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Fatty acid composition of muscle and adipose tissues of organic and conventional Blanca Andaluza suckling kids

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Abstract

Interest in the preservation of autochthonous breeds such as the Blanca Andaluza goat (meat breed), raised under grazing-based management, has recently increased among Spanish farmers. A study of the possibilities of transformation to organic production needs to analyze the quality of their products. The aim of this study was to evaluate the fatty acid (FA) composition of muscle and adipose tissues of Blanca Andaluza goat kids under organic and conventional grazing-based management system. Twenty-four twin kids (12 males, 12 females) were selected from each system. The FA profile was determined in the *longissimus thoracis* muscle, kidney and pelvic fat. The percentages of C17:0, C17:1, C20:1, C20:4 *n*-6, C22:2 and several *n*-3 FAs were higher in organic meat; C12:0, C18:1 *trans*-11, CLA and C20:5 *n*-3 were lower in organic meat. The fat depots from the conventional kids showed lower percentages of C12:0, C14:0, C15:0, C17:0, C17:1, C18:3 *n*-3 and atherogenicity index, and higher percentage of C18:0. In the pelvic fat, the conventional kids displayed lower percentages of C16:0, C18:2 *n*-6 *cis*, PUFA, *n*-3 and *n*-6 FAs, and greater percentages of C18:1 *n*-9 *cis* and MUFA. The conventional kids displayed a major n6:n3 ratio in the kidney fat. No gender differences were observed. 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, and due to this reason conventional grazing-based management farms could easily be transformed into organic production.

Additional key words: CLA; grazing; *n*-3 fatty acids; meat.

Introduction

In Spain there are 6,074 organic farms and Andalusia (in Southern Spain) contains the majority of these with 3,683 farms. Also, among countries in the European Union, Spain has the second highest goat head number (2.6 million) and Andalusia 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); 375 of which are meat production farms and 23 dairy farms (MAGRAMA, 2011). Organic farming is of particular interest in the Mediterranean area, where it may play a role in safeguarding agricultural functions and preserving rural villages, with positive effects on the quality of life in these communities.

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 Blanca Andaluza goat (meat breed), 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 Andalusia's mountain

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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).

zones. According to organic production system requirements, mountain goat systems, in which feeding is largely based on grazing (Ruiz *et al*., 2008), could 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 suckling kids meat.

The majority of goat farms raising the Blanca Andaluza breed are located in Andalusia's mountain zones. This breed is not as important economically or in census terms as the Malagueña or the Murciano-Granadina, but it is the one that best represents meat goat production linked to grazing. The main objective of these farms is the meat where kids must weigh 8-9 kg at slaughter. The reduced live weight at slaughter is owed to the lower economic value at higher weights.

Recently, much attention has been given to the manipulation of dietary fatty acids (FA), because of the impact of FA intake on human health. Conjugated linoleic acid (CLA) and polyunsaturated FA (PUFA), especially those of the *n*-3 series, are recognized for their positive effects on the cardiovascular system and their ability to prevent cancer (MacRae *et al*., 2005). Although gender effects on the FA content of goat meat and fat depots have been studied (Mahgoub *et al*., 2002; Todaro *et al*., 2004; Santos *et al*., 2007; Nudda *et al*., 2008; De la Vega *et al.,* 2013), there is little information about the FA composition of muscle and internal fat depots of goat kids under organic grazing-based management systems. In this respect and according to De la Vega *et al.* (2013), significant differences were found only in some FA percentages of muscle and adipose tissues of Payoya suckling kids raised in organic and conventional livestock production systems.

Therefore, the aim of this study was to evaluate the comparative fatty acid composition of muscle and internal fat depots of Blanca Andaluza goat kids, of both sexes, under organic and conventional grazing-based livestock production system.

Material and methods

Study area, experimental farm goats and kids

The study was carried out in Sierra of Huelva (Hinojales, Andalusia, Spain) and all goats included in this study were of the Blanca Andaluza breed. Currently, with this breed there are 16 organic and 33 conventional farms (Blanca Andaluza Breeders' Association, unpublished data). Within those farms, 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 the Spanish Animal Welfare Act 32/2007 (BOE, 2007). Twenty-four twin goat kids (12 males and 12 females) were selected from each farm during the same season. Kids had free access to dams but not to feedstuff.

