Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar
http://dx.doi.org/10.5424/sjar/2013113-3808

Spanish Journal of Agricultural Research 2013 11(3): 759-769
ISSN: 1695-971-X
eISSN: 2171-9292

Fatty acid composition of muscle and internal fat depots of organic and conventional Payoya goat kids

F. de-la-Vega[1], J. L. Guzmán[2], M. Delgado-Pertíñez[1]*, L. A. Zarazaga[2] and A. Argüello[3]

[1] *Departamento de Ciencias Agroforestales. Escuela Técnica Superior de Ingeniería Agronómica. Universidad de Sevilla. Ctra. Utrera, km 1. 41013 Sevilla, Spain*
[2] *Departamento de Ciencias Agroforestales. Escuela Técnica Superior de Ingeniería. Universidad de Huelva. "Campus de Excelencia Internacional Agroalimentario, ceiA3". Campus de la Rábida. 21819 Palos de la Frontera (Huelva), Spain*
[3] *Animal Science Department. Universidad de Las Palmas de Gran Canaria. C/ Transmontaña, s/n. 35413 Arucas, Spain*

Abstract

Interest in the preservation of autochthonous breeds such as the Payoya goat (dairy breed), raised using extensive or semi-extensive grazing, has also recently increased among Spanish farmers. A study of the possibilities of transformation to organic production needs to analyze the quality of their products, specially the suckled kids. The objective of this study was to evaluate the fatty acid (FA) composition of Payoya goat kids under organic and conventional grazing–based management system. Forty-eight goat kids were selected (12 males and 12 females from each management system). The FA profile was determined in the *Longissimus thoracis* muscle, kidney and pelvic fat. Few gender differences were observed in the muscle and in the fat depots. The ratios of C14:0, C18:1 *trans*-11-(VA), and several n-3 FA were higher in organic kid meat than in conventionally reared kid meat. Conventional kid fat depots have presented higher percentage of conjugated linoleic acid (CLA), lower CLA desaturase index, lower percentage of n-3 polyunsaturated fatty-acid (PUFA) and, consequently, higher n6:n3 PUFA ratio than organic kids. In conclusion, significant differences were found only in some FA percentages of muscle and adipose tissues of suckling kids raised in organic and conventional livestock production systems, probably due because the dams, in both experimental farms, were raised with similar semi-extensive system based on the grazing of natural pastures. Due to this reason, conventional grazing-based management farms could easily be transformed into organic production facilities.

Additional key words: Payoya goat; CLA; n-3 fatty acids; meat; organic livestock production.

Introduction

According to the European Union Directive (EC834/2007; EC, 2007) an organic animal production system should comply with the following requirements: contribute to the equilibrium of agricultural systems integrated with the natural environment, contribute to sustainable agriculture development, minimize all types of contamination, respect animal well-being, avoid systematic use of chemically synthesized substances, and renounce to the use of genetically modified organisms. The number of organic livestock production systems has substantially increased in recent years, the development can be attributed to increased consumer interest in organic products while, at the same time, farmers are interested in converting to organic production methods instead, often stimulated by government support or subsidies (Hermansen, 2003). Organic farming techniques are of particular interest to the Mediterranean region, where the quality of life in rural communities depends on the safeguard of agriculture, the care and conservation of the landscape, and the preservation of rural villages.

* Corresponding author: pertinez@us.es
Received: 03-12-12. Accepted: 11-07-13.

Abbreviations used: ARA (arachidonic acid); CLA (conjugated linoleic acid); DHA (docosahexaenoic acid); EPA (eicosapentaenoic acid); FA (fatty acid); GLM (general linear model); MUFA (monounsaturated fatty acids); PUFA (polyunsaturated fatty acids); RA (rumenic acid); SFA (saturated fatty acids); UFA (unsaturated fatty acids); VA (vaccenic acid).

In the European Union, Spain has the second highest goat head number (2.6 million) and Andalusia (in southern Spain) is the region with major census (35.7% of the national total) (MAGRAMA, 2012) and also with the highest number (398) of goat herd organic farms (65% of the national total); of which 375 are meat production farms and 23 are dairy farms (MAGRAMA, 2011). Interest in the preservation of autochthonous breeds, raised using extensive or semi-extensive grazing, has also recently increased among Spanish farmers and many of these breeds, such as the Payoya goat, are considered as special protection breeds (BOE, 2006).

Converting these breeds to organic production should be straightforward owing to the adaptive capacity and disease resistance of autochthonous breeds and to the rustic environment and nutritional resources available in mountain zones of Andalusía. According to organic production system requirements, mountain goat systems, in which feeding is largely based on grazing (Ruiz *et al*., 2008), could fairly easily be transformed into organic production (Mena *et al*., 2009a,b). A study of the possibilities of transformation to organic production needs to analyze, not only the technical and economical viability of the organic production systems, but also the quality of their products, specially the suckled kids.

The majority of goat farms raising the Payoya breed are located in the Sierra Norte of Cádiz (Andalucía, Spain). This breed is not as important economically or in census terms as the Malagueña or the Murciano-Granadina ones, but it is the one that best represents dairy goat production linked to grazing. The main objective of these farms is the yield marketable milk, and secondly the meat, for which kids must weigh 8-9 kg at slaughter. The reduced live weight at slaughter is due, on the one hand, to the fact that, if the weight is higher quickly it depreciates its economic value and, on the other hand, because the farmers want to take advantage of the productive potential milk faster (Mena *et al*., 2005).

Manipulation of dietary fatty acids (FA) is common because of the impact of FA intake on human health (MacRae *et al*., 2005). Myristic and palmitic acids are considered to negatively impact health, whereas conjugated linoleic acid (CLA) and polyunsaturated FA (PUFA), especially those of the n-3 series, are considered to be beneficial to human health; healthful FA benefit the cardiovascular system and lipid metabolism and may help to prevent cancer (MacRae *et al*., 2005). Although gender effects on the FA content of goat meat and fat depots have been studied (Johnson *et al*., 1995; Mahgoub *et al*., 2002; Todaro *et al*., 2004; Santos *et al*., 2007; Nudda *et al*., 2008), the fatty acid composition of muscle and internal fat depots of goat kids under organic grazing-based management systems is not known.

The objective of this study was to evaluate the comparative fatty acid composition of muscle and internal fat depots of Payoya goat kids under organic and conventional grazing-based livestock production system.

