages, etc) and concentrates which are used in animal diets and different feeding strategies, which also affect, in different way, milk FA profile. An additional complicating factor when discussing effects of organic farming on food quality (e.g. FA profile of milk fat) is that organic production systems are not well-defined, but differ widely between countries, or in some cases even within the same country. In Denmark, for example, the conventional farms compared with the organic ones use different forages (Noziere et al. 2006), whereas in Sweden the feeding strategies between the two systems are very similar (Toledo et al. 2002). Taking into account that diet is the main factor which affects the milk FA profile, the direct comparison between organic and conventional production system is not easy (Sundrum, 2001) and highlights the importance of repeated studies of sufficient sample size in different countries, to represent local management practices.

This study aimed to show the potential of the production system (organic vs. conventional) of dairy sheep and goats practiced in Greece to affect the composition of milk. The feeding system of dairy sheep and goats in Greece is based on seasonal (spring-early summer) natural grazing and on supplementary feeding (autumn-winter) which consists of home grown roughages (mainly alfalfa hay and straw) and concentrates (Zervas et al. 1996).

The type and the level of integration to be used depends on animal productivity, feedstuffs availability and milk price. Thus there is large variation among individual farms which makes the comparison of milk composition really difficult since it is well known that such a comparison should take into account the farm management system as well as seasonal and nutritional factors which are responsible for potential differences in milk FA profile. In this study, in order to avoid any confounding factors, the farms were selected to have comparable management, feeding per animal species and productive system. Ellis et al. (2006) found that there was a significant effect of farming system (organic vs. conventional) in PUFA and ω-3 FA content of cows milk, even after accounting for some potentially confounding management and nutritional factors in the analyses.

Milk fat content of both OS and OG (Table 3) was significantly lower compared with the respective conventional. In the former study of Zervas et al. (2000) no difference in milk composition between organic and conventional dairy sheep was found, because their feeding regimen was controlled and comparable. The observed differences in milk fat content, in this study, between the two systems (conventional vs. organic) could be attributed to the lower NDF and ADF content of the OS and OG regimen compared with that of the conventional, which is the consequence of the higher grass or grass/shrubs intake by organically farmed sheep and goats respectively (Table 1). These results disagree with those of Pirisi et al. (2002) who found no differences in sheep milk composition between the two farming systems with the exception of higher casein production in conventional system and those of Tudisco et al. (2010) who found significantly higher milk fat content in OG compared with the CG. However, significantly lower milk fat content has been observed in dairy cows in an organic, compared with a conventional farming system by Jahreis et al. (1996), but in that study only one organic farm was included.

The concentration of MCSFA in sheep and goats organic milk was significantly lower than the respective conventional samples (Table 3). A similar trend was observed for the SCSFA content but the difference was significant only in the goats' milk. The relatively higher pasture and shrubs intake that characterize sheep and goats reared in the organic farms respectively compared with the conventional farms (Table 1) could explain these differences. The higher content of unsaturated fatty acids in pasture and shrubs (Table 2) exert a potent inhibitor effect on the *de novo* synthesis of fatty acids at the mammary gland which is responsible for the decrease of SCSFA and MCSFA concentration in milk fat (Barber et al. 1997).

The significantly higher content of α-LNA in OS and OG milk compared with conventional milk is due to the

Table 2. Chemical composition (g/kg dry matter) and the main fatty acids (% of total FA) of shrubs (n=6) and other feedstuffs (n=6)

	Quercus coccifera	*Pyrus amugdaliformis*	*Arbutus unedo*	*Spartum junceum*	*Phlomis fruticosa*	*Olea europea*	Pasture	Alfalfa hay	Maize grain	Concentrates
Chemical composition										
Crude protein	72·00	67·01	63·14	138·02	95·90	120·72	10·32	125·23	92·34	156·23
Ether extracts	11·93	17·02	20·52	18·52	18·71	37·12	19·52	14·02	33·24	22·12
NDF	525·62	514·73	524·22	355·34	518·91	400·91	356·32	435·22	86·21	178·24
Fatty acids										
$C_{14:0}$	2·05	2·50	4·50	6·69	2·30	2·60	3·50	2·10	0·13	0·23
$C_{16:0}$	18·06	20·30	22·30	17·96	15·60	17·50	18·02	21·01	11·57	16·16
$C_{18:0}$	3·30	3·50	9·90	3·68	5·03	3·02	3·50	2·43	1·68	1·94
$C_{18:1}$	6·50	3·60	2·05	4·25	5·20	7·50	4·60	12·82	0·49	0·68
$C_{18:2n6c}$	18·70	12·40	13·50	16·94	14·30	11·03	16·35	13·11	83·27	76·84
$C_{18:2n6t}$	2·34	2·30	1·00	5·02	6·08	2·01	3·02	0·00	0·00	0·00
$C_{18:3n3}$	35·37	30·20	29·50	30·06	27·50	33·15	35·60	37·03	1·82	2·66
$C_{22:6}$	2·00	1·02	3·50	1·00	3·06	5·60	0·60	0·00	0·11	0·00