The dams, in both experimental farms, were raised with similar semi-extensive system based on the grazing of natural pastures. The systems are characterized by a large land surface per animal, abrupt and difficult topography, hard climatology, grazing during all year and supplemented with concentrates only during the suckling phase. The average size of the farms is small (less than 100 breeding female) and, frequently, are mixed flocks/herd (sheep-goats) (Blanca Andaluza Breeders' Association, unpublished data).

In this study, a supplementary feed concentrate was added at a flat rate of 0.6 kg head^{-1} day^{-1} (composed of beans and peas) for the conventional farm and at 0.35 kg head^{-1} day^{-1} (commercial concentrate, organic constituents) for the organic farm (Table 1). On the rangeland, the diet was composed of herbaceous plant species and leaves and stems from Mediterranean shrubs and trees (mainly *Mirtus communis*, *Pistacia lentiscus*, *Quercus ilex, Cistus salvifolius* and *Arbutus unedo*).

Slaughter, muscle and adipose tissues sampling

All goat kids were slaughtered at a body weight of 7.75 ± 0.11 kg at the Huelva municipality slaughterhouse after 21.02 ± 0.32 h 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 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.

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)	88	93
Organic matter (g/100 g, DM basis)	97	94
Crude protein (g/100 g, DM basis)	22	19
Ether extract (g/100 g, DM basis)	1	2
Fatty acid profile (% of total FA)		
C8:0	0.07	0.11
C10:0	0.09	1.51
C12:0	0.07	1.25
C13:0	0.04	0.05
C14:0	0.35	4.75
C15:0	0.12	0.49
C16:0	22.52	26.59
C16:1	0.12	3.17
C17:0	0.2	0.67
C17:1	0.08	0.21
C18:0	9.83	9.20
C18:1 *n*-9 *cis*	24.97	23.04
C18:2 *n*-6 *trans*	0.1	0.18
C18:2 *n*-6 *cis*	35.77	21.58
C18:3 *n*-6 γ	0.1	0.09
C20:0	0.17	0.53
C18:3 *n*-3 α	3.56	2.88
C20:1 *n*-9	0.13	0.69
C21:0	0.35	0.15
C20:2	0.23	0.52
C20:3 *n*-6	0.17	0.43
C20:4 *n*-6	0.35	0.08
C20:3 *n*-3	0.13	1.50
C20:5 *n*-3	0.32	0.17
C22:5 *n*-3	0.11	0.11
C22:6 *n*-3	0.07	0.03
SFA[c]	33.80	45.30
MUFA[c]	25.29	27.11
PUFA[c]	40.91	27.58

[a] Supplement ingredients (%): beans (60), peas (40) and mineral blocks containing trace elements and vitamins. [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.

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). FA 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, USA), 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), 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)], *Δ*9C18 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]} were estimated . Finally, the atherogenicity index (C12:0 + 4 × C14:0 + 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 percentages of the individual FA and the FA groups in the *longissimus thoracis* muscle, pelvic and kidney fats of Blanca Andaluza goat kids stratified by livestock production system and gender are shown from Table 2 to Table 4. No significant differences were found in the majority of individual or group FA analyzed between the two productions systems. The percentages of C17:0 ($p < 0.01$), C17:1, C20:1 ($p < 0.001$), ARA ($p < 0.05$), C22:2 ($p < 0.001$), and several *n*-3 FA (C22:5 *n*-3 —DPA— and DHA) ($p < 0.001$) were higher in organic kid meat than in conventionally reared kid meat. In contrast, C12:0 ($p < 0.01$), C18:1 *trans*-11 ($p < 0.05$), CLA *cis*-9, *trans*-11, CLA total ($p < 0.01$) and EPA ($p < 0.05$) were lower in organic kid meat than in conventional meat.