Material and methods

Study area, experimental farm goats and kids

All goats utilized in this study were of the Payoya breed and located in the Sierra Norte of Cádiz (Andalucía, Spain). There are four organic and twenty seven conventional farms currently working with this breed (Association of Payoya Breeders, unpublished data). To evaluate the technical and economical viability of organic and conventional dairy goat farms of the Andalusian mountains and analyze the transition from conventional to organic production, 18 farms (14 conventional; 4 organic) were selected in collaboration with the Association of Payoya Breeders (Mena *et al*., 2009a,b). Within those farms and for the present study, one farm from each management system (certified organic under EC 834/2007 (EC, 2007) and conventional) was selected. Care and management of goats and kids was in accordance with Spanish Animal Welfare Act 32/2007 (BOE, 2007).

The dams in both experimental farms were raised with similar semi-extensive system based on the grazing of natural pastures (Ríos-Castaño, 2008; Mena *et al.,* 2009a). The systems are characterized by a large land surface per animal, few sanitary problems, and grazing as an integral part of animal feeding, and the main difference is the major consumption of concentrates per animal and year in the conventional farm. In this sense and according to the previous technical characterization of the farms (Ríos-Castaño, 2008), a supplementary feed concentrate was added at a flat rate of 1.0 kg head^{-1} d^{-1} for the conventional farm and at 0.5 kg head^{-1} d^{-1} (organic constituents) for the organic farm (Table 1). On the rangeland, the diet was composed of herbaceous plant species and leaves and stems

Table 1. Proximate chemical composition and fatty acid profile of the concentrate supplements for conventional and organic livestock production systems

	Conventional[a]	Organic[b]
Dry matter (g/100 g)	92	93
Organic matter (g/100 g, DM basis)	93	94
Crude protein (g/100 g, DM basis)	21	19
Ether extract (g/100 g, DM basis)	2	2
Fatty acid profile (% of total FA)		
C8:0	0.07	0.11
C10:0	1.04	1.51
C12:0	0.10	1.25
C13:0	0.04	0.05
C14:0	3.17	4.75
C15:0	0.28	0.49
C16:0	26.56	26.59
C16:1	2.84	3.17
C17:0	0.79	0.67
C17:1	0.50	0.21
C18:0	11.66	9.20
C18:1 n-9 *cis*	18.14	23.04
C18:2 n-6 *trans*	0.10	0.18
C18:2 n-6 *cis*	29.13	21.58
C18:3 n-6 γ	0.07	0.09
C20:0	0.39	0.53
C18:3 n-3 α	2.44	2.88
C20:1 n-9	0.26	0.69
C21:0	0.16	0.15
C20:2	0.26	0.52
C20:3 n-6	0.26	0.43
C20:4 n-6	0.07	0.08
C20:3 n-3	0.59	1.50
C20:5 n-3	0.08	0.17
C22:5 n-3	0.06	0.11
C22:6 n-3	0.04	0.03
SFA[c]	45.16	45.30
MUFA[c]	21.73	27.11
PUFA[c]	33.11	27.58

[a] Supplement ingredients (%): maize grain (26), soybean meal (18.2), wheat grain (12), gluten feed (12), barley grain (10), beet pulp (9.5), sunflower meal (5), sugarcane molasses (2), calcium carbonate (1.8), fat by-pass (1.5), sodium bicarbonate (0.8), salt (0.8), oxide of manganese (0.2), mineral-vitamin supplement (0.2). [b] Supplement ingredients (%): barley grain (74), wheat husk (5), green pea (5), wheat bran (4), carob (4), sunflower seed (5), calcium carbonate (2.5), salt (0.5). [c] SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.

from Mediterranean shrubs and trees (mainly *Mirtus communis*, *Pistacia lentiscus*, *Quercus ilex, Cistus salvifolius* and *Arbutus unedo*).

Twenty-four goat kids of twin births (12 males and 12 females) born in October were selected from each farm (n = 48, 24 for each farm). The kids had free access to suckling 18-20 hours a day. The feedstuff usually is given in the milking parlour, thus goat kids did not have access to the concentrate.

Slaughter, muscle and adipose tissues sampling

All goat kids were slaughtered at a body commercial weight of 8.40 ± 0.06 kg at the Huelva municipality slaughterhouse after 16.33 ± 0.12 hours of fasting with free water access. After slaughter, carcasses were chilled at 4°C for 24 h and then the left half of each carcass was removed according to the procedure of

Colomer-Rocher *et al*. (1987) and transported under temperature for refrigeration to Huelva University. Prior to dissection on the left half of carcass, the pelvic and kidney fats were removed; vacuum packed and frozen at –20°C until analysis. After the rib joints was obtained, the *Longissimus thoracis* were dissected, vacuum packed and frozen at –20°C until analysis.

Fatty acid composition

After thawing the *Longissimus thoracis* and pelvic and kidney fats, total FA were extracted, methylated and analyzed as described by Aldai *et al*. (2006). Fatty-acid methyl esters were quantified with an Agilent 6890N gas chromatograph (Agilent Technologies Spain, S.L., Madrid, Spain) equipped with a flame ionization detector, an HP 7683 automatic sample injector, and an HP-88 J&W fused silica capillary column (100 m, 0.25 mm i.d., 0.2 µm film thickness; Agilent Technologies Spain, S.L.). Nonadecanoic acid methyl ester (C19:0 methyl ester; 10 mg mL^{-1}) was used as an internal standard. The FA in the supplementary concentrate were extracted and methylated using the one-step procedure described by Sukhija & Palmquist (1988) and then analyzed under the same gas chromatography conditions as those described herein for meat FA.

Fatty-acids were identified by comparing gas chromatograph peak retention times with those of FA methyl ester standards (Component FAME Mix; Supelco 37, Bellefonte, PA, USA). In addition, PUFA were identified by comparison with the PUFA-2 standard (Matreya Inc., Pleasant Gap, PA, USA), a non-conjugated 18:2 isomer mixture comprised of all *cis*-5, 8, 11, 14, 17 C20:5 (eicosapentaenoic acid, EPA), all *cis*-4, 7, 10, 13, 16, 19 C22:6 (docosahexaenoic acid, DHA), all *cis*-5, 8, 11, 14 C20:4 (arachidonic acid, ARA), all *cis*-6, 9, 12 C18:3, and all *cis*-9, 12, 15 C18:3. High-purity CLA *cis*-9, *trans*-11 and *trans*-10, and *cis*-12 (Matreya Inc.) were used as standards to identify these CLA isomers of interest. Additional standard CLA isomers *cis*-9, *cis*-11 C18:2, *trans*-9, *trans*-11 C18:2, *trans*-11, *trans*-13 C18:2 (77% *cis*, *trans*; 2% *cis*, *cis*; 6% *trans*, *trans*) (Matreya Inc.), the CLA mix standard (Nu-Check-Prep, Inc., Elysian, MN), and published isomeric profiles (Kramer *et al*., 2004) were used to identify the other CLA isomers. The relative amount of each FA (% of total FA methyl esters) was reported as a percentage of total peak area for all FA.

