How forage form can affect the fatty acid composition of animal products in the autumn-lambing flock

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Abstract. The study was carried out to evaluate the effect of forage form around parturition on fatty acid (FA) composition of ewes milk and on meat from suckling lambs (10-12 kg BW). Forty eight Churra Tensina ewes rearing single lambs were assigned to one of four treatments in a 2 x 2 factorial design The factors were the physiological status (pre-partum, last month of pregnancy, *vs* post-partum 5 weeks of lactation) and the feeding system (grazing *vs* hay indoors) From lambing to the target BW of lambs weekly milk samples were recorded After slaughter, samples of *M. Longissimus dorsi* muscle were taken. Both products were used to determine FA content Results show that forage form around parturition affects milk FA of ewes, the post-partum period exerting greater influence than the pre-partum period Forage source influences the intramuscular FA composition of suckling lambs meat to a lesser extent CLA and n6/n3 ratio are the most affected by grazing, with a positive effect of this feeding management for human health. Pre-partum grazing, regardless of post-partum feeding can improve the FA composition, increasing the CLA content in both milk and meat

Keywords. Milk – Meat – Grazing – Hay – Suckling lamb

Influence de la forme de fourrage au cours du péri-partum dans la composition des acides gras du lait et de la viande de mouton

Résumé. *L étude a été réalisée pour évaluer l'effet de la forme de fourrage pendant le péripartum sur la composition en acides gras (AG) du lait de brebis et de la viande d'agneaux de lait (10-12 kg de poids corporel). Quarante-huit brebis Churra Tensina avec leurs agneaux uniques ont été attribués à l'un des quatre traitements dans un dispositif factoriel 2 x 2 Les facteurs ont été l'état physiologique (pré-partum, dernier mois de gestation,* vs *post-partum 5 semaines de lactation) et la forme de fourrage (pâturages permanents* vs *foin de prairie). De la naissance au poids d'abattage des agneaux, des échantillons de lait hebdomadaires ont été prélevés Après l'abattage, des échantillons de muscle* L dorsi *ont été prélevés Les deux échantillons ont été utilisés pour déterminer la teneur en AG La forme de fourrage pendant le péripartum affecte la composition en AG du lait La source de fourrage pendant le post-partum a un effet plus important sur les AG du lait que pendant la période pré-partum La forme du fourrage a moins d'effet dans la composition des AG de la graisse intramusculaire d'agneaux de lait Les CLA et n6/n3 sont les paramètres les plus influencés par le pâturage, avec un effet positif de ce système d'alimentation sur la santé humaine Le pâturage au cours du pré-partum, indépendamment du type de fourrage dans la période post-partum peut améliorer les AG, l'augmentation de la teneur en CLA dans le lait et dans la viande*

Mots-clés. *Lait – Viande – Pâturage – Foin – Agneau de lait*

I – Introduction

Lamb production in Spain (second-ranked in the European Union) is based on young lambs from autochthonous genotypes which are slaughtered either at 20-24 kg body-weight (BW) (light lambs) or at 12-14 kg BW (suckling lambs) Much of the variation in animal product quality is determined by the feeding system Pasture plays a key role in improving the fatty acid composition for healthy benefits. However, not all forages have the same effect, depending on maturity, variety of forage and preservation (Woods and Fearon, 2009) Hay making process leads to a loss of fatty acid precursors of conjugated linoleic acid (CLA), reducing total fatty acid by over 50% with a higher loss of linolenic acid

In earlier works, it was demonstrated that light lambs can be raised by their dams on pasture during the spring season (Carrasco *et al.*, 2009) with minimum detrimental effects on lamb performance The capacity to produce suckling lambs for Christmas in a grazing system during autumn, when the herbage production is scarce, had not been studied. The aim of the study was to evaluate the effect of forage form (hay *vs* pasture) around parturition (pre- *vs* post-partum period) on FA composition of milk from dams and of meat from suckling lambs raised in autumn.