The fat depots from the conventional goat kids showed lower percentages of C12:0, C14:0, C15:0, C17:0, C17:1, C18:3 *n*-3 ($p < 0.05$) and AI index ($p < 0.01$), and higher percentage of C18:0 ($p < 0.001$) than those from organic kids. In the pelvic fat, the conventional kids displayed lower percentages of C16:0 ($p < 0.001$), C18:2 *n*-6 *cis*, PUFA, *n*-3 FA and *n*-6 FA ($p < 0.05$), and greater percentages of C18:1 *n*-9 *cis* and MUFA ($p < 0.01$) than organic kids. Also, the conventional kids displayed a major n6:n3 PUFA ratio ($p < 0.05$) in the kidney fat depot than organic kids. CLA *cis*-9, *cis*-11 was not detected in fat depots.

Discussion

In the present study, the kids were fed exclusively with milk by suckling their dams. Although 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, we have considered opportune to discuss the feeding of the dams and how it influences the milk composition. Actually, during the suckling phase, when goat kids are functionally non-ruminants, no ruminal biohydrogenation of the milk FA occurs prior to absorption by

Table 2. Profile of fatty acids (% total fatty acids, mean ± SE), in the *longissimus thoracis* muscle of Blanca Andaluza goat kids, stratified by livestock production system and gender