After analyses, the FA composition data were grouped as follows: saturated FA (SFA), monounsaturated FA (MUFA), polyunsaturated FA (PUFA), unsaturated FA (UFA), n-3 PUFA, n-6 PUFA, and total CLA (CLA *cis*-9*, trans*-11 + CLA *trans*-10*, cis*-12 + CLA *cis*-9*, cis*-11). Ratios between the different fractions, namely PUFA:SFA, UFA:SFA and n-6:n-3 were calculated. The desaturase activities were estimated indirectly as (product) /(precursor + product). Thus, activity indices of Δ9C16 desaturase [(C16:1 n-9 + C16:1 n-7) / (C16:0 + C16:1 n-9 + C16:1 n-7)], Δ9C18 desaturase [(C18:1 n-9 *cis* + C18:1 n-9 *trans*) / (C18:0 + C18:1 n-9 *cis* + C18:1 n-9 *trans*)], and CLA desaturase index {[C18:2 *cis*-9, *trans*-11 (rumenic acid, RA)] / [C18:1 *trans*-11 (vaccenic acid, VA) + RA]} (Nudda *et al*., 2008) were estimated. Finally, the atherogenicity index (C12:0 + 4 × 14:0 + C16:0) / (MUFA + PUFA) and thrombogenicity index (C14:0 + C16:0 + C18:0) / (0.5 × MUFA + 0.5 × n-6-PUFA + 3 × n-3-PUFA + (n-3-PUFA/n-6-PUFA)] were calculated according to Ulbricht & Southgate (1991).

Statistical analyses

Differences in FA were assessed by analysis of variance using the general linear model (GLM) of the SPSS for Windows 18.0 package (SPSS Inc., Chicago, IL, USA), including the fixed effects of production system and gender. The linear model used for each parameter was as follows:

$$Y_{ijk} = \mu + PS_i + G_j + (PS \times G)_{ij} + \varepsilon_{ijk}$$

where Y_{ijk} = observations for dependent variables; μ = overall mean; PS_i = fixed effect of production system (i = organic system or conventional system); G_j = fixed effect of gender; PS × G = interactions between production system and gender, and ε_{ijk} = random effect of residual.

Results

The contents of C14:0 ($p < 0.05$), C18:1 *trans*-11 (VA) ($p < 0.001$), and several n-3 FA (EPA, DHA and DPA) were greater in organic reared kid meat than in conventionally reared kid meat. In contrast, C16:1 n-7 ($p < 0.05$), C18:0 and CLA desaturase index ($p < 0.01$) were lower in organic kid meat than in conventional meat (Tables 2 to 4). The fat depots from the conventional goat kids showed higher percentage of CLA

Table 2. Fatty acid profile (% of total fatty acids) in the *Longissimus thoracis* muscle of suckling Payoya kids according to livestock production system and gender

Fatty acid[a]	Production system (PS)		Gender (G)		SEM[b]	Effects[c]		
	Conventional	Organic	Male	Female		PS	G	PS × G
Fat (g/100 g)	2.08	1.94	1.99	2.02	0.062	ns	ns	ns
C12:0	0.78	0.90	0.86	0.82	0.043	ns	ns	ns
C14:0	4.57	5.17	4.93	4.81	0.128	*	ns	ns
C15:0	0.57	0.49	0.55	0.51	0.055	ns	ns	ns
C16:0	25.61	25.93	25.59	25.95	0.217	ns	ns	ns
C16:1 n-7	2.36	2.01	2.06	2.30	0.076	*	ns	ns
C16:1 n-9	0.42	0.48	0.48	0.42	0.042	ns	ns	ns
C17:0	1.32	1.36	1.29	1.39	0.079	ns	ns	ns
C17:1	0.43	0.43	0.38	0.47	0.021	ns	*	ns
C18:0	16.69	15.12	16.63	15.18	0.303	**	**	ns
C18:1 n-9 *cis*	34.02	33.17	33.00	34.18	0.396	ns	ns	ns
C18:1 *trans*-11 (VA)	0.45	0.62	0.47	0.60	0.028	***	**	ns
C18:2 n-6 *cis*	6.75	7.22	7.09	6.87	0.195	ns	ns	ns
C20:0	0.09	0.48	0.27	0.31	0.036	***	ns	ns
C18:3 n-3	0.35	0.31	0.27	0.39	0.026	ns	*	ns
CLA *cis*-9, *trans*-11 (RA)	0.33	0.25	0.24	0.34	0.023	ns	*	*
CLA *trans*-10, *cis*-12	0.07	0.06	0.06	0.06	0.013	ns	ns	ns
CLA *cis*-9, *cis*-11	0.05	0.05	0.04	0.06	0.009	ns	ns	ns
C21:0	0.05	0.06	0.03	0.07	0.010	ns	ns	ns
C20:3 n-6	0.15	0.15	0.15	0.13	0.010	ns	ns	ns
C20:4 n-6 (ARA)	1.50	1.44	1.50	1.44	0.110	ns	ns	ns
C20:3 n-3	1.82	1.65	1.89	1.59	0.088	ns	ns	ns
C20:5 n-3 (EPA)	0.24	0.41	0.33	0.32	0.035	*	ns	ns
C22:4 n-6	0.25	0.26	0.25	0.26	0.018	ns	ns	ns
C22:5 n-3 (DPA)	0.38	0.79	0.58	0.59	0.049	***	ns	ns
C22:6 n-3 (DHA)	0.10	0.19	0.14	0.15	0.015	**	ns	ns
SFA	49.69	49.51	50.15	49.05	0.270	ns	*	ns
MUFA	37.98	37.18	36.83	38.33	0.325	ns	*	ns
PUFA	12.33	13.31	13.02	12.62	0.250	ns	ns	ns
UFA	50.31	50.49	49.85	50.95	0.268	ns	*	ns
CLA	0.45	0.35	0.34	0.46	0.033	ns	*	ns
n-3	2.90	3.35	3.22	3.03	0.131	ns	ns	ns
n-6	8.63	9.07	8.99	8.71	0.191	ns	ns	ns
n6/n3	3.16	2.84	2.99	3.01	0.100	ns	ns	ns
PUFA/SFA	0.25	0.27	0.26	0.26	0.005	ns	ns	ns
UFA/SFA	1.01	1.02	1.00	1.04	0.011	ns	ns	ns
ΔC16	0.10	0.09	0.09	0.09	0.003	ns	ns	ns
Δ9C18	0.67	0.70	0.67	0.69	0.005	ns	ns	ns
CLA index	0.40	0.28	0.33	0.35	0.023	**	ns	ns
AI	0.89	0.94	0.93	0.91	0.015	ns	ns	ns
TI	1.46	1.39	1.44	1.40	0.023	ns	ns	ns

