Fatty acid composition of different fat depots of lambs fed diets rich in n3 polyunsaturated fatty acids

C.I. Sánchez[1*], M.T. Díaz[2], C. Fernández[1], J. De la Fuente[3], I. Álvarez[2], M.C. Pérez[3], S. Lauzurica[3] & V. Cañeque[2]

[1]Instituto Tecnológico Agrario de Castilla y León, Estación Tecnológica de la Carne, Avda. Filiberto Villalobos, s/n, 37770 Guijuelo, Spain.

[2]Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, Departamento de Tecnología de los alimentos, Carretera de la Coruña km 7.5, 28040 Madrid, Spain.

[3]Universidad Complutense de Madrid, Facultad de Veterinaria, Departamento de Producción Animal Avda. Puerta de Hierro, s/n, 28040 Madrid, Spain.

[4]Universidad Complutense de Madrid, Facultad de Veterinaria, Departamento de Fisiología Animal (Biología), Avda. Puerta de Hierro, s/n, 28040 Madrid, Spain.

*E-mail: sangoncl@itacyl.es.

Abstract

The present study evaluated the effect of diets containing different sources of n3 PUFA, linolenic acid (C18:3n3; LNA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), on fatty acid composition in different fat depots of lambs. The experimental diets, with similar fatty acid levels, were: control, linseed, linseed plus microalgae, and fish oil. Male lambs with an initial live weight of 12 Kg were offered one of the four diets until a 26 Kg of slaughter live weight. Fatty acids of subcutaneous, kidney knob and channel fat (KKCF), and intramuscular fat depots were analyzed. As expected, lambs fed the linseed diet had the highest LNA proportion (2.2-2.5%) in all fat depots. On the other hand, lambs fed control or fish oil diets had the lowest LNA proportion (0.25-0.40%). Lambs fed linseed plus microalgae had an intermediate proportion (1.5-1.8%). Feeding fish oil increased long-chain n3 fatty acid (DHA and EPA) in all fat depots. However, EPA and DHA were mainly deposited in intramuscular fat, except in lambs fed the control diet, where differences among fat depots were not significant. Fat from lambs fed diets rich in n3 showed a lower n6/n3 ratio (1.2-2.6) than lambs fed control diet (8.0-10.1). KKCF of control lambs showed the highest n6/n3 ratio (10.1).

Introduction

There is great interest in modifying the fatty acid profile in the meat of ruminants to reduce saturated fatty acids (SFA) and increase polyunsaturated fatty acids (PUFA), especially those belonging to the n3 family (Raes et al., 2004). Vegetable oils like linseed, which contains linolenic acid, or marine products like fishmeal, fish oils, and microalgae, which are greater sources of EPA and DHA have been used as sources rich in n3 fatty acids (Wachira et al., 2002; Kitessa et al., 2001). Since dietary fatty acids are hydrogenated in the rumen, the composition of fatty acids in the fat depots of ruminants is not greatly influenced by dietary fat (Gulati et al., 1997). However, Palmquist (1994) showed that the rate of ruminal lipolysis is directly related to the level of fat unsaturation. Some authors (Fievez, et al., 2000) have found a lower rate of lipolysis of fatty acids in fish oil and algae compared to vegetable oils (Dohme et al., 2003) and have observed at the same time lower percentages of biohydrogenation in the most polyunsaturated fatty acids (EPA and DHA) compared to other PUFAs. In ruminants, the fat of the internal depots (omental, mesenteric, and kidney knob and channel) is more saturated than that of subcutaneous and intramuscular depots which are related with the quality meat (Lee et al., 2007).

The present study evaluated the effect of diets containing different sources of n3 PUFA: linolenic acid (LNA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) on fatty acid composition in different fat depots of lambs.

Materials and methods

This study was carried out with 44 Manchega breed male lambs with an initial live weight of 12 kg. All animals were fattened in individual boxes with experimental diets: control, linseed, linseed plus microalgae, and fish oil. Fatty acid composition of the four experimental diets is shown in Table 1.

Table 1. Fatty acid composition (%) of the four experimental diets

	Control	Linseed	Microalgae plus linseed	Fish oil
C16:0	57.3	13.8	14.8	27.8
C18:0	18.2	3.3	3.2	5.0
C18:1	6.0	17.9	20.1	20.0
LA	13.4	29.1	28.6	22.8
LNA	3.2	34.7	28.6	2.4
EPA	-	-	0.1	2.8
DHA	-	-	0.4	6.3

Lambs were slaughtered at a live weight of 26 kg. Samples selected for analysis were subcutaneous fat tissue (SC), kidney knob and channel fat (KKCF), and intramuscular fat (IM) of *longissimus* muscle. Fat was obtained by a modified Bligh & Dyer method (Hanson & Olley, 1963) from different samples. Fatty acid methyl esters (FAMES) were prepared by a modified Morrison & Smith method (Morrison & Smith, 1964). FAMES were analyzed by gas chromatography using an Agilent Technologies 6890 gas chromatograph (GC) equipped with a flame ionization detector (FID). Separation was carried out on an Omegawax 320 fused-silica capillary column (30m×0.32mm i.d., 0.25µm film thickness). GC conditions were: oven temperature 200 ºC, hold for 60 min, and injector and detector temperatures 260 ºC. Carrier gas was helium (11 psi) and samples were injected (0.2 µl) in the split mode (1:50). Individual FAMES were identified by comparing their retention times with those of standards supplied by Sigma Aldrich. Results are expressed as a percentage of the total of fatty acids analyzed: C10:0, C12:0, C14:0, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2n6 (LA), C18:3n4, C18:3n3 (LNA), C18:2c9-t11 (CLA), C20:0, C20:1n9, C20:4n6 (ARA), C20:4n3, C20:5n3 (EPA), C22:4n6, C22:5n3 (DPA) y C22:6n3 (DHA). An ANOVA was performed to analyze the effect of diet (D), fat depot (F) and the interaction DxF.