Fatty acid[a]	Production system (PS)		Gender (G)		Significance[b]		
	Conventional (n = 24)	Organic (n = 24)	Male (n = 24)	Female (n = 24)	PS	G	PS × G
Fat (g/100 g)	2.04 ± 0.07	2.02 ± 0.07	2.04 ± 0.07	2.03 ± 0.07	ns	ns	ns
C12:0	0.87 ± 0.06	0.65 ± 0.04	0.77 ± 0.05	0.75 ± 0.06	**	ns	ns
C14:0	4.23 ± 0.19	4.31 ± 0.17	4.44 ± 0.17	4.10 ± 0.18	ns	ns	ns
C15:0	0.43 ± 0.06	0.39 ± 0.04	0.38 ± 0.04	0.44 ± 0.06	ns	ns	ns
C15:1	0.10 ± 0.01	0.13 ± 0.01	0.11 ± 0.01	0.12 ± 0.01	ns	ns	ns
C16:0	25.36 ± 0.29	24.86 ± 0.30	25.01 ± 0.26	25.21 ± 0.33	ns	ns	ns
C16:1 *n*-7	1.96 ± 0.07	1.83 ± 0.11	1.94 ± 0.09	1.85 ± 0.09	ns	ns	ns
C16:1 *n*-9	0.32 ± 0.03	0.37 ± 0.06	0.31 ± 0.03	0.37 ± 0.06	ns	ns	ns
C17:0	0.96 ± 0.07	1.23 ± 0.06	1.16 ± 0.08	1.04 ± 0.07	**	ns	ns
C17:1	0.31 ± 0.02	0.46 ± 0.03	0.39 ± 0.04	0.38 ± 0.03	***	ns	ns
C18:0	18.16 ± 0.41	18.28 ± 0.34	17.98 ± 0.34	18.47 ± 0.40	ns	ns	ns
C18:1 *n*-9 cis	36.64 ± 0.61	35.40 ± 0.61	36.19 ± 0.61	35.86 ± 0.64	ns	ns	ns
C18:1 trans 11 (VA)	0.32 ± 0.03	0.21 ± 0.02	0.28 ± 0.03	0.27 ± 0.03	*	ns	ns
C18:2 *n*-6 cis	4.60 ± 0.26	5.01 ± 0.33	4.90 ± 0.31	4.72 ± 0.29	ns	ns	ns
C20:0	0.21 ± 0.09	0.30 ± 0.13	0.12 ± 0.01	0.40 ± 0.16	ns	ns	ns
C20:1	0.32 ± 0.03	0.48 ± 0.02	0.41 ± 0.03	0.39 ± 0.03	***	ns	ns
C18:3 *n*-3	0.31 ± 0.03	0.37 ± 0.01	0.34 ± 0.02	0.34 ± 0.03	ns	ns	ns
CLA cis 9,trans 11 (RA)	0.32 ± 0.03	0.20 ± 0.01	0.23 ± 0.02	0.29 ± 0.04	**	ns	ns
CLA trans 10,cis 12	0.05 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.06 ± 0.01	ns	ns	ns
CLA cis 9,cis 11	0.05 ± 0.01	0.04 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	ns	ns	ns
C21:0	0.11 ± 0.02	0.07 ± 0.02	0.11 ± 0.02	0.07 ± 0.02	ns	ns	ns
C20:2	0.05 ± 0.01	0.05 ± 0.01	0.05 ± 0.01	0.04 ± 0.01	ns	ns	ns
C20:3 *n*-6	0.17 ± 0.02	0.19 ± 0.02	0.19 ± 0.02	0.17 ± 0.02	ns	ns	ns
