Influence of feeding system on fatty acid composition of suckling lambs

Caparra P., Foti F., Scerra M., Cilione C., Vottari G., Galofaro V., Sinatra M.C., Scerra V.

in

Priolo A. (ed.), Biondi L. (ed.), Ben Salem H. (ed.), Morand-Fehr P. (ed.).
Advanced nutrition and feeding strategies to improve sheep and goat

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 74

2007
pages 95-99

Influence of feeding system on fatty acid composition of suckling lambs

P. Caparra, F. Foti, M. Scerra, C. Cilione, G. Vottari, V. Galofaro, M.C. Sinatra and V. Scerra
Dipartimento di Scienze e Tecnologie Agro-forestali e Ambientali, Università Mediterranea di Reggio Calabria, Piazza S. Francesco, 7, 89061 Gallina, Reggio Calabria, Italy

SUMMARY – The main objective of the present work was to determine ewe dietary treatment effects on intramuscular fatty acid composition of suckling lambs. Twenty-four pregnant Merinizzata Italiana ewes were divided into two groups of twelve each. One group was allowed to graze (grass group) and the other group was penned indoors and was fed hay ad libitum and commercial concentrate (stall group). After lambing, all ewes stayed with their respective lambs for the duration of the trial. The lambs were slaughtered at 100 days of age. Milk and lamb meat (*longissimus dorsi* muscle) fatty acids were analysed. The intramuscular fat of the grass group showed higher (P<0.001) proportions of polyunsaturated fatty acids (PUFA) than the stall group. The percentage of C12:0, C16:0 and C18:1 cis-9 were higher (P<0.05, P<0.001 and P<0.001) in the intramuscular fat of the stall group, whereas the grass group showed greater proportion of C18:3 (P<0.001). Moreover, eicosapentaenoic acid (C20:5 n−3) and docosapentaenoic acid (C22:5 n−3) were found in the highest amounts (P<0.001, P<0.01) in the meat of the grass group. PUFA/SFA ratio was higher (P<0.001) in the intramuscular fat of the grass group and n-6/n-3 ratio was lower (P<0.001) than the stall group. In contrast with previous work, this study has not found a significant difference in the proportion of C18:2 cis-9, trans-11 in the intramuscular fat within the two groups. This could be attributed to the poor condition of the pasture in the final phase of the trial and, mainly, to the young age of the lambs. This study confirmed that pasture enhanced the unsaturated fatty acid profile of intramuscular fat in lambs including omega-3 fatty acids.

Keywords: Concentrate, ewe milk, fatty acids, lamb meat, pasture.

RESUME – *"Influence du système d'alimentation sur la composition en acides gras d'agneaux allaitants". L'objectif principal du présent travail était de déterminer les effets du traitement alimentaire des brebis sur la composition intramusculaire en acides gras d'agneaux allaitants. Vingt-quatre brebis Merinizzata Italiana en gestation ont été divisées en deux groupes de douze. Un groupe pouvait pâturer (groupe à l'herbage) et l'autre groupe était en stabulation et recevait du foin à volonté et un concentré commercial (groupe en stabulation). Après l'agnelage, toutes les brebis restaient avec leurs agneaux respectifs pendant la durée de l'essai. Les agneaux étaient abattus à l'âge de 100 jours. Les acides gras du lait et de la viande d'agneau (muscle* longissimus dorsi*) étaient analysés. Le gras intramusculaire du groupe à l'herbage montrait des proportions supérieures (P<0,001) d'acides gras poly-insaturés (PUFA) par rapport au groupe en stabulation. Le pourcentage de C12:0, C16:0 et C18:1 cis-9 était supérieur (P<0,05, P<0,001 et P<0,001) dans le gras intramusculaire du groupe en stabulation, tandis que le groupe à l'herbage montrait une plus grande proportion de C18:3 (P<0,001). De plus, l'acide eicosapentaénoïque (C20:5 n−3) et l'acide docosapentaénoïque (C22:5 n−3) étaient en plus grande quantité (P<0,001, P<0,01) dans la viande du groupe à l'herbage. Le rapport PUFA/SFA était supérieur (P<0,001) dans le gras intramusculaire du groupe à l'herbage et le rapport n-6/n-3 était inférieur (P<0,001) comparé au groupe en stabulation. En contrast avec l'étude précédente, ce travail n'a pas trouvé de différence significative dans la proportion de C18:2 cis-9, trans-11 dans le gras intramusculaire chez les deux groupes. Ceci pourrait être attribué au mauvais état du pâturage pendant la phase finale de l'essai et, principalement, au jeune âge des agneaux. Cette étude confirme que le pâturage augmente le profil en acides gras insaturés du gras intramusculaire chez les agneaux y compris les acides gras omega-3.*

Mots-clés : *Concentré, lait de brebis, acides gras, viande d'agneau, pâturage*.