Table 3. Chemical composition, FA profile (% of total FA) and Δ^{-9} desaturase indexes of conventional and organic sheep and goat milk fat (Mean ± SEM)

Chemical composition	CS[1] n=41	OS[2] n=41	CG[3] n=40	OG[4] n=40
Fat	6·8^{a} ± 0·25	5·7^{b} ± 0·19	5·4^{a} ± 0·35	3·6^{b} ± 0·21
Protein	5·7 ± 0·19	5·5 ± 0·08	3·4 ± 0·12	3·5 ± 0·07
Lactose	5·2 ± 0·07	5·2 ± 0·05	4·8 ± 0·06	4·9 ± 0·04
SNF	11·6 ± 0·12	11·5 ± 0·09	6·7 ± 0·41	7·6 ± 0·25
TS	18·5^{a} ± 0·31	17·1^{b} ± 0·24	10·9 ± 0·56	10·7 ± 0·34
Fatty acids				
VA	3·9 ± 0·40	4·4 ± 0·38	2·2 ± 0·30	2·4 ± 0·19
α-LNA	0·7^{b} ± 0·07	**1·1**^{a} ± 0·07	0·3^{b} ± 0·14	**0·9**^{a} ± 0·09
LA	**3,2**^{a} ± 0,34	2,4^{b} ± 0,38	3·2 ± 0·15	2·7 ± 0·09
cis-9, *trans*-11 CLA	1·1^{b} ± 0·06	**1·3**^{a} ± 0·05	0·6 ± 0·06	0·6 ± 0·04
SCSFA	18·8 ± 0·41	17·9 ± 0·39	**20·4**^{a} ± 0·54	18·4^{b} ± 0·35
MCSFA	**43·2**^{a} ± 0·55	38·3^{b} ± 0·52	**38·7**^{a} ± 0·78	35·8^{b} ± 0·50
LCSFA	8·9^{b} ± 0·40	**11·3**^{a} ± 0·39	14·7^{b} ± 0·71	**18·5**^{a} ± 0·46
PUFA	5·5^{b} ± 0·01	**6·2**^{a} ± 0·13	3·9 ± 0·20	4·2 ± 0·13
MUFA	23·6^{b} ± 0·55	**26·3**^{a} ± 0·53	22·3 ± 0·76	23·1 ± 0·49
S/U	**2·5**^{a} ± 0·07	2·2^{b} ± 0·07	2·9 ± 0·10	2·7 ± 0·07
AI	**2·6**^{a} ± 0·09	2·2^{b} ± 0·09	**2·6**^{a} ± 0·11	2·2^{b} ± 0·07
ω-3	0·7^{b} ± 0·07	**1·2**^{a} ± 0·07	0·3^{b} ± 0·14	**0·9**^{a} ± 0·09
ω-6	3·4 ± 0·10	3·5 ± 0·10	3·3 ± 0·15	2·7 ± 0·09
ω-6/ω-3	**6·6**^{a} ± 0·43	4·3^{b} ± 0·41	5·9 ± 1·03	5·6 ± 0·66
Δ^{-9} desaturase indexes				
$C_{14:1}/C_{14:0}$	**0·02**^{a} ± 0·001	0·01^{b} ± 0·001	0·01 ± 0·004	0·02 ± 0·003
$C_{16:1}/C_{16:0}$	0·05 ± 0·001	0·05 ± 0·001	0·03 ± 0·000	0·02 ± 0·000
$C_{18:1}/C_{18:0}$	**2·20**^{a} ± 0·070	1·92^{b} ± 0·070	**1·42**^{a} ± 0·070	1·13^{b} ± 0·040
cis-9, *trans*-11 CLA/VA	0·35 ± 0·010	0·35 ± 0·010	0·29 ± 0·040	0·28 ± 0·030

[1] CS = Conventional Sheep
[2] OS = Organic Sheep
[3] CG = Conventional Goats
[4] OG = Organic Goats
Means with different superscripts (a and b) in the row for each parameter differ significantly ($P \leqslant 0{\cdot}05$)
VA is not included in the $C_{18:1}$ content

higher pasture and shrubs intake mentioned earlier. On the other hand, the significantly higher LA concentration in CS milk compared with the OS milk, can be attributed to higher concentrate intake (Table 1).