C20:4 *n*-6 (ARA)	1.06 ± 0.13	1.54 ± 0.16	1.37 ± 0.17	1.22 ± 0.13	*	ns	ns
C20:3 *n*-3	1.35 ± 0.16	1.34 ± 0.18	1.26 ± 0.15	1.44 ± 0.19	ns	ns	ns
C22:2	0.27 ± 0.03	0.60 ± 0.04	0.45 ± 0.06	0.43 ± 0.04	***	ns	ns
C20:5 *n*-3 (EPA)	0.39 ± 0.05	0.28 ± 0.02	0.33 ± 0.04	0.34 ± 0.04	*	ns	ns
C22:4 *n*-6	0.20 ± 0.03	0.15 ± 0.02	0.16 ± 0.02	0.19 ± 0.03	ns	ns	ns
C22:5 *n*-3 (DPA)	0.73 ± 0.06	1.03 ± 0.08	0.91 ± 0.08	0.85 ± 0.07	**	ns	ns
C22:6 *n*-3 (DHA)	0.09 ± 0.01	0.13 ± 0.01	0.11 ± 0.01	0.12 ± 0.01	**	ns	ns
SFA	50.34 ± 0.34	50.11 ± 0.43	49.96 ± 0.30	50.49 ± 0.45	ns	ns	ns
MUFA	41.04 ± 0.52	40.44 ± 0.63	41.01 ± 0.55	40.47 ± 0.60	ns	ns	ns
PUFA	8.61 ± 0.55	9.45 ± 9.03	9.02 ± 0.60	9.04 ± 0.56	ns	ns	ns
UFA	49.65 ± 0.33	49.89 ± 0.42	50.03 ± 0.29	49.51 ± 0.45	ns	ns	ns
CLA	0.43 ± 0.05	0.28 ± 0.03	0.31 ± 0.03	0.40 ± 0.05	**	ns	ns
n-3	2.88 ± 0.23	3.16 ± 0.25	2.96 ± 0.23	3.09 ± 0.25	ns	ns	ns
n-6	4.97 ± 0.29	5.36 ± 0.035	5.25 ± 0.33	5.08 ± 0.32	ns	ns	ns
n-6:*n*-3	1.81 ± 0.07	1.78 ± 0.08	1.83 ± 0.04	1.77 ± 0.09	ns	ns	ns
PUFA/SFA	0.17 ± 0.01	0.18 ± 0.01	0.18 ± 0.01	0.18 ± 0.01	ns	ns	ns
UFA/SFA	0.98 ± 0.01	0.99 ± 0.01	1.00 ± 0.01	0.98 ± 0.01	ns	ns	ns
Δ9C16	0.08 ± 0.01	0.08 ± 0.01	0.08 ± 0.00	0.08 ± 0.00	ns	ns	ns
Δ9C18	0.67 ± 0.01	0.66 ± 0.01	0.67 ± 0.01	0.66 ± 0.01	ns	ns	ns
CLA index	0.53 ± 0.05	0.53 ± 0.04	0.51 ± 0.04	0.55 ± 0.04	ns	ns	ns
AI	0.87 ± 0.01	0.86 ± 0.02	0.87 ± 0.02	0.85 ± 0.02	ns	ns	ns
TI	1.49 ± 0.03	1.45 ± 0.03	1.47 ± 0.03	1.48 ± 0.03	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, conjugated linoleic acid; Δ9C16, Δ9C16 desaturase index; Δ9C18, Δ9C18 desaturase index; AI, atherogenicity index; TI, thrombogenicity index. [b] * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ns: not significant, $p > 0.05$.