[a] VA, vaccenic acid; RA, rumenic acid; ARA, arachidonic acid; EPA, eicosapentaenoic acid; DPA, docosapentaenoic acid; DHA, docosahexaenoic acid. SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; UFA, unsaturated fatty acids; CLA, total conjugated linoleic acid, CLA *cis*-9, *trans*-11 + CLA *trans*-10, *cis*-12 + CLA *cis*-9, *cis*-11; n-3, all fatty acids with last double bond at 3rd carbon from the methyl end; n-6, all fatty acids with the last double bond at 6th carbon from the methyl end; Δ9C16, Δ9C16 desaturase index = (C16:1 n-9 + C16:1 n-7) / (C16:0 + C16:1 n-9 + C16:1 n-7); Δ9C18, Δ9C18 desaturase index = (C18:1 n-9 *cis* + C18:1 n-9 *trans*) / (C18:0 + C18:1 n-9 *cis* + C18:1 n-9 *trans*); CLA index, CLA desaturase index = (RA) /(VA + RA); AI, atherogenicity index = (C12:0 + 4 × 14:0 + C16:0) / (MUFA + PUFA); TI, thrombogenicity index =(C14:0 +C16:0 + C18:0) / [(0.5 × MUFA + 0.5 × n-6-PUFA + 3 × n-3-PUFA + (n-3-PUFA/n-6-PUFA)]. [b] Standard error of mean. [c] * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ns: not significant, $p > 0.05$. n = 48, 24 for each farm and each gender.

Table 3. Fatty acid profile (% of total fatty acids) in the kidney adipose tissue of suckling Payoya kids according to livestock production system and gender

Fatty acid[a]	Production system (PS)		Gender (G)		SEM[b]	Effects[c]		
	Conventional	Organic	Male	Female		PS	G	PS × G
Perirenal fat (g, left side)	57.17	53.57	48.81	61.93	3.092	ns	*	ns
C12:0	0.80	0.93	0.92	0.81	0.041	ns	ns	ns
C14:0	7.47	7.81	7.76	7.52	0.145	ns	ns	ns
C15:0	0.43	0.41	0.42	0.41	0.014	ns	ns	ns
C16:0	26.47	27.27	26.82	26.92	0.219	ns	ns	ns
C16:1 n-9	0.84	0.86	0.85	0.85	0.014	ns	ns	ns
C17:0	0.86	0.88	0.86	0.88	0.015	ns	ns	ns
C17:1	0.32	0.37	0.34	0.35	0.010	*	ns	ns
C18:0	24.55	23.48	23.92	24.12	0.234	*	ns	ns
C18:1 n-9 *cis*	30.87	31.41	31.01	31.28	0.195	ns	ns	ns
C18:1 n-9 *trans*	0.82	0.64	0.74	0.73	0.024	***	ns	ns
C18:1 *trans*-11 (VA)	2.05	1.37	1.69	1.73	0.070	***	ns	ns
C18:2 n-6 *trans*	0.23	0.18	0.22	1.19	0.009	ns	*	ns
C18:2 n-6 *cis*	1.71	1.66	1.75	1.62	0.032	ns	*	**
C20:0	0.20	0.23	0.23	0.20	0.007	ns	ns	ns
C18:3 n-3	0.15	0.35	0.26	0.25	0.016	***	ns	ns
CLA *cis*-9, *trans*-11 (RA)	0.67	0.52	0.57	0.62	0.018	**	ns	ns
CLA *trans*-10, *cis*-12	0.02	0.02	0.02	0.02	0.001	ns	ns	ns
C21:0	0.02	0.02	0.03	0.02	0.001	ns	ns	ns
C20:3 n-6	0.02	0.02	0.02	0.02	0.001	ns	ns	ns
C20:4 n-6 (ARA)	0.10	0.09	0.09	0.10	0.003	ns	ns	ns
C20:3 n-3	0.01	0.01	0.01	0.01	0.000	ns	ns	ns
C20:5 n-3 (EPA)	0.04	0.03	0.04	0.03	0.002	ns	ns	ns
C22:5 n-3 (DPA)	0.11	0.15	0.13	0.13	0.005	***	ns	ns
C22:6 n-3 (DHA)	0.03	0.05	0.04	0.04	0.002	***	ns	ns
SFA	61.50	61.77	61.70	61.57	0.202	ns	ns	ns
MUFA	35.34	35.10	35.08	35.36	0.186	ns	ns	ns
PUFA	3.16	3.13	3.22	3.07	0.042	ns	ns	ns
UFA	38.50	38.23	38.30	38.43	0.202	ns	ns	ns
CLA	0.69	0.54	0.59	0.64	0.018	***	ns	ns
n-3	0.35	0.59	0.48	0.46	0.020	***	ns	ns
n-6	2.07	1.97	2.11	1.94	0.036	ns	*	*
n6/n3	5.90	3.43	4.70	4.63	0.200	***	ns	ns
PUFA/SFA	0.05	0.05	0.05	0.05	0.001	ns	ns	ns
UFA/SFA	0.63	0.62	0.62	0.62	0.005	ns	ns	ns
Δ9C16	0.03	0.03	0.03	0.03	0.000	ns	ns	ns
Δ9C18	0.58	0.59	0.58	0.58	0.002	ns	ns	ns
CLA index	0.25	0.28	0.26	0.27	0.007	*	ns	ns
AI	4.26	4.55	4.48	4.34	0.091	ns	ns	ns
TI	2.94	2.85	2.89	2.90	0.025	ns	ns	ns

[a,b,c]: see Table 2.

($p < 0.001$), lower CLA desaturase index ($p < 0.05$), lower percentage of n-3 PUFA ($p < 0.001$) and, consequently, higher n6:n3 PUFA ratio ($p < 0.001$) than organic kids. Also, the conventional kids displayed a greater percentage of C18:0 ($p < 0.05$) in the perirenal fat and a major percentage of C18:1 trans-11 (VA) ($p < 0.001$) in both fat depots, than organic kids. Conjugated linoleic acid *cis*-9, *cis*-11 was not detected in fat depots.