The ω-6/ω-3 FA ratio was lower in OS compared with CS milk (Table 3), being closer to the suggested optimum ω-6/ω-3 FA ratio in the human diet of 1/1 (Simopoulos, 2002). These results agree with those of Ellis et al. (2006)

and Slots et al. (2009) who reported lower ω-6/ω-3 ratio in organic milk of dairy cows. This lower ratio of the OS milk gives a higher nutritional value to milk, indeed, as described by Thorsdottir et al. (2004) has been found a positive relationship between increasing milk ω-6/ω-3 FA ratio and the prevalence of type-2 diabetes and mortality due to coronary heart disease. Milk enriched with ω-3 FA favourably alters the plasma fat content, reducing the concentration of fatty acids associated with increased risk of cardiovascular disease (Baró et al. 2003; Carrero et al. 2004). However, there is a strong need of further investigations to verify a benefit to human health following consumption of low ω-6/ω-3 ratio.

The high variety of feeds used in dairy cows maybe responsible for the contradictory results concerning *cis*-9, *trans*-11 CLA milk fat content. Indeed, some researchers have observed significantly higher *cis*-9, *trans*-11 CLA in organic milk compared with the respective conventional (Jahreis et al. 1996; Bergamo et al. 2003; Butler et al. 2008; Slots et al. 2009; Prandini et al. 2009) whereas some others found no differences (Toledo et al. 2002; Ellis et al. 2006) in dairy cows. To our knowledge there is no report on organic sheep milk FA profiles, in order to make comparison. Only in the study of Tudisco et al. (2010) was significantly higher *cis*-9, *trans*-11 CLA milk fat content found in OG compared with the CG.

A significantly higher content of *cis*-9, *trans*-11 CLA was found in milk fat of the OS (Table 3) which could also be attributed to higher herbage intake, since herbage has high α-LNA (60% of the total FA) content (Cabiddu et al. 2005; Chilliard et al. 2007). On the contrary, in goats' milk fat *cis*-9, *trans*-11 CLA content did not differ between OG and CG milk (Table 3) despite the fact that herbage or shrubs intake with higher PUFA content was higher in the organic goats (Table 1). The shrub intake by goats, which are rich in tannins, may inhibit rumen biohydrogenation and consequently the *cis*-9, *trans*-11 CLA production (Cabiddu et al. 2009). In accordance with the results of this study, no significant differences on *cis*-9, *trans*-11 CLA content in goats' milk were observed by Tsiplakou et al. (2006) when the animals were kept indoors or outdoors (fed only herbage), or when the goats fed olive tree leaves with high α-LNA content (Tsiplakou et al. 2008). However, further to that, recent experimental data have shown that there are species differences between sheep and goats in their *cis*-9, *trans*-11 CLA milk fat content due to the differences in mRNA Δ^{-9} desaturase expression in their mammary gland, when the two animals species (sheep/goats) are fed with the same dietary treatments (Tsiplakou et al. 2009).

The majority of *cis*-9, *trans*-11 CLA in milk fat is of endogenous origin, synthesized from VA via Δ^{-9} desaturase enzyme. The best indicator of Δ^{-9} desaturase activity is the $C_{14:1}/C_{14:0,}$ because all $C_{14:0}$ in milk fat is produced by *de novo* synthesis in the mammary gland, whereas the other acid substrates ($C_{16:0}$ and $C_{18:0}$) can be absorbed from the gut (Cabiddu et al. 2005). In agreement with Addis et al. (2005), $C_{14:1}/C_{14:0}$ and $C_{16:1}/C_{16:0}$ ratios, obtained in this study, in sheep and goats' milk fat in both production systems were lower than the other two Δ^{-9} desaturase ratios (Table 3) because only a small proportion of $C_{14:0}$ and $C_{16:0}$ is desaturated to $C_{14:1}$ and $C_{16:1}$ respectively (Chilliard et al. 2000). A higher efficiency of Δ^{-9} desaturase activity was estimated in both animal species and both production systems on the basis of the ratio $C_{18:1}/C_{18:0}$ (Table 3). As matter of fact that $C_{18:0}$ is the most preferred substrate of Δ^{-9} desaturase in the mammary gland (Chilliard et al. 2000; Mosley & McGuire, 2003).

Conclusions

The results of this study have shown that the production system of goat and sheep species, organic vs. conventional, as practiced in Greece has an impact on milk composition and FA profile. Organic milk is characterized by a higher nutritional value due to the higher amounts of MUFA, PUFA, α-LNA, *cis*-9, *trans*-11 CLA and ω-3 in sheep and α-LNA and ω-3 in goats in comparison with respective conventional milk.

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