Table 3. Profile of fatty acids (% total fatty acids, mean ± SE), in the kidney adipose tissue of Blanca Andaluza goat kids, stratified by production system and gender

Fatty acid[a]	Production system (PS)		Gender (G)		Significance[b]		
	Conventional (n = 24)	Organic (n = 24)	Male (n = 24)	Female (n = 24)	PS	G	PS × G
Perirenal fat (g, left side)	27.89 ± 5.25	42.65 ± 6.78	32.02 ± 4.54	38.52 ± 7.53	ns	ns	ns
C12:0	0.66 ± 0.05	1.11 ± 0.05	0.94 ± 0.08	0.84 ± 0.06	***	ns	ns
C14:0	6.86 ± 0.22	7.66 ± 0.19	7.24 ± 0.24	7.29 ± 0.20	*	ns	ns
C15:0	0.35 ± 0.02	0.56 ± 0.01	0.46 ± 0.03	0.45 ± 0.03	***	ns	ns
C16:0	26.87 ± 0.21	26.87 ± 0.25	26.84 ± 0.23	26.90 ± 0.23	ns	ns	ns
C16:1 *n*-9	0.72 ± 0.03	0.82 ± 0.02	0.79 ± 0.03	0.76 ± 0.02	ns	ns	ns
C17:0	0.87 ± 0.04	1.05 ± 0.04	0.95 ± 0.05	0.98 ± 0.05	**	ns	ns
C17:1	0.28 ± 0.01	0.45 ± 0.03	0.37 ± 0.03	0.36 ± 0.02	***	ns	ns
C18:0	25.27 ± 0.27	23.21 ± 0.30	23.92 ± 0.35	24.50 ± 0.36	***	ns	ns
C18:1 *n*-9 cis	31.14 ± 0.34	30.75 ± 0.32	31.09 ± 0.33	30.80 ± 0.33	ns	ns	ns
C18:1 *n*-9 trans	0.67 ± 0.03	0.74 ± 0.04	0.72 ± 0.03	0.69 ± 0.05	ns	ns	ns
C18:1 trans-11 (VA)	2.04 ± 0.10	1.86 ± 0.09	2.00 ± 0.10	1.90 ± 0.10	ns	ns	ns
C18:2 *n*-6 trans	0.20 ± 0.02	0.19 ± 0.01	0.22 ± 0.02	0.17 ± 0.01	ns	ns	ns
C18:2 *n*-6 cis	1.40 ± 0.11	1.56 ± 0.07	1.50 ± 0.10	1.46 ± 0.08	ns	ns	ns
C20:0	0.32 ± 0.03	0.31 ± 0.01	0.30 ± 0.02	0.32 ± 0.02	ns	ns	ns
C18:3 *n*-3	0.19 ± 0.02	0.28 ± 0.02	0.25 ± 0.02	0.22 ± 0.02	**	ns	ns
CLA cis-9. trans-11 (RA)	0.57 ± 0.03	0.60 ± 0.02	0.62 ± 0.02	0.55 ± 0.02	ns	ns	ns
CLA trans-10. cis-12	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	ns	ns	ns
C21:0	0.03 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	ns	ns	ns
C20:3 *n*-6	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	ns	ns	ns
C20:4 *n*-6 (ARA)	0.08 ± 0.01	0.06 ± 0.00	0.07 ± 0.01	0.07 ± 0.01	ns	ns	ns
C20:3 *n*-3	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	ns	ns	ns
C20:5 *n*-3 (EPA)	0.06 ± 0.01	0.03 ± 0.00	0.04 ± 0.01	0.04 ± 0.00	ns	ns	ns
C22:5 *n*-3 (DPA)	0.13 ± 0.01	0.14 ± 0.01	0.14 ± 0.01	0.14 ± 0.01	ns	ns	ns
C22:6 *n*-3 (DHA)	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	ns	ns	ns
SFA	61.84 ± 0.30	61.72 ± 0.32	61.46 ± 0.30	62.08 ± 0.31	ns	ns	ns
MUFA	35.36 ± 0.32	35.24 ± 0.31	35.52 ± 0.30	35.08 ± 0.32	ns	ns	ns
PUFA	2.80 ± 0.16	3.04 ± 0.08	3.01 ± 0.14	2.84 ± 0.12	ns	ns	ns
UFA	38.16 ± 0.30	38.28 ± 0.32	38.54 ± 0.30	37.92 ± 0.31	ns	ns	ns
CLA	0.59 ± 0.03	0.62 ± 0.02	0.65 ± 0.02	0.57 ± 0.02	ns	ns	ns
n-3	0.43 ± 0.04	0.51 ± 0.02	0.48 ± 0.04	0.46 ± 0.03	ns	ns	ns
n-6	1.74 ± 0.12	1.87 ± 0.07	1.84 ± 0.12	1.77 ± 0.08	ns	ns	ns
n-6:*n*-3	4.20 ± 0.16	3.71 ± 0.15	3.97 ± 0.17	3.94 ± 0.15	*	ns	ns
PUFA/SFA	0.04 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	0.04 ± 0.00	ns	ns	ns
UFA/SFA	0.62 ± 0.01	0.62 ± 0.01	0.63 ± 0.01	0.61 ± 0.01	ns	ns	ns
Δ9C16	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	ns	ns	ns
Δ9C18	0.57 ± 0.00	0.59 ± 0.00	0.58 ± 0.00	0.58 ± 0.01	ns	ns	ns
CLA index	0.22 ± 0.01	0.25 ± 0.01	0.24 ± 0.01	0.23 ± 0.01	ns	ns	ns
AI	4.14 ± 0.11	4.63 ± 0.10	4.39 ± 0.13	4.38 ± 0.10	**	ns	ns
TI	2.95 ± 0.04	2.84 ± 0.04	2.85 ± 0.04	2.93 ± 0.04	ns	ns	ns