Gender has a low impact on goat kid meat quality. In meat from female goat kids, the proportions of C17:1, C18:3 n-3, ($p < 0.05$) and C18:1 *trans*-11

Table 4. Fatty acid profile (% of total fatty acids) in the pelvic adipose tissue of suckling Payoya kids according to livestock production system and gender

Fatty acid[a]	Production system (PS)		Gender (G)		SEM[b]	Effects[c]		
	Conventional	Organic	Male	Female		PS	G	PS × G
Pelvic fat (g, left side)	7.25	8.65	8.58	7.32	0.471	ns	ns	ns
C12:0	0.74	0.92	0.86	0.81	0.002	**	ns	ns
C14:0	7.36	8.09	7.79	7.64	0.141	**	ns	ns
C15:0	0.39	0.41	0.40	0.40	0.012	ns	ns	ns
C16:0	26.35	27.18	26.70	26.82	0.290	ns	ns	ns
C16:1 n-9	0.86	0.88	0.84	0.91	0.018	ns	*	ns
C17:0	0.85	0.85	0.84	0.86	0.011	ns	ns	ns
C17:1	0.36	0.37	0.35	0.37	0.007	ns	ns	ns
C18:0	23.47	22.30	22.95	22.85	0.339	ns	ns	ns
C18:1 n-9 *cis*	31.75	32.33	32.11	31.96	0.283	ns	ns	ns
C18:1 n-9 *trans*	0.69	0.71	0.68	0.71	0.020	ns	ns	ns
C18:1 *trans*-11 (VA)	2.36	1.30	1.74	1.95	0.108	***	ns	*
C18:2 n-6 *trans*	0.21	0.16	0.18	0.19	0.008	ns	ns	ns
C18:2 n-6 *cis*	1.80	1.67	1.76	1.72	0.043	ns	ns	ns
C20:0	0.24	0.23	0.24	0.22	0.005	ns	ns	ns
C18:3 n-3	0.18	0.38	0.29	0.27	0.017	***	ns	ns
CLA *cis*-9, *trans*-11 (RA)	0.64	0.52	0.55	0.60	0.018	***	ns	ns
CLA *trans*-10, *cis*-12	0.04	0.03	0.04	0.03	0.003	ns	ns	ns
C21:0	0.04	0.03	0.03	0.03	0.002	ns	ns	ns
C20:3 n-6	0.02	0.02	0.02	0.02	0.001	ns	ns	ns
C20:4 n-6 (ARA)	0.11	0.10	0.10	0.11	0.003	ns	ns	ns
C20:3 n-3	0.02	0.01	0.01	0.02	0.001	ns	ns	ns
C20:5 n-3 (EPA)	0.09	0.03	0.06	0.05	0.006	***	ns	ns
C22:5 n-3 (DPA)	0.11	0.17	0.13	0.14	0.007	***	ns	ns
C22:6 n-3 (DHA)	0.04	0.05	0.04	0.05	0.003	ns	ns	ns
SFA	60.12	60.72	60.50	60.32	0.279	ns	ns	ns
MUFA	36.52	36.05	36.21	36.37	0.266	ns	ns	ns
PUFA	3.36	3.22	3.28	3.30	0.055	ns	ns	ns
UFA	39.88	39.28	39.50	39.68	0.279	ns	ns	ns
CLA	0.68	0.55	0.59	0.63	0.019	***	ns	ns
n-3	0.43	0.65	0.54	0.53	0.020	***	ns	ns
n-6	2.18	1.98	2.10	2.07	0.050	ns	ns	ns
n6/n3	5.34	3.14	4.21	4.21	0.240	***	ns	ns
PUFA/SFA	0.06	0.05	0.05	0.05	0.001	ns	ns	ns
UFA/SFA	0.66	0.65	0.65	0.66	0.008	ns	ns	ns
Δ9C16	0.03	0.03	0.03	0.03	0.001	ns	ns	ns
Δ9C18	0.60	0.61	0.60	0.60	0.004	ns	ns	ns
CLA index	0.22	0.29	0.25	0.25	0.007	***	ns	ns
AI	4.04	4.46	4.28	4.21	0.097	*	ns	ns
TI	2.75	2.71	2.73	2.73	0.033	ns	ns	ns

[a,b,c]: see Table 2.

($p < 0.01$) were greater and C18:0 was lower ($p < 0.01$) than in male goat kids. Meat from female goat kids had higher percentages of MUFA, UFA and CLA ($p < 0.05$) and lower SFA percentage ($p < 0.05$) than meat from males. Meat from conventionally reared female goat kids had higher CLA *cis*-9, *trans*-11 (RA) content than meat from conventionally reared males or organically reared males or females ($p < 0.05$). Regarding the fat depots, no differences between male and female kids were observed for the most studied parameters; there were only differences between groups for C18:2 n-6 *cis*, C18:2 n-6 *trans* and n-6 PUFA ($p < 0.05$) in the kidney fat, and for C16:1 n-9 ($p < 0.05$) in the pelvic fat.

Discussion

The FA ratio (C16:0, C18:0 and C18:1 n-9 *cis*) in the muscle tissue and fat depots of goat kids were in the range of those reported for unweaned ruminants (Mahgoub *et al*., 2002; Todaro *et al*., 2004; Santos *et al*., 2007; Nudda *et al*., 2008; Horcada *et al.,* 2012) and weaned ruminants (Bas *et al*., 2005) and were also similar to those reported for other red-meat animal species (Banskalieva *et al*., 2000). Differences in FA composition between fat depots of farm animals have been demonstrated (Duncan & Garton, 1967). Generally, there is a progressive increase in saturation from peripheral to deep sites in farm animals (Wood, 1984; Casey & Van Niekerk, 1985; Potchoiba *et al.,* 1990).

In the present study, the kids were fed exclusively with milk by suckling their dams, and even though the suckled milk is the main factor that influence the FA composition, since milk composition was not monitored, this will have to be tested in future studies. However, it seems opportune to discuss the feeding of the dams (the principal difference is the major consumption of concentrates per animal and year in the conventional farm, see M&M) and how it influences the milk composition. In fact, during the suckling phase, when goat kids are functionally non-ruminants, no ruminal biohydrogenation of the milk FA occurs prior to absorption by the intestine; thus, differences in the meat FA profile reflects the FA profile of the suckled milk (Sanz Sampelayo *et al*., 2006; Nudda *et al.*, 2008). The C18:2 n-6, C18:3 n-3 and total PUFA ratios were similar to those reported in other goat studies (Banskalieva *et al*., 2000; Mahgoub *et al*., 2002; Todaro *et al*., 2004; Bas *et al*., 2005; Werdi Pratiwi *et al*., 2007). Nevertheless, these proportions were lower than those reported in other studies (Yeom *et al*., 2002; Nudda *et al*., 2008), likely due to the higher concentration of C18:2 n-6 and C18:3 n-3 FA in the supplemented feed to the dams.