II – Material and methods

The experiment was conducted in La Garcipollera Research Station, in the Pyrenees (North-eastern Spain, 42°37'N, 0°30'W, 945 m a.s.l.) during autumn 2008 Forty-eight pregnant adult ewes (46 5±0.66 kg BW and 3 0±0 03 body condition score, BCS) were used The experimental design was a 2 x 2 factorial design The factors studied were the pre-partum and post-partum forage form (permanent pasture outdoors *vs* meadow hay indoors). The last month of pregnancy was considered the pre-partum period whereas the 5 weeks of lactation were the post-partum period The last 4 weeks of pregnancy, half of the ewes were fed *ad libitum* on low mountain pastures (43-46% NDF, 18-20% CP) or eventually fed alfalfa pellets (35-37% NDF, 14-17% CP) when the snow was limiting pasture availability, and the rest of the flock was fed pasture hay *ad libitum* (49-52% NDF, 11-13% CP) Hay was made in late spring, from the same pasture paddocks to those grazed in autumn

After lambing (19 October±8 days), half of the ewes were exchanged from their initial treatment and the rest remained in it during the 5 weeks of lactation, in a factorial arrangement Ewe parity, BW, BCS and lamb sex were taken into account to balance groups The study finished when lambs reached 10-12 kg BW (suckling lamb commercial category)

Milk production was recorded weekly by the oxytocin technique proposed by Doney *et al* (1979) and machine milking with hand finishing up (4 h-interval). Two individual milk samples (50 ml) were taken and kept stored at -20°C until chemical and FA analysis

When lambs reached 10-12 kg of BW they were transported to the experimental abattoir of the Research Institute in Zaragoza, which is located 180 km away from the farm. Immediately after arrival, lambs were slaughtered according to EU laws. Carcasses were chilled at 4°C during 24 h and split *M. Longissimus dorsi* (LD) portion from 10t^{h} to 12th thoracic vertebrae was taken for fatty acid composition of intramuscular fat All samples were vacuum-packed and frozen (-20°C) until analysis

Milk lipid separation to determine the fatty acid composition was conducted according to Luna *et al* (2005) and meat lipids according to Bligh and Dyer (1959). Fatty acids were converted to methyl esters and quantified using a HP5890 gas chromatograph, with a HP-88 capillary column (100 m x 0 25 mm x 0.2 µm). Fatty acid content was expressed as a percentage out of the total amount of the fatty acids identified After individual FA determination, the sum of saturated fatty acids (SFA), mono-unsaturated FA (MUFA), poly-unsaturated FA (PUFA), as well as PUFA/SFA and PUFA n6/n3 ratios were calculated

Milk FA composition was analysed with the mixed model procedure of SAS statistical software (SAS, 2002), considering pre-partum feeding (pasture *vs* hay), post-partum feeding (pasture *vs* hay), week relative to lambing (from 1 to 5) and their second degree interactions as fixed effects and ewe as a random effect. *Longissimus dorsi* FA composition were analysed with a general linear model procedure of SAS, considering pre-partum feeding (pasture *vs* hay), post-partum feeding (pasture *vs* hay) and its interaction as fixed effects Results are reported as least square means and their associated standard errors. Multiple comparisons among treatments were performed by the Tukey's method. The level of significance was set at 0.05

III – Results and discussion

1. Milk fatty acid composition

Main milk fatty acids groups are shown in Table 1 No interaction between pre- and post-partum forage form was observed (P>0 05), and therefore both effects are discussed separately Post-partum forage form had greater effect on FA categories than pre-partum forage form, in agreement with the premise that diet had an immediate effect on milk FA profile (Nudda *et al.*, 2008) Post-partum forage form had significant effect on the sum of PUFA, PUFA n-3, PUFA/SFA ratio and conjugated linoleic acid (CLA) content (P<0.01), whereas pre-partum forage form only had effect on PUFA and CLA content (P<0 05)

Table 1. Influence of pre- and post-partum feeding system (hay *vs* grazing) on main FA categories in ewe's milk

	Pre-partum		Post-partum		SE	*P*-value†		
	Hay	Grazing	Hay	Grazing		PRE	POST	Week
SFA	56 15	56 39	56.37	56.17	0.447	0 72	0 77	0 005
MUFA	31 34	30 20	31 61	29 93	0 619	0 19	0 06	0 43
PUFA	5 80^b	6.09^a	5.70^b	6 19^a	0 092	0 03	<0 001	<0 001
CLA c9 t11	1 36^b	1 56^a	1 29^b	1 63^a	0 061	0 03	<0 001	<0 001
PUFA/SFA	0.10	0 11	0 10^b	0 11^a	0 002	0 10	<0 001	<0.001
PUFA n6	2 54	2.48	2 53	2 48	0 052	0 40	0 47	0 002
PUFA n3	1 61	1 71	1 58^b	1 74^a	0 044	0 10	0 01	0 001
n6/n3	1.62	1.47	1.64^a	1 46^b	0.054	0.06	0.02	0 01

a,b: Within a row and effect different letter denotes statistical differences between feeding strategy (P<0.05)
†Pre x Post interaction was not significant (P>0.05)