[a,b]: see Table 2.

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 largest percentages of FA (C16:0, C18:0 and C18:1 *n*-9 *cis*) in goat kid muscle tissue and fat depots 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; De la Vega *et al.,* 2013) 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 various sites and fat depots in the body of farm animals have been shown. Generally, there is a progressive

Table 4. Profile of fatty acids (% total fatty acids. mean ± SE), in the pelvic adipose tissue of Blanca Andaluza goat kids, stratified by production system and gender

Fatty acid[a]	Production system (PS)		Gender (G)		Significance[b]		
	Conventional (n = 24)	Organic (n = 24)	Male (n = 24)	Female (n = 24)	PS	G	PS × G
Pelvic fat (g, left side)	4.81 ± 0.84	7.40 ± 1.27	6.21 ± 1.19	6.00 ± 1.03	ns	ns	ns
C12:0	0.60 ± 0.03	1.11 ± 0.06	0.88 ± 0.08	0.84 ± 0.06	***	ns	*
C14:0	6.60 ± 0.18	7.55 ± 0.17	7.06 ± 0.21	7.11 ± 0.20	***	ns	ns
C15:0	0.33 ± 0.02	0.56 ± 0.02	0.45 ± 0.03	0.45 ± 0.03	***	ns	ns
C16:0	25.57 ± 0.32	27.1 ± 60.29	26.47 ± 0.36	26.30 ± 0.34	***	ns	ns
C16:1 *n*-9	0.77 ± 0.04	0.87 ± 0.02	0.81 ± 0.03	0.83 ± 0.03	ns	ns	ns
C17:0	0.81 ± 0.03	1.07 ± 0.04	0.93 ± 0.04	0.96 ± 0.04	***	ns	ns
C17:1	0.31 ± 0.02	0.48 ± 0.03	0.38 ± 0.03	0.41 ± 0.03	***	ns	ns
C18:0	25.42 ± 0.49	22.17 ± 0.28	23.56 ± 0.52	23.96 ± 0.53	***	ns	ns
C18:1 *n*-9 cis	32.47 ± 0.28	31.19 ± 0.32	31.86 ± 0.34	31.78 ± 0.32	**	ns	ns
C18:1 *n*-9 trans	0.67 ± 0.10	0.74 ± 0.07	0.75 ± 0.10	0.66 ± 0.07	ns	ns	ns
C18:1 trans-11 (VA)	2.28 ± 0.17	2.05 ± 0.21	2.17 ± 0.18	2.15 ± 0.21	ns	ns	ns
C18:2 *n*-6 trans	0.14 ± 0.01	0.15 ± 0.01	0.15 ± 0.01	0.15 ± 0.01	ns	ns	ns
C18:2 *n*-6 cis	1.34 ± 0.09	1.59 ± 0.05	1.48 ± 0.08	1.46 ± 0.07	*	ns	ns
C20:0	0.27 ± 0.02	0.27 ± 0.01	0.27 ± 0.01	0.27 ± 0.01	ns	ns	ns
C18:3 *n*-3	0.20 ± 0.02	0.32 ± 0.01	0.26 ± 0.02	0.26 ± 0.02	***	ns	ns
CLA cis-9, trans-11 (RA)	0.58 ± 0.02	0.60 ± 0.03	0.61 ± 0.02	0.57 ± 0.03	ns	ns	ns
CLA trans-10, cis-12	0.03 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.03 ± 0.00	ns	ns	ns
C21:0	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	ns	ns	ns
C20:3 *n*-6	0.02 ± 0.00	0.03 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	ns	ns	ns
C20:4 *n*-6 (ARA)	0.08 ± 0.01	0.06 ± 0.00	0.07 ± 0.01	0.07 ± 0.00	ns	ns	ns
C20:3 *n*-3	0.01 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	ns	ns	ns
C20:5 *n*-3 (EPA)	0.12 ± 0.01	0.04 ± 0.01	0.08 ± 0.01	0.07 ± 0.01	ns	ns	ns
C22:5 *n*-3 (DPA)	0.11 ± 0.01	0.15 ± 0.01	0.13 ± 0.01	0.13 ± 0.01	ns	ns	ns
C22:6 *n*-3 (DHA)	0.03 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	0.04 ± 0.00	ns	ns	ns
SFA	60.24 ± 0.18	60.93 ± 0.25	60.50 ± 0.27	60.69 ± 0.18	ns	ns	ns
MUFA	37.01 ± 0.22	35.94 ± 0.24	36.53 ± 0.30	36.40 ± 0.21	**	ns	ns
PUFA	2.74 ± 0.13	3.13 ± 0.07	2.98 ± 0.12	2.90 ± 0.10	*	ns	ns
UFA	39.76 ± 0.18	39.07 ± 0.25	39.50 ± 0.27	39.31 ± 0.18	ns	ns	ns
CLA	0.61 ± 0.02	0.64 ± 0.03	0.64 ± 0.02	0.60 ± 0.03	ns	ns	ns
n-3	0.47 ± 0.03	0.56 ± 0.02	0.52 ± 0.03	0.51 ± 0.03	*	ns	ns
n-6	1.62 ± 0.10	1.87 ± 0.02	1.75 ± 0.09	1.74 ± 0.07	*	ns	ns
n-6:*n*-3	3.59 ± 0.18	3.39 ± 0.14	3.47 ± 0.17	3.50 ± 0.16	ns	ns	ns
PUFA/SFA	0.04 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	0.05 ± 0.00	ns	ns	ns
UFA/SFA	0.66 ± 0.00	0.64 ± 0.01	0.65 ± 0.01	0.65 ± 0.01	ns	ns	ns
Δ9C16	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	ns	ns	ns
Δ9C18	0.58 ± 0.00	0.60 ± 0.00	0.60 ± 0.00	0.59 ± 0.00	ns	ns	ns
CLA index	0.21 ± 0.01	0.24 ± 0.01	0.23 ± 0.01	0.22 ± 0.01	ns	ns	ns
AI	3.73 ± 0.08	4.56 ± 0.11	4.18 ± 0.15	4.13 ± 0.12	***	ns	ns
TI	2.74 ± 0.02	2.72 ± 0.03	2.72 ± 0.03	2.75 ± 0.02	ns	ns	ns

[a,b]: see Table 2.

increase in saturation from peripheral to deep sites in farm animals (Potchoiba *et al.*, 1990). Also, the influence of breed on FA profiles of intramuscular, subcutaneous and kidney knob fat depots is evident (Horcada *et al.,* 2012). Intramuscular fat depot was proposed as a differentiating factor between dairy and meat breed goat kids, but not between meat breed kids.