In the present study, the CLA content in muscle and fat depots was similar or slightly higher than that reported by Todaro *et al*. (2004) in pelvic fat from suckling kids, but was lower than that reported for the intramuscular fat of suckling kids from lactating dams on diets supplemented with concentrates rich in C18:2 and C18:3 (Nudda *et al*., 2008) or in PUFA-rich protected fat (Sanz Sampelayo *et al.*, 2006). Also was lower than that reported in intramuscular fat depot by Horcada *et al.* (2012) in different Spanish breeds; however, the authors did not specify in detail the feeding management, especially with regard to food supplemented, which would be important to explain the differences found. Although grazing animals on grass pasture have higher CLA concentrations in their milk (Atti *et al*., 2006; Butler *et al*., 2008; D'Urso *et al*., 2008; Lucas *et al*., 2008; Pajor *et al*., 2009) and meat (Caputi *et al.,* 2007; Paradis *et al.,* 2008; Talpur *et al.,* 2008), compared to non or low grazing animals; the feeding on Mediterranean shrublands or a diet containing tannins did not increase the milk (Tsiplakou *et al*., 2006; Mancilla-Leytón *et al*., 2013; Delgado-Pertíñez *et al*., 2013) or meat (Vasta *et al*., 2007) CLA contents. These results could be due to effects of tannins on ruminal biohydrogenation (Vasta *et al*., 2009, 2010) and although in present study goat kids were fed exclusively by suckling, this could explain the lack of effect showed on meat. High CLA concentrations can also be achieved by high-concentrate diets supplemented with whole oily seeds or their oils (Sanz Sampelayo *et al*., 2007; Nudda *et al*., 2008). Nudda *et al*. (2008) also observed strong relationships between the concentrations of VA, RA and linolenic acid in the muscle of suckling kids and those in their mothers' milk. This way, the higher intake of concentrate enriched by C18:2 and PUFA in the conventional lactating does, due to the ingredients of the concentrate (*i.e.* 18% of soybean meal, see Table 1), could explain the higher CLA content in the conventional kids in the fat depots. Moreover, in the present study we have shown higher CLA desaturase index of the muscle of the kids from the conventional system than the kids from the organic system. However, the opposite happened for the fat depots. This might be explained because for kids suckling from goats fed on concentrate-rich diets, VA desaturation to CLA primarily occurs in the muscle rather than the mammary gland (Nudda *et al*., 2008), probably in response to an increase in desaturase gene expression induced by insulin (Daniel *et al*., 2004), and this could explain the greater value of CLA desaturase index in the muscle of the conventional kids. Nevertheless, lower desaturase activity associated with higher content of RA in milk fat (Morales *et al*., 2000) and in tissues (Palmquist *et al*., 2004) has been reported, and that might explain the lower desaturase activity in fat depots of the conventional kids. These differences between tissues suggest a different metabolic control of the fat deposition and needs to be determined in future studies.

The n-3 FAs are considered the most important dietary FA for human health. Current human health recommendations include a dietary n-6:n-3 FA optimum of 2.0-2.5, but most human foodstuffs have a ratio nearer to 5.0-10.0 (MacRae *et al*., 2005). In the present study, the n-6 PUFA:n-3 PUFA ratio was lower than those reported in other studies on goats (Todaro *et al*., 2004; Sanz Sampelayo *et al*., 2006; Nudda *et al.,* 2008) but was comparable to those reported for the fat depots and muscles of grazing goats (Bas *et al*., 2005; Horcada *et al.,* 2012). In addition, organic kid meat and specially the fat depots displayed higher percentages of n-3 FAs than conventionally reared meat, which might be a consequence of high pasture intake by organically managed dams due to reduced feedstuff supplementation. In this regard, goats fed on rangeland (herbaceous plants, leaves and shrubs) (Bas *et al*., 2005) and sheep fed on grass pasture (Bas & Morand-Fehr, 2000) have shown to have higher n-3 FA ratios in fat and muscle than animals fed diets based on concentrate. Also, because of potentially increased risks of atherogenicity of C16:0, fat with a high atherogenicity index is assumed to be detrimental to human health (Ulbricht & Southgate, 1991). Except for pelvic fat, in this study there were no significant differences between the atherogenicity index in goat kid from organic or conventional managed dams. There are no known values of this index in studies of goats, nevertheless, the index values for both groups were lower that those reported in milk of sheep fed Mediterranean forages (Addis *et al*., 2005). The low fat content and FA profile (especially the PUFA content and the n-6:n-3 PUFA ratio) of meat from kids reared in both production systems indicates the beneficial characteristics of this meat with respect to human health.

Gender effects on the FA profile in meat are inconsistent (Banskalieva *et al*., 2000). No or minimal effects of gender on the FA profiles in meat (Nudda *et al*., 2008) or fat depots (Rojas *et al*., 1994; Mahgoub *et al*., 2002; Todaro *et al*., 2004) have been reported. In agreement with our results, Banskalieva *et al*. (2000) reported higher levels of C18:1 and lower levels of C18:0 in meat from females than males. Mahgoub *et al*. (2002) and Santos *et al*. (2007) reported that meat from males had higher levels of C15, C18:2 and C18:3 but lower levels of total C10, C14, C16, C18 and C18:1 than meat from females. The effects of sex on FA composition are reduce and may be explained in terms of differences in overall fat contents (Wood, 1984). The overall fat content of the animal and muscle have an important impact on proportionate fatty acid composition because of the different fatty acid compositions of neutral lipid and phospholipid (Wood *et al*., 2008). The major lipid class in adipose tissue (> 90%) is triacylglycerol or neutral lipid. In muscle, a significant proportion is phospholipid, which has a much higher PUFA content in order to perform its function as a constituent of cellular membranes (Wood *et al*., 2008). In the present study, minimal effects in fat depots have been obtained, in agreement with the results of Matsuoka *et al*. (1997) for Japanese Saanen goats which show that sex differences in fatty acid composition are more pronounced in phospholipids than in neutral lipids.

The results obtained in the present experiment indicates that the muscle and adipose tissues of suckling kids, coming from organic and conventional livestock production systems, are different only in some FA percentages. This fact could be due because the dams, in both experimental farms, were managed in a similar way based on the grazing of natural pastures. As consequence, conventional grazing-based management farms could be easily transformed into organic production livestock's. The effect of sex on FA profile was reduced.