It is well documented that grazing ewes present higher proportion of C18:3 n-3 than stall fed ewes. In the present study, milk from grazing ewes showed a higher proportion of PUFA-n3 and CLA than those fed hay indoors, being the effect more significant in post-partum feeding period (Fig. 1) That result may be related to the herbage FA composition, which is affected by the plant phenological stage CLA and PUFA-n3 contents in milk are higher when pasture is in vegetative phase, whereas when the same pasture is in the reproductive phase the CLA falls considerably In the present study, the pasture grazed in autumn was in vegetative stage whereas the hay came from the spring cut, when herbage was in reproductive phase. Although both diets were forage-based, the differences between them were important: fresh *vs* hay, vegetative vs reproductive phase

The PUFA n6/n3 ratio was always lower in grazing ewes Milk from grass-fed ewes contained lower SFA levels and higher MUFA and PUFA content (Valvo *et al*, 2005), although in the present study only PUFA was increased significantly In that sense Scerra *et al.* (2007) observed that milk from grazing ewes presented higher PUFA content but different response was observed when preserved forage was supplied This difference could be related with the losses of PUFA during field wilting.

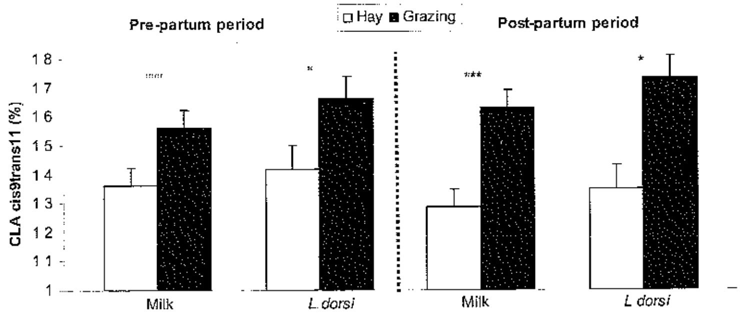

Fig. 1. Influence of feeding system during the pre-partum and post-partum period on milk and *L. dorsi* conjugated linoleic acid (CLA) *cis9, trans11* contents from suckling lambs.

Week of lactation had influence on all FA categories (P<0.05), except MUFA (P>0.05). The significant effect of week of lactation was in agreement with De la Fuente *et al* (2009), who observed that the day of testing was one of the most important factor of variation of FA (35-70% of total variance). CLA content in milk fat was greater at the first week of lactation than at the rest (1 63 *vs* 1 42±0 05%)

2. *M. Longissimus dorsi* fatty acid composition

Lamb sex did not affect the FA composition (P>0.05) Most of FA studied in meat from suckling lambs were not affected by ewe's feeding system (grazing *vs* hay) during the pre-partum period, except CLA content (Fig. 1, P<0.05). Post-partum feeding system, as described for the case of ewes' milk, affected a large number of FA categories, as CLA content, sum of PUFA n3, and PUFA/SFA and PUFA n6/n3 ratios (Table 2; P<0.05) This result reflects FA composition of the ewe s milk as dietary FA profile is not modified by microbial biohydrogenation in the rumen. During the suckling period, FA absorbed from intestine contribute to the majority of the total deposited FA, while *de novo* synthesised FA will contribute only to 6-20% (Osorio *et al* , 2007)

Grass feeding system is an efficient way of improving the quality of sheep products in animals raised exclusively on maternal milk, due to the healthful of grazing sheep milk According to Valvo *et al.* (2005) there is a strong correlation between ewe feeding system and meat FA composition of suckling lambs, which disappears after weaning. The present result shows that the FA composition of meat from suckling lambs is influenced by the feeding system of ewes

PUFA/SFA ratio was affected only by feeding system during the post-partum period (P<0 05), being the ratio greater in grazing treatment (Table 2), with values lower than those recommended. Similarly, Joy *et al.* (2008), when comparing grazing lambs and indoor lambs, did not observe any effect of the feeding system on this ratio, which was found to be between 0.21 and 0.23 These results support the premise that in ruminants this ratio is more affected by genetic factors than by dietary n-3 source (Osorio *et al.* 2007)

From the present study we can conclude that forage form around parturition affects milk FA of ewes, exerting greater effect in post-partum period Feeding strategy influences to a lesser extent the intramuscular FA composition of suckling lambs meat. CLA and n6/n3 ratio are the most affected by grazing with a positive effect for human health. Pre-partum grazing, regardless of post-partum feeding, can improve the FA composition, increasing the CLA content in both milk and meat.