Results and discussion

Table 2 shows the effect of the different experimental diets and of the type of fat depot on the proportion of the fatty acids of most interest.

Table 2. Mean values of fatty acid proportions of fat depots (F) and experimental diets (D)

	Control			Linseed			Microalgae plus linseed			Fish oil				significance		
	IM	KKCF	SC	IM	KKCF	SC	IM	KKCF	SC	IM	KKCF	SC	RSEM	F	D	F*D
C16:0	23.33	23.36	26.44	22.28	18.96	22.39	22.64	18.27	23.43	27.30	21.64	26.89	1.71	**	**	**
C18:0	13.69	26.59	13.73	13.00	23.91	14.01	11.86	21.91	12.89	12.20	22.71	14.56	2.30	**	*	NS
C18:1	43.88	37.50	43.83	41.59	41.29	44.95	43.92	45.21	46.56	37.69	39.85	40.11	2.44	**	**	**
LA	7.03	3.92	3.61	8.17	4.90	4.42	7.35	4.31	3.75	5.00	3.23	2.72	0.98	**	**	NS
LNA	0.38	0.31	0.33	2.49	2.46	2.19	1.79	1.78	1.51	0.29	0.29	0.25	0.35	NS	**	NS
CLA	0.33	0.29	0.40	0.45	0.40	0.57	0.60	0.52	0.70	0.59	0.50	0.62	0.22	NS	**	NS
ARA	2.22	0.08	0.18	2.10	0.08	0.14	1.96	0.07	0.13	2.18	0.24	0.30	0.34	**	NS	NS
EPA	0.17	0.02	0.03	0.60	0.05	0.09	0.52	0.04	0.08	1.80	0.42	0.55	0.19	**	**	**
DPA	0.41	0.04	0.09	0.83	0.15	0.21	0.67	0.12	0.18	1.18	0.49	0.60	0.12	**	**	**
DHA	0.21	0.01	0.04	0.52	0.08	0.16	0.62	0.07	0.17	2.65	0.86	1.62	0.33	**	**	**
n3	1.20	0.40	0.50	4.49	2.75	2.67	3.64	2.03	1.96	6.07	2.17	3.12	0.714	**	**	**
n6	9.50	4.03	3.85	10.45	5.00	4.60	9.46	4.40	3.92	7.31	3.51	3.08	1.243	**	**	NS
n6/n3	8.05	10.14	8.16	2.33	1.83	1.74	2.61	2.18	2.02	1.25	1.80	1.21	0.75	**	**	**
PUFA/SFA	0.27	0.09	0.11	0.39	0.17	0.18	0.35	0.16	0.16	0.31	0.13	0.14	0.05	**	**	NS

significance; * P <0.01; ** P <0.01; NS: no significant.

The type of fat deposit influenced fatty acid composition. Kidney knob and channel fat, as the most internal depot, had the highest stearic acid (C18:0) proportion. Intramuscular fat, conversely, had a higher content in linoleic acid (LA) and arachidonic acid (ARA), as well as, total n6 PUFA. Intramuscular depot also showed the highest PUFA/SFA ratio.

There was also an effect of diet on the deposition of some fatty acids. As expected, lambs fed linseed diet had the highest LNA proportion (2.4%). On the other hand, lambs fed control or fish oil diets had the lowest LNA proportion (0.3%), while lambs fed linseed plus microalgae had an intermediate proportion (1.7%). The CLA was found in a lower proportion in animals that received the control rations (0.3%) than in

those that received the supplemented diets (0.5, 0.6, and 0.6% for linseed, microalgae plus linseed, and fish oil, respectively). Total n6 PUFA proportion also was the lowest in lambs fed fish oil.

A significant interaction ($P < 0.01$) was observed between diet and the type of fat depot in the proportions of

C16:0, C18:1, n3 long chain fatty acids (EPA, DPA and DHA), total n3, and the n6/n3ratio. EPA, DPA, and DHA and, hence, total n3 fatty acids, were deposited in a higher proportion in intramuscular fat than in KKCF or subcutaneous fat. The differences between the depots were greater in animals fed fish oil diet than in those fed the other supplemented diets and above all the animals with the control diet. The highest proportion of n3 fatty acid in animals supplemented with fish oil was due to the highest long chain fatty acids (DHA, EPA, and DPA) proportion, while in animals fed linseed and linseed plus microalgae was due to LNA (Wachira et al., 2002).

Conclusions

As expected, lambs fed linseed diet had the highest LNA proportion in all fat depots and lambs fed control or fish oil diets had the lowest LNA proportion. Feeding fish oil increased long-chain n3 fatty acid (DHA and EPA) in all fat depots especially in intramuscular fat. Fat from lambs fed diets rich in n3 showed lower n6/n3ratio than lambs fed the control diet. KKCF of control lambs showed the highest n6/n3ratio.

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