Acknowledgments

The authors are grateful to Instituto Andaluz de Investigación y Formación Agraria, Pesquera, Alimentaria y de la Producción Ecológica from Consejería de Agricultura y Pesca de la Junta de Andalucía for the financial support granted through proposal No. 75 (Expdte.: 92162/1). The authors are also grateful to goat farmers Daniela Hinojo Antille and Francisco Marín for their collaboration.

References

Addis M, Cabiddu A, Pinna G, Decandia M, Piredda G, Pirisi A, Molle G, 2005. Milk and cheese fatty acid composition in sheep fed Mediterranean forages with reference to conjugated linoleic acid *cis*-9*, trans*-11. J Dairy Sci 88: 3443-3454.

Aldai N, Osoro K, Barron LJR, Nájera AI, 2006. Gas-liquid chromatographic method for analysing complex mixtures of fatty acids including conjugated linoleic acids (*cis*9-

*trans*11 and *trans*10-*cis*12 isomers) and long-chain (n-3 or n-6) polyunsaturated fatty acids – Application to the intramuscular fat of beef meat. J Chromatography 1110(A): 133-139.

Atti N, Rouissiand H, Othmane MH, 2006. Milk production, milk fatty acid composition and conjugated linoleic acid (CLA) content in dairy ewes raised on feedlot or grazing pasture. Livest Sci 104: 121-127.

Banskalieva V, Sahlu T, Goetsch AL, 2000. Fatty acid composition of goat muscle fat depots: a review. Small Rumin Res 37: 255-268.

Bas P, Morand-Fehr P, 2000. Effect of nutritional factors on fatty acid composition of lamb fat deposits. Livest Prod Sci 64: 61-79.

Bas P, Dahbi E, El Aich A, Morand-Fehr P, Araba A, 2005. Effect of feeding on fatty acid composition of muscles and adipose tissues in young goats raised in the Argan tree forest of Morocco. Meat Sci 71: 317-326.

BOE, 2006. APA/661/2006, Order of 3 March, by replacing the annex to Royal Decree 1682/1997 of 7 November, which updates the Catalog Livestock Breeds of Spain. Boletín Oficial del Estado 59, 10 March 2006, pp: 9656-9657. [In Spanish].

BOE, 2007. Spanish Animal Welfare Act 32/2007: Caring of animals during the production time, transport, experimentation and slaughter time. Boletín Oficial del Estado 268, 8 November 2007, pp: 45914-45920. [In Spanish].

Butler G, Nielsen JH, Slots T, Seal C, Eyre MD, Sanderson R, Leifert C, 2008. Fatty acid and fat-soluble antioxidant concentrations in milk from high- and low-input conventional and organic systems: seasonal variation. J Sci Food Agric 88: 1431-1441.

Caputi Jambrenghi A, Colonna MA, Giannico F, Cappiello G, Vonghia G, 2007. Effect of goat production systems on meat quality and conjugated linoleic acid (CLA) content in suckling kids. Ital. J Anim Sci 6 (suppl 1): 612-614.

Casey NH, Van Niekerk WA, 1985. Fatty acid composition of subcutaneous and kidney fat depots of Boer goats and the response to varying levels of maize meal. South Afr J Anim Sci 15: 60-62.

Colomer-Rocher F, Morand-Fehr P, Kirton H, 1987. Standard methods and procedures for goat carcass evaluation, jointing and tissue separation. Livest Prod Sci 17: 149-159.

Daniel ZCTR, Richards SE, Salter AM, Buttery PJ, 2004. Insulin and dexamethasone regulate stearoyl-CoA desaturase mRNA levels and fatty acid synthesis in ovine adipose tissue explants. J Anim Sci 82: 231-237.

Delgado-Pertíñez M, Gutiérrez-Peña R, Mena Y, Fernández-Cabanás VM, Laberye D, 2013. Milk production, fatty acid composition and vitamin E content of Payoya goats according to grazing level in summer on Mediterranean shrublands. Small Rumin Res. [In press].

Duncan WRH, Garton GA, 1967. The fatty acid composition and intramuscular structure of triglycerides derived from different sites in the body of the sheep. J Sci Food Agr 18: 99-102.

D'Urso S, Cutrignelli MI, Calabro S, Bovera F, Bovera, Tudisco R, Piccolo V, Infascelli F, 2008. Influence of pasture on fatty acid profile of goat milk. J Anim Phys Anim Nut 92: 405-410.

EC, 2007. Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. DO L 189, 20-7-2007.

Hermansen JE, 2003. Organic livestock production systems and appropriate development in relation to public expectations. Livest Prod Sci 80 (1-2): 3-15.

Horcada A, Ripoll G, Alcalde MJ, Sañudo C, Teixeira A, Panea B, 2012. Fatty acid profile of three adipose depots in seven Spanish breeds of suckling kids. Meat Sci 92: 89-96.

Johnson DD, McGowan CH, Nurse G, Anous MR, 1995. Breed type and sex effects on carcass traits, composition and tenderness of young goats. Small Rumin Res 17: 57-63.

Kramer JKG, Cruz-Hernández C, Deng ZY, Zhou JQ, Jahreis G, Dugan MER, 2004. Analysis of conjugated linoleic acid and trans 18:1 isomers in synthetic and animal products. Am J Clin Nutr 79(6): 1137-1145.

Lucas A, Coulon JB, Agabriel C, Chilliard Y, Rockd R, 2008. Relationships between the conditions of goat's milk production and the contents of some components of nutritional interest in Rocamadour cheese. Small Rumin Res 74: 91-106.

MacRae J, O'Reilly L, Morgan P, 2005. Desirable characteristics of animal products from a human health perspective. Livest Prod Sci 94: 95-103.

Mahgoub O, Khan AJ, Al-Maqbaly RS, Al-Sabahi JN, Annamalai K, Al-Sakry NM, 2002. Fatty acid composition of muscle and fat tissues of Omani Jebel Akhdar goats of different sexes and weights. Meat Sci 61: 381-387.

MAGRAMA, 2011. Anuario de Estadísticas agrarias on-line 2011. Ministerio de Medio Ambiente y Medio Rural y Marino. Available in http://www.magrama.gob.es/estadistica/pags/anuario/2011/AE_2011_15.pdf. Consulted in July, 2013. [In Spanish].

MAGRAMA, 2012. Informe Ovino-Caprino on-line 2012. Ministerio de Agricultura, Alimentación y Medio Ambiente. Available in http://www.magrama.gob.es/es/estadisticas-agrarias/Informe_de_Ovino-Caprino_2012_tcm7-286211.pdf. Consulted in July, 2013. [In Spanish].