Table 2. **Influence of pre- and post-partum ewe's feeding (hay *vs* grazing) on main FA categories in *M. Longissimus dorsi* from suckling lambs**

	Pre-partum		Post-partum		SE	*P*-value†	
	Hay	Grazing	Hay	Grazing		PRE	POST
SFA	42 20	42 07	42 48	41 79	0.54	0 87	0 37
PUFA	13 74	12 92	12 21	14 46	0 80	0 48	0 06
MUFA	44 06	45 00	45.31	43 75	0 85	0 44	0.21
PUFA/SFA	0 33	0 31	0.29^{b}	0 35^{a}	0 02	0.55	0 05
CLA c9,t11	1.42^{b}	1 66^{a}	1 35^{b}	1 73^{a}	0.08	0 04	0 001
PUFA n6	7 55	6 91	6 87	7 59	0 50	0 38	0 32
PUFA n3	4 77	4.35	3 98^{b}	5.14^{a}	0 35	0 40	0 02
n6/n3	1 66	1 62	1 76^{a}	1 52^{b}	0 05	0.64	0 002

Within a row and effect different letter denotes statistical differences between feeding strategy (P<0 05)
†Sex effect and Pre x Post interaction were not significant (P>0.05)

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References

Bligh E.G. and Dyer W.J., 1959. A rapid method of total lipid extraction and purification In: *Can. J Bioch Phys*, 37, pp 911-917

Carrasco S., Ripoll G., Sanz A., Álvarez-Rodríguez J., Panea B., Revilla R. and Joy M., 2009. Effect of feeding systems on growth and carcass characteristics of Churra Tensina light lambs In: *Liv Sci* 121 pp. 56-63

De la Fuente L.F., Barbosa E., Carriedo J.A., Gonzalo C., Arenas R., Fresno J.M. and San Primitivo F., 2009. Factors influencing variation of fatty acid content in ovine milk. In: *J Dairy Sci*, 92 pp 3791-3799.

Doney J.M., Peart J.N., Smith W.F. and Louda F., 1979. A consideration of the techniques for estimation of milk yield by suckled sheep and a comparison of estimates obtained by two methods in relation to the effect of breed, level of production and stage of lactation In: *J. Agric. Sci Camb*, 92 pp 123-132

Joy M., Álvarez-Rodríguez J., Revilla R., Delfa R. and Ripoll G., 2008. Ewe metabolic performance and lamb carcass traits in pasture and concentrate-based production systems in Churra Tensina breed. In: *Small Ruminant Research* 75(1), pp 24-35

Luna P., Juárez M. and de la Fuente M.A., 2005. Validation of a rapid milk fat separation method to determine the fatty acid profile by gas chromatography. In: *J Dairy Sci*, 88, pp 3377-3381.

Nudda P., Palmquist D.L., Battaccone G., Fancellu S., Rassu S.P.G. and Pulina G., 2008. Relationships between the contents of vaccenic acid, CLA and n-3 fatty acids of goatl milk and the muscle of their suckling kids In: *Liv Sci*, 118, pp 195-203.

Osorio M.T., Zumalacárregui J.M., Figueira A. and Mateo J., 2007. Fatty acid composition in subcutaneous, intermuscular and intramuscular fat deposits of suckling lamb meat: effect of milk source. In: *Small Rum Res*, 73, pp 127-134

SAS (2002). *SAS/STAT User's Guide*, Version 9. 1 SAS Institute Inc, Cary NC, USA

Scerra M., Caparaa P., Foti F., Galofaro V., Sinatra M.C. and Scerra V., 2007. Influence of ewe feeding systems on fatty acid composition of suckling lambs In: *Meat Sci*, 76 pp 390-394.

Tsiplakou E., Mountzouris K.C. and Zervas G., 2006. Concentration of conjugated linoleic acid in grazing sheep and goat milk fat In: *Liv. Sci*, 103, pp. 74-84

Valvo M.A., Lanza M., Bella M., Fasone V., Scerra M., Biondi I. and Priolo A., 2005. Effect of ewe feeding system (grass *vs* concentrate) on intramuscular fatty acids of lambs raised exclusively on maternal milk. In: *Anim Sci* 81, pp 431-436

Woods V.B. and Fearon A.M., 2009. Dietary sources of unsaturated fatty acids for animals and their transfer into meat milk and eggs: a review In: *Liv Sci.*, 126, pp 1-20