Effect of dietary sources rich in n3 fatty acids on fatty acid composition of different lamb muscles

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Abstract

The present work studied dietary manipulation of the fatty acid profile in different lamb muscles, using vegetable and marine sources rich in n3 polyunsaturated fatty acids (PUFA). Manchego breed lambs were fed with four experimental diets with similar fatty acid levels: control, linseed, microalgae plus linseed, and fish oil, from an initial live weight of 12 Kg to a slaughter live weight of 26 Kg. Three different muscles: *infraespinatus*, *longissimus*, and *psoas major* were analyzed. High proportion of medium chain n3 PUFA (1.8-2.8% of linolenic acid (LNA)) was obtained in the muscles from lambs fed the linseed and microalgae plus linseed diets. In relation to long chain n3 PUFA (eicosapentaenoic acid (EPA)), a significant interaction between diet and muscle was observed. Thus, animals fed control, linseed, or microalgae plus linseed diets showed similar EPA proportion in the three muscles studied; however, in animals fed the fish oil diet, *infraespinatus* muscle had a higher EPA proportion than *longissimus* and *psoas major* muscles. The n6/n3 ratio, related to human health, was lowest in the fish oil diet (1.3) and highest in the control diet (8.0).

Introduction

The excess consumption of saturated fats and cholesterol is associated with the onset of cardiovascular diseases. Nevertheless, diets rich in polyunsaturated fatty acids , especially those of n3 family, have been related to lower incidence of these types of diseases (Connor, 2000). Therefore, different ways of change the fatty acids composition of ruminants meat, increasing the proportion of n3 fatty acids and reducing the n6/n3 ratio, have been suggested (Gibney, 1993). Vegetable fats and oils, such as linseed oil, which provide linolenic acid (LNA) (Wachira et al., 2002), and marine products, such as fishmeal and fish oil and microalgae (Wachira et al., 2002; Kitessa et al., 2001; Ponnampalam et al., 2001, 2002), which are the major sources of EPA and docosahexaenoic acid (DHA), have been used in the diets of animals in order to obtain elevated n3 PUFAs levels in ruminant tissue. EPA and DHA have beneficial effects on human health, acting to prevent cardiovascular disease and some cancers (Simopoulos, 2002).

The aim of this work was to study the deposition of n3 fatty acids in meat of lamb fattened with different sources of n3 (fish oil, linseed, or microalgae plus linseed), and with a control diet which provide fat in the form of hydrogenated vegetable fat.

Material and methods

Forty-four Manchego breed lambs with a mean initial weight of 12 kg, were used. The lambs were fattened with four experimental diets with similar levels of fatty acid: control, linseed, microalgae plus linseed, and fish oil. The fatty acid composition of the four experimental diets is shown inTtable 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

The lambs were slaughtered at a mean live weight of 26 kg. After 24 hours of refrigeration at 4ºC, *infraespinatus* (IN), *longissimus* (L) and *psoas major* (PM) muscles were dissected for analysis. The intramuscular fat was extracted following the method of Hanson & Olley (1963) (modification of the method of Bligh & Dyer, 1959) and the fatty acid methyl ester profiles was determined (modification of the method of Morrison & Smith, 1964). The equipment used was an Agilent Technologies 6890 chromatograph with a flame ionization detector (GC-FID). A Omegawax 320 fused-silica capillary column (30m×0.32mm i.d., 0.25µm film thickness) was used, and the oven temperature was programmed to 200 ºC, held for 60 min. Helium was used as carrier gas and samples were injected (0.2 µl) in the split mode (1:50). Identification and quantification of the fatty acids was carried out using Sigma–Aldrich (Missouri, USA) reference standards, and nonadecanoic acid (C19:0) was used as the internal standard. Fatty acid profiles were expressed as a percentage of the total fatty acids identified. The quantified fatty acids were: 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) and C22:6n3 (DHA). A two-way analysis of variance was performed to compare the treatments.

Results and discussion

Table 2 shows the effect of the feeds used and of the type of muscle on the proportion of fatty acids of most interest.

