Animal Feed Science and Technology 165 (2011) 1–7

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Performance, immune response and fatty acid profile in lambs supplemented with a CLA-mixture

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ARTICLE INFO

Article history:
Received 24 March 2010
Received in revised form 21 October 2010
Accepted 27 October 2010

Keywords:
Lamb
Conjugated linoleic acid
Immune response
Meat

ABSTRACT

Forty-nine weaned Ripollesa lambs (15 ± 2.9 kg of BW, 41 ± 6.9 d old) were used to study the effects of CLA-mixture supplementation on meat fatty acid profile, and humoral immune response during the fattening period. Lambs were placed in six pens and allocated to one of three treatments: a control concentrate (CT), a concentrate supplemented with 2.5 g/kg CLA-mixture (50:50, c9t11 CLA and t10c12 CLA) (Low-CLA), and a concentrate supplemented with 10 g/kg CLA-mixture (High-CLA). Straw and water were offered *ad libitum* until reaching the slaughter weight (25 ± 1.6 kg of BW). Lambs were weighed weekly to control slaughter BW. One week after weaning (48 ± 6.9 d of age), 2 mg of ovalbumin were injected subcutaneously to lambs. Blood samples were collected before vaccination and 14 d later to evaluate humoral immune response. The *Longissimus dorsi* from the right side of the carcass was sampled from five female lambs per treatment. Body weight at slaughter, carcass weight and carcass yield were similar among all treatments. There were no differences in antibody response to ovalbumin. Fat content in muscle was also similar among all treatments. However, the isomers of CLA c9t11, and t10c12 were greater in High-CLA than in Low-CLA and CT lambs (0.39, 0.30, and 0.26 g/100 g FAME for c9t11 CLA, and 0.051, 0.013, and 0.014 g/100 g FAME for t10c12, respectively). In conclusion, humoral immunity was not affected by CLA supplementation, but meat FA profile was modified by increasing c9t11, and t10c12 CLA levels.

1. Introduction

Beneficial activities of some CLA isomers have been widely reported in animal models, including decreased fat mass, prevention and reduction of growth of preformed atherosclerotic lesions, anti-carcinogenic and anti-inflammatory effects, and beneficial effects on immune system and bone metabolism (Bhattacharya et al., 2006). Ruminant products are natural sources of conjugated linoleic acid (CLA) and the *cis*-9, *trans*-11 (c9t11) CLA is the major isomer of CLA in natural foods (920 g/kg of total CLA in lamb meat; Dhiman et al., 2005). Nevertheless, the inclusion of CLA-mixtures (50:50, c9t11 and *trans*-10, *cis*-12 (t10c12) CLA isomers) (Wynn et al., 2006) or a change of the fatty acid (FA) profile (Bolte et al., 2002) in lamb diets can improve nutritional quality of lamb meat by increasing the content of CLA.

Abbreviations: BW, body weight; CLA, conjugated linoleic acid; c9, t11, *cis*-9, *trans*-11 CLA isomer; FAs, fatty acids; LD, *Longissimus dorsi*; t10, c12, *trans*-10, *cis*-12 CLA isomer; PBS, phosphate buffered saline.

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doi:10.1016/j.anifeedsci.2010.10.014

Farm animals can also benefit from CLA (*e.g.* immune and anti-inflammatory effects). The favourable effects of CLA on the immune system could: (i) enhance vaccine efficacy, as observed in subjects that reached greater protective antibody levels following hepatitis B vaccine when consuming a CLA-mixture compared to control subjects (Albers et al., 2003), and (ii) help to prevent some infectious diseases by improving CD8+ lymphocyte proliferation (Bassaganya-Riera et al., 2001).

In lambs, few studies have evaluated the possibility of enriching meat with CLA through dietary CLA supplementation (Wynn et al., 2006), but to our knowledge none of them have considered the immune effects of CLA on lambs. The objective of this study was to evaluate the effects of supplementing a CLA-mixture on muscle FA profile, and humoral immune response in lambs belonging to a Mediterranean sheep breed located in the northeast of Spain named Ripollesa, which is mainly used to produce meat.

