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Effect of the production system in the fatty acid profile of Payoya goat kids

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Abstract. The importance of organic livestock production is increasing in Spain and especially in Andalucía, but nevertheless still exist reduced number of studies about the quality of these products. The aim of this study was to evaluate the effect of management system (conventional *vs* organic) on the fatty acid profile (with special reference on the conjugated linoleic acids, CLA) in the meat of Payoya goat kids. Twenty-four male kids (12 from a farm with conventional system and 12 from a farm with organic system) were used. The farms were located in the Sierra Norte of Cádiz (Andalucía, Southern Spain) and were fed in a grazing-based management, ranging mainly between semi-extensive and semi-intensive systems. Kids in both groups were born from twin births. They were raised with natural milk and slaughtered at same average live weight (8.4±0.31 kg). After 24 hours of chilling, carcasses were splitted along the dorsal midline and *Longissimus thoracis* muscle was obtained, packed to the emptiness and preserved at -20ºC up to analysis. There were no significant differences in a high number of the studied fatty acids according to production system, except for C14:0, C18:1, C20:0, C21:0, and C22:5*n*3 (with higher percentage in organic kids, P<0.05) and of C15:1 and C18:0 (higher percentage in conventional kids, P<0.01). In relation to calculated indexes, organic kids have showed highest values in the Δ^9C18 desaturase activity index and in atherogenicity index (P<0.05). In conclusion, no significant differences were found in the fatty acid composition of meat from kids raising in organic and conventional systems.

Keywords. Goat kids – Payoya – Conventional – Organic – Fatty acid.

Effet du système de production sur le profil en acides gras chez les chevreaux de race Payoya

Résumé. *L'importance de l'élevage biologique est de plus en plus importante en Espagne et surtout en Andalousie, mais il existe un nombre réduit d'études sur la qualité des produits obtenus dans ce système et encore moins réalisées sur des races autochtones de chèvre comme la Payoya. L'objectif de cette étude a été d'évaluer l'effet du système d´élevage (biologique* vs *traditionnel) sur le profil des acides gras (avec une référence particulière aux acides linoléiques conjugués, CLA) de la viande des chevreaux de race Payoya. Vingt-quatre chevreaux mâles (12 animaux par système d'élevage) ont été utilisés. Les fermes se trouvaient dans la Sierra Norte de Cádiz (Andalousie, sud de l'Espagne) et l'alimentation provenait principalement de pâturages, entre semi-extensifs et semi-intensifs. Tous les chevreaux sont nés de mises bas gémellaires. Ils ont été élevés avec du lait et abattus à poids vif moyen de 8,4 ± 0,31 kg. Après 24 heures de refroidissement, les carcasses ont été découpées le long de la ligne médiane dorsale et le muscle* Longissimus thoracis *a été prélevé, emballé sous vide et conservé à -20 ºC jusqu'à l'analyse. Il n'y avait pas de différences significatives sur la plupart des acides gras étudiés en fonction du système de production, à l'exception du C14: 0, C18: 1, C20: 0, C21: 0 et C22: 5n3 (avec un pourcentage plus élevé chez les chevreaux biologiques, P <0,05) et du C15: 1 et C18: 0 (pourcentage plus élevé chez les chevreaux du système traditionnel, P<0,01). En ce qui concerne le calcul des différents index, les chevreaux biologiques ont présenté des valeurs plus élevées de l'index d'activité de Δ^9C18 désaturase et de l'index d'atherogénicité (P<0,05). En conclusion, aucune différence significative n'a été trouvée dans la composition en acides gras de la viande provenant des chevreaux élevés dans les systèmes biologiques et conventionnels.*

Mots-clés. *Chevreaux – Payoya – Système traditionnel – Elevage biologique – Acides gras.*

I – Introduction

The organic production systems (controlled by the Regulation CE 834/2007) has experienced in the last years a great development. The prospects of organic farming plows of particular interest for the less favored Mediterranean areas, where it may contribute to the safeguard of agricultural functions, like care and preservation of landscape, and safeguarding of rural villages with positive effects on the quality of life in rural communities (Ronchi and Nardone, 2003). In Spain there are 3,813 organic farms, locating Andalucía (South Spain) in the first position with 2,073. As far as the number of goat heads, Andalucía represents 55% of the national total with 99 farms, of which 74 are of meat and 25 of milk (MARM, 2008).