Introduction

Dietary cholesterol is an important issue of public health because of its relationship with the incidence of atherosclerosis. Numerous studies (Keys, 1970) have confirmed that there is a strong relationship between the lipids consumed in the human diet and total plasma cholesterol. A low intake of saturated fat and an increased polyunsaturated to saturated fatty acid ratio are associated with reduced risk of human coronary heart disease (Keys *et al.*, 1965; Ulbricht and Southgate, 1991; Clarke *et al.*, 1997; Bonanome and Grundy, 1998). Currently, consumers are especially conscious of

their dietary intake of high-fat animal feed that contain saturated fats and cholesterol, which, in turn, elevate serum cholesterol. Lipid comprise about 40% of the energy value of the average diet, a value which, according to the Government's Committee on Medical Aspects of food Policy (COMA) (Department of Health, 1994), is too high because of the risk of inducing high levels of plasma cholesterol thereby increasing the possibility of coronary heart disease. The committee suggested that the consumers should be encouraged to eat less fat (less than 35% of energy food) and that no more than 10% should be derived from saturated fatty acids. At the same time, COMA indicated that polyunsaturated fatty acids could, with benefit, be substituted in the diet for saturated fatty acids, thereby increasing the P:S ratio.

The effect of production system and in particular of grass *vs* concentrate feeding on suckling lamb intramuscular fatty acids has been studied (Velasco *et al*., 2001 and 2004; Valvo *et al*., 2005). However, in the trial of Velasco *et al*. (2004), the lambs were slaughtered when reaching the specified slaughter weight of 14 kg, whereas in the experiment of Valvo *et al*. (2005), lambs were slaughtered at 38 days of age, and were fed exclusively with maternal milk. In the present trial, lambs were raised by their dams at pasture or in stall and were slaughtered at age 100 days at 20 kg live weight.

Materials and methods

Twenty-four pregnant Merinizzata Italiana ewes were selected before lambing and were divided into two groups of twelve. One group of ewes was allowed to graze a natural pasture every day (pasture group). The pasture was divided into six paddocks of equal areas so that animals grazed rotationally. The second group was penned indoors in a multiple box and was fed hay *ad libitum* and commercial concentrate (stall group). After lambing, all ewes stayed with their respective lambs for the duration of the trial. The concentrate supplied to the stall group was regulated every week with the aim to obtain the same daily gain between the pasture and stall lambs. The lambs were weighed weekly during the feeding trial. The lambs were fed with maternal milk but were also allowed to solid feed, following their continuous presence with their mothers. All the lambs were slaughtered at 100 days of age.

Intramuscular fat was extracted, from a 5 g ground meat sample, according to Folch *et al.* (1957). Fatty acids were quantified as methyl esters (French *et al*., 2000). The gas-chromatograph used was Thermo Finnigan, TRACE with the software Chrom-Card [Thermo Finnigan, San Jose, CA, USA, interfaced to a flame ionization detector (F.I.D.)]. Separation of fatty acid methyl esters in hexane was done by a capillary column SP-2340 in fused silica (60 m x 0.25 mm i.d.; 0.20 µm film thickness). The conditions were the following: initial temperature, 150°C; initial isotherm, 5 min; temperature increasing, 1°C per min up to 160°C; intermediate isotherm, 11 min, then temperature increasing 7°C per min up to 230°C; final isotherm 9 min; carrier gas was Helium with a flow of 1.5 ml/min. Injector temperature 200°C; detector temperature, 250°C. The different fatty acids were identified by the retention time (minutes) with reference to fatty acid standards. The different fatty acid standards were purchased from Larodan Fine Chemicals AB (Malmo, Sweden). Fatty acids were calculated using chromatogram peak areas and are expressed as g/100g identified fatty acids methyl esters.

Statistical analysis

A t-test was done to compare the effects of ewe production system on milk fatty acids, lamb performance and lamb intramuscular fatty acids. Single animals were considered as experimental units.