The CLA content in muscle and fat depots, in the present study, 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 similar than that reported by De La Vega *et al.* (2013) in muscle and adipose tissues of Payoya suckling kids raised in organic and conventional livestock production systems, but was lower than that reported in intramuscular fat depot by Horcada *et al.* (2012) in the same breed; however, the authors of this study 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 (Pajor *et al*., 2009) and meat (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) and meat (Vasta *et al*., 2007; De la Vega *et al*., 2013) CLA contents. This result could be due to effects of tannins on ruminal biohydrogenation (Vasta *et al*., 2010) and although goat kids were fed exclusively by suckling, could explain the lack of effect showed in the present study on meat. High CLA concentrations can also be achieved by high-concentrate diets supplemented with whole oilseeds 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 α-linolenic acid in the muscle of suckling kids and those in their mothers' milk. In this study, the conventional lactating does were not supplemented with oilseeds, but the higher intake of concentrate enriched by C18:2 and PUFA (see Table 1) could explain partially the higher VA, RA and CLA total percentages in meat from conventionally reared kids than from organically reared ones. In addition, differences in ingestion and nutritional composition of the herbage could explain those results. Nevertheless, since total forage ingestion and chemical composition were not monitored, this will have to be tested in future studies.

The *n*-3 FAs are considered the most important dietary FA for human health. Some recommendations have been made on the basis of the ratio of *n*-6 to *n*-3 fatty acids. For example, MacRae *et al*. (2005) observed that the present 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. Simopoulos (2002) observed that the optimal ratio varies from 1 to 4 depending on the disease under consideration. Nevertheless, World Health Organization has changed its recommendation from 5-10 (WHO, 1995) to conclude recently that there is no rational for a specific recommendation for *n*-6 to *n*-3 ratio, if intakes of *n*-6 and *n*-3 fatty acids lie within the recommendation established (WHO, 2010). 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; De la Vega *et al*., 2013). Also, organic kid meat and specially the fat depots displayed higher percentages of several *n*-3 FA than conventionally reared meat, in agreement with a study of goats under similar grazing based system (De la Vega *et al*., 2013), which might be a consequence of high pasture intake by organically managed dams due to reduced feedstuff supplementation. Goats fed on rangeland (herbaceous plants, leaves and shrubs) (Bas *et al*., 2005) and sheep fed on grass pasture (Bas & Morand-Fehr, 2000) have been shown to have higher *n*-3 FA percentages in fat and muscle than animals fed diets based on concentrate. In addition, a positive correlation was obtained in goats between the percentages of net energy obtained from grazing on Mediterranean shrublands and the contents in milk of total and several *n*-3 FAs, while a negative correlation was obtained with the *n*-6:*n*-3 ratio (Delgado-Pertíñez *et al*., 2013). Also and except for fat depots, in this study there were no significant differences between the atherogenicity index in goat kid from organic or conventional managed dams. In addition, the atherogenicity index values for both groups were similar to those observed by De la Vega *et al.* (2013), but lower than 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.

Regarding the meat and fat depots, none differences between male and female kids were observed for the studied parameters (Table 2 to Table 4). Gender effects on the FA profile in meat are controversial (Banskalieva *et al*., 2000). No or minimal effects of gender on the FA profiles in meat (Nudda *et al*., 2008; De la Vega *et al*., 2013) or fat depots (Mahgoub *et al*., 2002; Todaro *et al*., 2004; De la Vega *et al*., 2013) have been reported. The effects of sex on FA composition in such species as cattle are small and may be explained in terms of differences in overall fat contents (Wood *et al*., 2008).

As conclusions, 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 as consequence of that, the dams, in both cases, were raised with small differences in the feeding management based on the grazing of natural pastures. Due to this reason, conventional farms could easily be transformed into organic production facilities. In addition, the low fat content and FA profile (especially the PUFA content and the *n*-6:*n*-3 PUFA ratio) of the meat from the kids reared in both production systems were within the ranges considered beneficial to human health, and this might be used in promotion of local and regional products. There was no effect of sex on FA profile in meat or fat depots.

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