Exist also an interest that grows up in for the conservation of autochthonous breeds, raised in extensive or semi extensive regimes of operation, and in many cases in extinction danger, as it is the case of the Payoya breed. This situation makes especially interesting to these breeds for its transformation to the organic production. At the present time the great majority of goat farms located by the area of distribution of the Payoya breed (Sierra Norte of Cádiz, Andalucía), including the organic ones, sells their goat kids with 8-9 kg of life weight (Mena *et al.*, 2005).

Special attention is currently paid to manipulations of dietary fatty acids (FA), because of the impact of FA intake on human health (MacRae *et al.*, 2005). Conjugated linoleic acid (CLA) and polyunsaturated FA and especially those of the *n*-3 series, have beneficial effects on human health (on the cardiovascular system or the prevention of the cancer) (MacRae *et al.*, 2005). Although every time are more the number of works that study the effect of different factors in the FA composition of goat meat, nor studies are known on the effect of the organic production system, or the effect of Spanish native breeds like the Payoya.

The aim of this study was to evaluate the effect of two different livestock systems (conventional *vs* organic) on the fatty acid profile (with special reference on the conjugated linoleic acids, CLA) in the intramuscular fat of *Longissimus thoracis* muscle of Payoya goat kids.

II – Materials and methods

For the making of this work two goat farms of Payoya autochthonous breed have been chosen, one with a conventional system and the other with the organic system (following EU 1804/99 Regulation on organic farming). The farms were located in the Sierra Norte of Cádiz (Andalucía, Southern Spain), where this breed predominates and were feed in a grazing-based management, ranging mainly between semi-extensive and semi-intensive systems. Goats were grazing 4-8 hours/day during suckling phase. A supplementary concentrate was added at a flat rate of 1.0 kg/d in conventional system (DM basis: 92% OM, 17% CP, 4,9% EE, and 8% CF) and 0.5 kg/d in organic system (DM basis: 94% OM, 13% CP, 4,3% EE, and 8,5% CF).

Twenty-four male kids have been used, from which 12 came from a farm with conventional system (CG) and the other 12 from a farm with organic system (OG). Kids in both groups were born from twin births (October, 2006). They were raised with natural milk and slaughtered at same average live weight (8.40 ± 0.31 kg). After 24 hours of chilling, carcasses were splitted along the dorsal midline and *Longissimus thoracis* muscle (LT) was obtained, packed to the emptiness and preserved at -20ºC up to analysis. After defrost it was come to the analysis of different fatty acids.

The total fatty acids were extracted, methylated and analysed by an adaptation of the method described by Aldai *et al.* (2006). Separation and quantification of the FAMEs (fatty acid methyl esters) was carried out using a gas chromatograph (GC, Varian Star 3400CX, Varian Associates Inc., California, USA) equipped with a flame ionisation detector (FID) and fitted with a BPX-70 capillary column (120 m, 0.25 mm i.d., 0.2 lm film thickness, SGE, Australia). Tricosanoic acid methyl ester (C23:0 ME) at 10 mg/ml was used as an internal standard. Individual FAMEs were identified by comparing their retention times with those of an authenticated standard fatty acid mix Supelco 37 (Sigma Chemical Co. Ltd., Poole, UK). Identification of the CLA isomers cis9–trans11, cis11–13trans, trans10–cis12 and cis10–cis12 CLA was achieved by comparing retention times with those of another authenticated standard mix (Sigma Chemical Co. Ltd., Poole, UK). Fatty acids were expressed as a percentage of total fatty acids identified and also were grouped as follows: saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), unsaturated fatty acids (UFA), n-3 PUFA, n-6 PUFA, and total conjugated linoleic acids (CLA). Ratios between the different fractions, namely PUFA/SFA, UFA/SFA and n-6/n-3 were calculated. Activities of Δ9C16 (C16:1 n-9+C16:1 n-7)/C16:0+C16:1 n-9+C16:1 n-7) and Δ9C18 (C18:1 n-9 cis+C18:1 n-9 trans)/C18:0+C18:1 n-9 cis+C18:1 n-9 trans) indices were estimated. Finally, the atherogenicity (AI) and thrombogenecity (TI) indices were calculated according to Ulbricht and Southgate (1991).