Results and discussion

Intramuscular fatty acids proportions are reported in Table 1. The saturated fatty acids lauric (C12:0) and myristic (C14:0) were higher in the fat from lambs raised by ewes given concentrates but only the first one showed significant differences ($P<0.05$).

Palmitic acid (C16:0) was higher ($P<0.001$) in the fat from lambs raised by ewes given concentrates, whereas there was not significant differences for stearic acids (C18:0) among the two

groups. Therefore, the saturated fatty acids were higher (P<0.001) in the fat from lambs of the stall group. This results were probably linked with the different levels of these fatty acids in milk consumed by lambs and agrees with those of Valvo *et al.* (2005) and Velasco *et al.* (2001; 2004). However, in the experiment of Valvo *et al*. (2005), lambs were fed exclusively with maternal milk, and in that trial and in the studies of Velasco *et al*. (2001) the lambs were slaughtered at lower weights. Probably in our experiment the lambs, maybe in final part of the trial, ate a little bit of solid feed, following the continuous presence of the lambs with their mothers.

Table 1. Effect of ewes diet on lambs' intramuscular fatty acid composition (g/100g of methylesters)

	Feeding system		SEM	significance
	Pasture	Stall		
C12:0	0.18	0.26	0.018	*
C14:0	1.50	1.76	0.090	NS
C14:1 cis 9	0.19	0.21	0.008	NS
C16:0	15.36	17.79	0.344	***
C16:1 cis 9	0.61	0.92	0.039	***
C18:0	10.54	10.64	0.197	NS
C18:1 trans 11 (VA)	1.52	1.63	0.035	NS
C18:1 cis 9 (OA)	16.21	21.05	0.576	***
C18:2 trans n-6	1.05	1.18	0.028	*
C18:2 cis n-6 (LA)	14.88	13.07	0.332	NS
C18:3 n-6 (y-linolenic acid)	0.78	0.51	0.051	**
C18:3 cis n-3	10.21	5.83	0.498	***
C18:2 cis-9, trans-11 (CLA)	0.76	0.84	0.030	NS
C18:2 trans-10, cis-12	0.05	0.04	0.007	NS
C20:2 n-6	0.30	0.25	0.016	NS
C20:3 n-3	0.17	0.16	0.021	NS
C20:4 n-6 (AA)	10.42	10.52	0.184	NS
C20:5 n-3 (EPA)	5.32	4.07	0.162	***
C22:5 n-3 (DPA)	7.17	6.40	0.160	*
C22:6 n-3 (DHA)	2.82	2.89	0.152	NS
n-3 fatty acids	25.69	19.35	0.739	***
n-6 fatty acids	27.43	25.53	0.363	*
n-6/n-3 ratio	1.07	1.32	0.034	***
SFA[†]	27.57	30.45	0.444	***
MUFA[†]	18.53	23.81	0.619	***
PUFA[†]	53.92	45.76	0.983	***

[†]SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA =polyunsaturated fatty acids.
*P<0.05; ***P<0.001; NS: not significant.

The monounsaturated fatty acids palmitoleic (C16:1 cis 9) and oleic (C18:1 cis 9) were higher (P<0.001) in the fat from lambs of the stall group, whereas there was not significant differences for trans-vaccenic acid (C18:1 trans 11).

In our experiment linoleic (C18:2 n-6) and arachidonic (C20:4) acids did not show significant differences among the two groups. This result contrasts with other studies that raised ruminants on pasture or with high amounts of grass silage (Valvo *et al*., 2005; Velasco *et al*., 2001, 2004; Rowe *et al.,* 1999). However, in the experiment of French *et al*. (2000) that studied effects of decreasing the

concentrate proportion in a concentrate-grass based diet using continental crossbred steers, the authors only observed an effect of the diet on the intramuscular LNA (C18:3 n-3) content and no effect of diet on LA or ARA (C20:4 n-6) was detected, as in our experiment.

Linolenic acid (C18:3 n-3) was increased by twofold ($P<0.001$) in the fat of lambs from the grass group compared to lambs fed by ewes given concentrates. This was probably strictly correlated with the level of this fatty acid in the milk that was almost twofold higher in the milk from ewes of grass group. This is because the grass have a higher concentration of linolenic acid, mainly in a young pasture (Chillard *et al*., 2001).