2. Materials and methods

2.1. Animals and treatments

Animals were housed in the Experimental Farm of Institut de Recerca i Tecnologia Agroalimentàries at Torre Marimon (Caldes de Montbui, Barcelona). All animals were managed according to the recommendations of the Animal Care Committee of IRTA.

A total of 33 Ripollesa ewes lambed from 10 June to 9 July 2008. Ewes and lambs were split into three groups distributed by type of lambing (single or double) and gender (male and female). As a result, 16 lambs (from 10 ewes) were fed a control diet (CT), 18 lambs (from 13 ewes) were fed a diet containing a starter concentrate mixture with 2.5 g/kg of rumen protected CLA-mixture (LodeStar^{TM}, Wormerveer, The Netherlands) (Low-CLA), and 15 lambs (from 10 ewes) were fed a diet containing a starter with 10 g/kg of rumen protected CLA-mixture (High-CLA). The CLA-mixture contained 560 g/kg pure CLA (as methyl esters), of which half was c9t11 CLA and the other half was t10c12 CLA, 82.3 g/kg palmitic acid, 54.1 g/kg stearic acid, and 303.6 g/kg oleic acid. Therefore, the final dose of CLA-mix in the starter was 1.4 g/kg for Low-CLA and 5.6 g/kg for High-CLA. The CLA-mix was included in the concentrate formula by replacing corn meal. Ewes were fed a basal diet with alfalfa hay and barley in all three treatments. The starter concentrate was consumed *ad libitum* in each treatment group (Tables 1 and 2). Lambs were kept with their mothers until weaning (15 ± 2.9 kg of BW, 41 ± 6.9 d of age). At weaning, lambs from each treatment were distributed in 2 pens each one, according to initial treatments (CT, Low-CLA, and High-CLA), and were fed the starter concentrate mixture treatment and barley straw *ad libitum*.

One week after weaning (48 ± 6.9 d of age), 2 mg of ovalbumin (GradeVII, Sigma–Aldrich, Saint Louis, MO, USA) suspended in 1 ml of PBS were injected subcutaneously to lambs to determine humoral immune response to ovalbumin vaccine.

Table 1
Ingredient and chemical composition of lamb starter concentrate mixtures.

Item	Starter concentrate mixtures[a]		
	CT	Low-CLA	High-CLA
Ingredient composition, g/kg DM			
Barley	505	505	505
Corn meal	150	148	140
Wheat middling's	60	60	60
Soybean meal	180	180	180
Carob	40	40	40
Tallow	5	5	5
Dried milk whey	20	20	20
Dicalcium phosphate	1	1	1
Sodium chloride	3	3	3
Calcium carbonate	15	15	15
Microminerals[b]	4	4	4
CLA-mix[c]	–	2.5	10
Nutrient composition, g/kg DM			
Crude protein	185	191	182
Ether extract	13	12	18
aNDFom	158	160	154
ADFom	49	51	47
Non-fiber carbohydrates[d]	570	561	566
Ash	74	76	80

[a] CT: starter concentratre without conjugated linoleic acid, Low-CLA: starter concentrate with 2.5 g/kg conjugated linoleic acid, High-CLA: starter concentrate with 10 g/kg conjugated linoleic acid.

[b] Premix composition: Vitamin A 3.333.333 IU/kg, Vitamin D_3 333.333 IU/kg, Vitamin E 5.886 mg/kg, Vitamin B_1 686 mg/kg, Vitamin B_2 333 mg/kg, Fe 11.666 mg/kg, Mn 13.333 mg/kg, Co 65 mg/kg, Zn 13.333 mg/kg, I 166 mg/kg, Se 100 mg/kg, Ca 152.8 g/kg, Mg 50.5 g/kg, and S 33.3 g/kg.

[c] LodeStar^{TM} (CLA methyl esters) total CLA > 560 g/kg, *cis*-9, *trans*-11 CLA > 280 g/kg, *trans*-10, *cis*-12 CLA > 280 g/kg, GE 9.36 Mcal/kg.

[d] Calculated as 1000 − (CP + fat + NDF + ash, g/kg).