All data were analysed statistically (Anova), according to the following model: $Y_{ik} = \mu + M_i + \varepsilon_{ik}$, where Y_{ik} = single observation; μ = general mean; M_i = livestock system; ε_{ik} = error. The SPSS statistical software package (SPSS, 2006) was used for the statistical analysis.

III – Results and discussion

The fatty acid composition of LT in kids suckling from dams according to production system is in Table 1. There were no significant differences in a high number of the studied fatty acid according to production system, except for C14:0, C18:1, C20:0, C21:0 and C22:5*n*3 (with higher percentage in organic kids, P<0.05) and of C15:1 and C18:0 (higher percentage in conventional kids, P<0.01). In relation to calculated indexes, only organic kids have showed highest values in the Δ^9C18 desaturase activity index and in atherogenicity index (P<0.05) (Table 1).

The proportions of major FA: C16:0, C18:0 and C18:1 *n*-9 *cis*, were in the range of those reported in other studies on goats (Banskalieva *et al.*, 2000; Bas *et al.*, 2005 and Nudda *et al.*, 2008). The present study has been particularly focused on C18:2 *cis*-9, *trans*-11 (rumenic acid, the main isomer of CLA), C18:1 *trans*-11 (VA), and on their ruminal precursors, C18:2 n-6 (linoleic acid) and C18:3 n-3 (linolenic acid). During the suckling phase, when the kids are functional non-ruminants, so there is no ruminal biohydrogenation of the milk fatty acids before they are absorbed from the intestine, differences in their meat fatty acid profile reflected the fatty acid profile of the suckled milk (Sanz Sampelayo *et al.*, 2006; Nudda *et al.*, 2008). In the present study the C18:2*n*-6, C18:3*n*-3 as well as total PUFA proportions were in the range of those found in other studies on goats (Banskalieva *et al.*, 2000; Bas *et al.*, 2005). Nevertheless, these proportions appeared in the low range of those reported in other studies (Nudda *et al.*, 2008), due to the higher concentration of C18:2 n-6 and C18:3 n-3 fatty acids in the offered fed supplemental (cottonseed and linseed). Linoleic and linolenic acids are of dietary origin; they are not synthesized by ruminant tissue, and their concentration in milk and meat is dependent on the amount that flows out of the rumen. With respect to CLA content, Todaro *et al.* (2004) reported a similar content of pelvic fat in suckling kids than in our study, but lower than that reported in intramuscular fat of suckling kids from lactating goats supplemented with concentrates rich in C18:2 and C18:3 (Nudda *et al.*, 2008) or with PUFA rich protected fat (Sanz Sampelayo *et al.*, 2006). Recent works showed that endogenous synthesis in the mammary gland by desaturation of vaccenic acid via Δ^9 desaturase is the primary source of CLA in the milk fat of lactating cows (Mosley *et al.*, 2006). Though grazing animals was found to increase the CLA concentration of milk (Sanz Sampelayo *et al.*, 2007), the lower content found in this study could be due to the fact that the desaturase enzyme activity could be induced by concentrate-rich diets, probably in response to an increase in desaturase gene expression induced by insulin (Daniel *et al.*, 2004a; Daniel *et al.*, 2004b). In this respect and with concentrate-rich diets, a major proportion has been observed of VA desaturated to CLA in the muscle than in the mammary gland (Nudda *et al.*, 2008).

Table 1. Fatty acid profile (% total fatty acids)† (mean ± SE) in *Longissimus thoracis* muscle of Payoya goat kids according to the conventional and organic production systems