In our experiment the isomer *cis*-9, *trans*-11 of CLA did not show significant differences among the two groups. This value could be correlated to the young age of the animals.

Eicosapentaenoic (C20:5 n-3; EPA) and docosapentaenoic (C22:5 n-3; DPA) acids were higher ($P<0.001$ and $P<0.05$ respectively) in the intramuscular fat from lambs of grass group compared to stall group. Therefore, the intramuscular fat of lambs from the grass group was richer in n-3 PUFA ($P<0.001$) compared to lambs from the stall group.

The level of polyunsaturated fatty acid was higher ($P<0.001$) in the lambs of the grass group, whereas the rate of saturated fatty acid was higher ($P<0.001$) in the fat from lamb raised by ewes given concentrates, consequently the ratio PUFA:SFA was higher ($P<0.001$) in the lambs of grass group.

Accordingly to higher levels of polyunsaturated fatty acids n-3 in lambs meat from ewes allowed pasture, the ratio Σ n-6:Σ n-3 was significantly lower in this group. However, the value of this ratio in the meat from lambs of stall group was under the rate suggest from COMA (Department of Health,1994).

Conclusion

This trial has deepened the studies already published by Valvo *et al.* (2005) and Velasco *et al*. (2001; 2004) on suckling lamb showing that grass feeding system appear to be the better means to improve the healthy quality, even for suckling lambs slaughtered at 100 days of age.

References

Bonanome, A. and Grundy, S.M. (1998). Effect of dietary stearic acid on plasma cholesterol and lipoprotein levels. *New England J. of Medicine*, 388: 1244-1248.

Chilliard, Y., Ferlay, A., and Doreau, M. (2001). Effect of different types of forages, animal fat or marine oils in cow's diet on milk fat secretion and composition, especially conjugated linoleic acid (CLA) and polyunsaturated fatty acids. *Livest. Prod. Sci*., 70: 31-48.

Clarke, R., Frost, C., Collins, R., Appleby, P. and Peto, R. (1997). Dietary lipids and blood cholesterol: quantitative meta-analysis of metalic ward studies. *British Medical J*., 314: 112-117.

Department of Health (1994). *Nutritional aspects of cardiovascular disease*. Report of Health and Social Subjects No. 46. Her Majesty's Stationery Office, London.

Folch, J., Lees, M. and Sloane-Stanley, G.H.S. (1957). A simple method for the isolation and purification of total lipids from animal tissues. *J. of Biological Chemistry,* 226: 497-509.

French, P., Stanton, C., Lawless, F., O'Riordan, E.G., Monahan, F.J., Caffrey, P.J. and Moloney, A.P. (2000). Fatty acid composition, including conjugated linoleic acid, of intramuscular fat from steers offered grazed grass, grass silage, or concentrate-based diets. *J. of Anim. Sci*., 78: 2849-2855.

Keys, A., Anderson, J.T. and Grande, F. (1965). Serum cholesterol response to changes in the diet. *Metabolism,* 14: 747-787.

Keys, A. (1970). Coronary heart disease in seven countries. *Circulation,* 41(Suppl. 1): 1-211.

Rowe, A., Macedo, F.A.F., Visentainer, J.V., Souza, N.E. and Matsushita, M. (1999). Muscle composition and fatty acid profile in lambs fattened in drylot or pasture. *Meat Sci*., 51: 283-288.

Ulbricht, T.L.V. and Southgate, D.A.T. (1991). Coronary heart disease: Seven dietary factors. *Lancet,* 338: 985-992.

Valvo, M.A., Lamza, M., Bella, M., Fasone, V., Scerra, M., Biondi, L. and Priolo, A. (2005). Effect of

ewe feeding system (grass *vs* concentrate) on intramuscular fatty acids of lambs raised exclusively on maternal milk. *Animal Science*, 81: 431-436.
Velasco, S., Cañeque, V., Pérez, C., Lauzurica, S., Díaz, M.T., Huidobro, F., Manzanares, C. and Gonzáles, J. (2001). Fatty acid composition of adipose depots of suckling lambs raised under different production systems. *Meat Sci*., 59: 325-333.
Velasco, S., Caneque, V., Lauzurica, S., Pérez, C. and Huidobro, F. (2004). Effect of different feeds on meat quality and fatty acid composition of lambs fattened at pasture. *Meat Sci*., 66: 457-465.