Mancilla-Leytón JM., Martín Vicente A, Delgado-Pertíñez M, 2013. Summer diet selection of dairy goats grazing in a Mediterranean shrubland and the quality of secreted fat. Small Rumin Res 113: 437-445.

Matsuoka A, Furokawa N, Takahashi T, 1997. Carcass traits and chemical composition of meat in male and female goats. J Agric Sci 42: 127-135.

Mena Y, Castel JM, Caravaca FP, Guzmán JL, González P, 2005. Situación actual, evolución y diagnóstico de los sistemas semiextensivos de producción caprina en Andalucía Centro-Occidental. Ed Consejería de Agricultura y Pesca, Junta de Andalucía, Sevilla, Spain. [In Spanish].

Mena Y, Ligero M, Ruiz FA, Nahed J, Castel JM, Acosta JM, Guzmán JL, 2009a. Organic and conventional dairy goat production systems in Andalusian mountainous areas. Opt Mediterr A 91: 253-256.

Mena Y, Nahed J, Ruiz FA, Castel JM, Ligero M, 2009b. Proximity to the organic model of dairy goat systems in the Andalusian mountains (Spain). Trop Subtrop Agroec 11: 69-73.

Morales MS, Palmquist DL, Weiss WP, 2000. Effects of fat source and copper on unsaturation of blood and milk triacylglycerol fatty acids in Holstein and Jersey cows. J Dairy Sci 83: 2105-2111.

Nudda A, Palmquist DL, Battacone G, Fancellu S, Rassu SPG, Pulina G, 2008. Relationships between the contents of vaccenic acid, CLA and n-3 fatty acids of goat milk and the muscle of their suckling kids. Livest Sci 118: 195-203.

Pajor F, Gallo O, Steiber O, Tasi J, Poti P, 2009. The effect of grazing on the composition of conjugated linoleic acid isomers and other fatty acids of milk and cheese in goats. J Anim Feed Sci 18(3): 429-439.

Palmquist DL, St-Pierre N, McClure KE, 2004. Tissue fatty acids profiles can be used to quantify endogenous rumenic acid synthesis in lambs. J Nutr 134: 2407-2414.

Paradis C R, Lafrenière C, Gervais R, Chouinard PY, 2008. Conjugated linoleic acid content in adipose tissue of calves suckling beef cows supplemented with raw or extruded soybeans on pasture. J Anim Sci 86: 1624-1636.

Potchoiba MJ, Lu CD, Pinkerton F, Sahlu T, 1990. Effects of all-milk diet on weight gain, organ development, carcass characteristics and tissue composition, including fatty acids and cholesterol contents, of growing male goats. Small Rumin Res 3(6): 583-592.

Ríos Castaño P, 2008. Profundización en el manejo alimentario de las cabras de raza Payoya en pastoreo: estrategias para conseguir un manejo más ecológico. Proyecto fin de carrera. Universidad de Sevilla. 147 pp. [In Spanish].

Rojas A, López-Bote C, Rota A, Martín L, Rodríguez PL, Tovar JJ, 1994. Fatty acid composition of Verata goat kids fed either goat milk or commercial milk replacer. Small Rumin Res 14(1): 61-66.

Ruiz FA, Castel JM, Mena Y, Camúñez J, González-Redondo P, 2008. Application of the technico-economic analysis for characterizing, making diagnoses and improving pastoral dairy goat systems in Andalusia (Spain). Small Rumin Res 77: 208-220.

Santos VAC, Silva AO, Cardoso JVF, Silvestre AJD, Silva SR, Martins C, Azevedo JMT, 2007. Genotype and sex effects on carcass and meat quality of suckling kids protected by the PGI "Cabrito de Barroso". Meat Sci 75: 725-736.

Sanz Sampelayo MR, Fernández JR, Ramos E, Hermoso R, Gil Extremera F, Boza J, 2006. Effect of providing a polyunsaturated fatty acid-rich protected fat to lactating goats on growth and body composition of suckling goat kids. Anim Sci 82: 337-344.

Sanz Sampelayo MR, Chilliard Y, Schmidely Ph, Boza J, 2007. Influence of type of diet on the fat constituents of goat and sheep milk. Small Rumin Res 68: 42-63.

Sukhija PS, Palmquist DL, 1988. Rapid method of determination of total fatty acid content and composition of feedstuff and faeces. J Agr Food Chem 36: 1202-1206.

Talpur FN, Bhanger MI, Sherazi STH, 2008. Intramuscular fatty acid profile of longissimus dorsi and semitendinosus muscle from Pateri goats fed under traditional feeding systems of SINDO, Pakistan. Meat Sci 80: 819-822.

Todaro M, Corrao A, Alicata ML, Schinelli R, Giaccone P, Priolo A, 2004. Effects of litter size and sex on meat quality traits of kid meat. Small Rumin Res 54: 191-196.

Tsiplakou E, Mountzouris KC, Zervas G, 2006. Concentration of conjugated linoleic acid in grazing sheep and goat milk fat. Lives Sci 103: 74-84.

Ulbricht TLV, Southgate DAT, 1991. Coronary heart disease: seven dietary factors. The Lancet 338: 49-56.

Vasta V, Pennisi P, Lanza M, 2007. Intramuscular fatty acid composition of lambs given a tanniniferous diet with or without polyethylene glycol supplementation. Meat Sci 76: 739-745.

Vasta V, Makkar HPS, Mele M, Priolo A, 2009. Ruminal biohydrogenation as affected by tannins *in vitro.* Brit J Nut 102: 82-92.

Vasta V, Yáñez-Ruiz RD, Mele M, Serra A, Luciano G, Lanza M, Biondi L, Priolo A, 2010. Bacterial and protozoal communities and fatty acid profile in the rumen of sheep fed a diet containing added tannins. Appl Environ Microbiol 76(8): 2549-2555.

Werdi Pratiwi NM, Murray PJ, Taylor DG, 2007. Feral goats in Australia: A study on the quality and nutritive value of their meat. Meat Sci 75: 168-177.

Wood JD, 1984. Fat deposition and the quality of fat tissue in meat animals. In: Fats in animal nutrition (Wisseman JW, ed), Butterworths, London. pp: 407-435.

Wood JD, Enser M, Fisher AV, Nute GR, Sheard PR, Richardson RI, Hughes SI, Whittington FM, 2008. Fat deposition, fatty acid composition and meat quality: a review. Meat Sci 78: 343-358.

Yeom KH, Van Trierum G, Hovenier R, Schelligerhout AB, Lee KW, Beynen AC, 2002. Fatty acid composition of adipose tissue in goat kids fed milk replacers with different contens of α-linolenic and linoleic acid. Small Rumin Res 43: 15-22.