	Conventional (CG) (n=12)	Organic (OG) (n=12)	P††
C12:0	0.82 ± 0.09	0.91 ± 0.07	NS
C14:0	4.48 ± 0.21	5.37 ± 0.21	*
C15:0	0.65 ± 0.12	0.44 ± 0.09	NS
C15:1	0.06 ± 0.00	0.03 ± 0.00	**
C16:0	25.26 ± 0.45	25.91 ± 0.33	NS
C16:1 n-7	2.10 ± 0.08	2.03 ± 0.16	NS
C16:1 n-9	0.47 ± 0.08	0.48 ± 0.07	NS
C17:0	1.26 ± 0.18	1.33 ± 0.14	NS
C17:1	0.35 ± 0.04	0.41 ± 0.04	NS
C18:0	17.90 ± 0.52	15.37 ± 0.62	**
C18:1 n-9 cis	33.07 ± 0.36	32.94 ± 0.68	NS
C18:1	0.37 ± 0.03	0.57 ± 0.05	*
C18:2 n-6 cis	6.80 ± 0.44	7.39 ± 0.24	NS
C20	0.07 ± 0.01	0.46 ± 0.06	*
C20:1	0.34 ± 0.06	0.43 ± 0.06	NS
C18:3 n-3	0.28 ± 0.06	0.27 ± 0.04	NS
CLA cis-9, trans-11	0.23 ± 0.04	0.25 ± 0.04	NS
CLA trans-10. cis-12	0.06 ± 0.03	0.06 ± 0.02	NS
CLA cis-9, cis-11	0.04 ± 0.01	0.04 ± 0.01	NS
C21:0	0.02 ± 0.00	0.04 ± 0.01	*
C20:2	0.02 ± 0.00	0.01 ± 0.00	NS
C20:3 n-6	0.17 ± 0.03	0.14 ± 0.01	NS
C22:1 n-9	1.58 ± 0.17	1.42 ± 0.18	NS
C20:3 n-3	2.10 ± 0.16	1.67 ± 0.25	NS
C22:2	0.40 ± 0.10	0.49 ± 0.04	NS
C20:5 n-3	0.27 ± 0.03	0.40 ± 0.10	NS
C22:4 n-6	0.26 ± 0.03	0.23 ± 0.03	NS
C22:5 n-3	0.43 ± 0.10	0.74 ± 0.06	*
C22:6 n-3	0.12 ± 0.03	0.17 ± 0.02	NS
SFA	50.47 ± 0.29	49.84 ± 0.67	NS
MUFA	38.35 ± 0.38	38.31 ± 0.61	NS
PUFA	11.19 ± 0.22	11.86 ± 0.53	NS
UFA	49.53 ± 0.29	50.16 ± 0.67	NS
CLA	0.33 ± 0.05	0.35 ± 0.07	NS
n3	3.20 ± 0.26	3.25 ± 0.29	NS
n6	7.23 ± 0.41	7.76 ± 0.26	NS
n6/n3	2.54 ± 0.32	2.51 ± 0.14	NS
PFA/SFA	0.22 ± 0.00	0.24 ± 0.01	NS
UFA/SFA	0.98 ± 0.01	1.01 ± 0.03	NS
Δ^9C16	0.09 ± 0.00	0.09 ± 0.01	NS
Δ^9C18	0.65 ± 0.01	0.68 ± 0.01	*
Atherogenicity index	0.89 ± 0.02	0.97 ± 0.03	*
Thrombogenecity index	1.46 ± 0.05	1.42 ± 0.05	NS

† Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), unsaturated fatty acids (UFA), n-3 PUFA, n-6 PUFA, total conjugated linoleic acids (CLA).

†† NS, no significant, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Among the fatty acids, also great attention is given to n–3 fatty. Present recommendations would be for a dietary fatty acid optimum n-6: n-3: 2.0-2.5, but most human foodstuffs have a ratio nearer to 5.0-10.0 (MacRae *et al*., 2005). In this study the n-6 PUFA/n-3 PUFA ratio was lower than those reported in other studies on goats (Todaro *et al*., 2004; Bas *et al*., 2005; Sanz Sampelayo *et al.,* 2006; Nudda *et al.,* 2008). These results agreed with those obtained in previous studies in which sheep and cattle fed on grass pasture had lower C18:2*n*-6 and higher C18:3*n*-3 proportions in fat depots and muscle than animals fed with diets based on concentrate or with complete diets (Bas and Morand-Fehr, 2000; Bas and Sauvant, 2001).

The atherogenicity index characterizes the atherogenicity of dietary fat; fat with high atherogenicity index value is assumed more detrimental to the human health. In this study, this index was the lowest in conventional kids, probably related to the lower level of saturated fatty acids (especially C14:0). Nevertheless the results obtained in this study in both groups were lower that the obtained in milk of ewes fed with Mediterranean forages (Addis *et al*., 2005).

IV – Conclusion

No important differences were identified in the FA composition of goat kids raised in organic and conventional livestock production systems with grazing-based management. Both kids raising systems produced animals with lower proportions of FA "bad" for health but higher proportions of FA "good" for health, such as PUFA and a better *n*-6:*n*-3 PUFA ratio.

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