Table 2. Mean values of fatty acid proportions of experimental diets (D) and muscles (M) of lambs

	Control			Linseed			Microalgae plus linseed			Fish oil				significance		
	IN	L	P M	IN	L	P M	IN	L	P M	IN	L	P M	SEM	M	D	M*D
C16:0	21.13	23.33	22.39	20.23	22.28	21.33	20.77	22.64	21.76	23.68	27.30	25.39	1.29	**	**	NS
C18:0	12.57	13.69	13.38	12.18	13.00	13.34	11.13	11.86	11.66	11.88	12.20	12.58	1.15	NS	**	NS
C18:1	42.41	43.88	42.47	38.83	41.59	39.50	41.87	43.92	42.00	35.58	37.69	36.95	2.21	**	**	NS
LA	10.25	7.03	8.97	11.66	8.17	10.53	10.14	7.35	9.60	7.07	5.00	6.48	1.52	**	**	NS
LNA	0.47	0.38	0.60	2.71	2.49	2.59	1.98	1.79	2.00	0.35	0.29	0.33	0.44	NS	**	NS
CLA	0.34	0.33	0.31	0.45	0.45	0.43	0.61	0.60	0.58	0.54	0.59	0.58	0.21	NS	**	NS
ARA	3.62	2.22	2.93	3.60	2.10	2.81	3.17	1.96	2.70	4.17	2.18	2.83	0.78	**	NS	NS
EPA	0.23	0.17	0.24	0.83	0.60	0.68	0.70	0.52	0.61	3.00	1.80	2.24	0.39	**	**	**
DPA	0.70	0.41	0.58	1.30	0.83	1.01	1.00	0.67	0.86	1.64	1.18	1.49	0.24	**	**	NS
DHA	0.36	0.21	0.29	0.85	0.52	0.63	0.96	0.62	0.76	3.80	2.65	2.99	0.43	**	**	NS
n3	1.78	1.20	1.73	5.75	4.49	4.98	4.71	3.64	4.29	8.98	6.07	7.23	1.15	**	**	NS
n6	14.29	9.50	12.23	15.56	10.45	13.60	13.54	9.46	12.51	11.43	7.31	9.47	2.20	**	**	NS
n6/n3	8.15	8.05	7.78	2.71	2.33	3.21	2.92	2.61	2.95	1.33	1.25	1.36	0.99	NS	**	NS
PUFA/ SFA	0.44	0.27	0.36	0.61	0.39	0.50	0.53	0.35	0.47	0.53	0.31	0.41	0.09	**	**	NS

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

Diet had a significant effect on all the fatty acids (P <0.01), except with respect to arachidonic acid (ARA) (P >0.05), and on the n6/n3 and PUFA/SFA ratios (P <0.01). The proportion of n6 fatty acids was lower in animals supplemented with fish oil (9.4%) than in the rest of the groups (12.0, 13.2, and 11.8% for control, linseed and microalgae plus linseed, respectively) mainly due a lower deposition of linoleic acid (LA). This agrees with the results obtained by Kittesa et al. (2000). As expected, the deposition of n3 fatty

acids was greater for animals fed supplemented feeds (5.1, 4.2, and 7.4% for linseed, microalgae plus linseed, and fish oil, respectively) than for the control group (1.5%). The highest proportion of long-chain fatty acids (DHA, EPA, and DPA) occurred in animals supplemented with fish oil, and the highest level of linoleic acid was found in those supplemented with linseed and microalgae plus linseed. Therefore, the n6/n3 ratio was higher in the control group (8.0) than in the linseed and microalgae plus linseed diets (2.8) or in the fish oil diet (1.3).The n6/n3 ratio was eight times lower in the animals supplemented with fish oil and three times lower in animals supplemented with linseed and microalgae plus linseed (Elmore et al., 2000). The PUFA/SFA ratio was greater in supplemented animals (0.50, 0.45, and 0.41 for lamb fed linseed, microalgae plus linseed, and fish oil diets, respectively) and close to the value recommended by the Department of Heath (1994). On the other hand, the control group showed lower values (0.35).

Palmitic acid (C16:0), oleic acid (C18:1), LA, ARA, DPA, and the PUFA/SFA ratio were affected by muscle type ($P < 0.01$). *Infraespinatus* muscle had lower C16:0 and higher LNA, ARA, DPA, and DHA and, therefore, a higher PUFA/SFA ratio than *longissimus* and *psoas major* muscles. However, *longissimus* muscle had the highest proportion of C16:0 and C18:1. There was a significant interaction ($P < 0.01$) between muscle and diet for EPA proportion. Animals fed fish oil diet had higher deposition of EPA in *infraespinatus* muscle, while animals fed with the other diets showed similar EPA deposition in all of the muscles.

Conclusions

As expected, the deposition of *n-3* fatty acids is greater for the animals given supplemented diets (5.1, 4.2, and 7.4% for linseed, microalgae plus linseed, and fish oil, respectively) than for the control group (1.5%). In relation muscle type, results showed that *infraespinatus* muscle had lower C16:0 and higher PUFAs than *longissimus* and *psoas major* muscles.

Acknowledgements

This work was made possible by funding from the Spanish INIA (Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria; RTA2005-00071-C03).

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