Meat Science 96 (2014) 1304–1312

Contents lists available at ScienceDirect

Meat Science

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

Effects of different sources of fat (calcium soap of palm oil vs. extruded linseed) in lactating ewes' diet on the fatty acid profile of their suckling lambs

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ARTICLE INFO

Article history:
Received 8 March 2013
Received in revised form 30 October 2013
Accepted 31 October 2013

Keywords:
Suckling lamb
Fatty acid
Intramuscular
Subcutaneous
Meat
Extruded linseed

ABSTRACT

The main objective of this study was to evaluate the effects of supplementing lactating ewe diets with extruded linseed on the fatty acid (FA) composition of intramuscular and subcutaneous fat depots of suckling lambs. Twenty-four pregnant Churra ewes were divided into two groups based on the milk production, age, body weight and parity, and assigned to one of two treatments. Each ewe of the Control treatment was supplemented with 70 g/day of FAs from a calcium soap of palm oil, while the other treatment group (Lin) was supplemented with 128 g/day of extruded linseed. All lambs were reared exclusively on milk and were slaughtered when they reached 11 kg live weight. FA profiles of ewe milk, lamb meat and subcutaneous adipose tissue were determined by GC. Lamb performance was not affected by the treatments. Muscle fat and adipose tissue from the Lin treatment showed higher proportions of polyunsaturated fatty acids (PUFA). The percentages of α-linolenic (C18:3 n − 3), docosahexaenoic (C22:6 n − 3), vaccenic (*trans*-11 C18:1) and rumenic (*cis*-9, *trans*-11 C18:2) acids in both fat depots were higher in Lin than in Control suckling lambs. Furthermore, meat fat from Lin carcasses displayed a lower n − 6/n − 3 ratio than Control samples. Intramuscular depots clearly showed a greater content of PUFA, including *cis*-9, *trans*-11 C18:2, and a lower n − 6/n − 3 ratio than subcutaneous fat. The results from this study demonstrate that dietary extruded linseed supplementation of lactating ewes enhances the nutritional quality of suckling lamb fat depots such as intramuscular and subcutaneous fats.

1. Introduction

Suckling lamb meat is widely consumed in some geographical areas of the world such as in Mediterranean countries and is an important commodity in the north of Spain. These lambs, reared exclusively on dam milk, are slaughtered at 30–35 days of age and usually at 10–12 kg of body weight. Lamb producers are trying to adapt their product to consumer preferences in order to enhance sales. In recent years there has been a growing interest in healthy food and more specifically in increasing the n − 3 polyunsaturated fatty acid (PUFA) and conjugated linoleic acid (CLA) contents in meat (Raes, De Smet, & Demeyer, 2004; Schmid, Collomb, Sieber, & Bee, 2006; Wood et al., 2008).

It is well documented that the n − 3 PUFAs have different beneficial effects on neural function, reduce the risk of cardiovascular events, and manifest anti-inflammatory activity and lipid lowering potential (Kaur, Cameron-Smith, Garg & Sinclair, 2011; Simopoulos, 2008). On the other hand, the most important isomer of CLA in ruminants, *cis*-9, *trans*-11 C18:2 (rumenic acid, RA), is thought to have anticarcinogenic and antiatherosclerotic properties (Lock, Kraft, Rice, & Bauman, 2009). Furthermore, *trans*-11 C18:1 (vaccenic acid, VA), the major *trans* fatty acid (FA) in ruminant fats and the precursor of RA in tissues, may also impart additional health benefits to those associated with this CLA isomer (Field, Blewett, Proctor, & Vine, 2009).

In humans, ruminant derived foods represent the major dietary source of CLA, with meat accounting for about 25%. Moreover, the highest CLA content in meat has been found in lamb (Bauman et al., 2006; Schmid et al., 2006). Meat FA composition depends on several factors, with diet being one of the most relevant (Raes et al., 2004; Schmid et al., 2006; Wood et al., 2008). Suckling lambs are considered as being functional monogastric from a digestive point of view, as their reticular groove functionality prevents milk from passing into the rumen, so there is no ruminal biohydrogenation of the milk FAs before intestinal absorption. Therefore, changes in milk FA composition due to supplements in the dam diet can induce important differences in the FA profile of the meat and fat depots of the suckling lamb (Lanza et al., 2006; Manso, Bodas, Vieira, Mantecón, & Castro, 2011; Osorio, Zumalacárregui, Figueira, & Mateo, 2007).

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http://dx.doi.org/10.1016/j.meatsci.2013.10.040

Several strategies have been tested in recent years to improve the FA profile of ewe fat, focused on enhancing the contents of VA, RA and C18:3 n − 3 (α-linolenic acid, ALA) in derived foods. Fresh pasture has been shown to be an excellent source of ALA to increase this FA in milk (Gómez-Cortés, Frutos, et al., 2009) and subsequently in suckling lamb meat fat (Scerra et al., 2007). When fresh pasture is not available, linseed supplementation (oil or seed) is a reliable alternative feeding strategy to enrich the VA, RA and n − 3 PUFA contents in milk fat from ewes (Bodas et al., 2010; Gómez-Cortés, Bach, Luna, Juárez, & De la Fuente, 2009; Mele et al., 2011). Nevertheless, dietary fat rich in PUFA, like linseed supplements, may significantly alter the ruminal microbial ecosystem (Palmquist & Jenkins, 1980) and may negatively affect milk production (Palmquist, Lock, Shingfield, & Bauman, 2005). Vegetable oils have a more depressing effect on ruminal digestion than oilseeds, and processed oilseeds (extruded, rolled, micronised, roasted…) are more effective at increasing milk CLA content than raw seeds but less efficient than free oil (Doreau, Aurousseau, & Martin, 2009; Doreau, Laverroux, Normand, Chesneau, & Glasser, 2009). Extrusion, the most common technique used, has been proposed in order to decrease ruminal degradability and reduce the negative effects of PUFAs on the ruminal environment (Mughetti et al., 2007).

The information available on the transfer of healthy FAs from ewe milk to suckling lambs when a dam diet is supplemented with linseed is limited (Berthelot, Bas, Pottier, & Normand, 2012; Manso et al., 2011). It could be hypothesised that feeding diets enriched with ALA to lactating ewes improve the content of this omega-3 FA as well as their long chain metabolites in young suckling lambs. So, the aim of the present work was to investigate whether the supplementation of Churra ewe diet with extruded linseed would be a suitable strategy for improving the intramuscular and subcutaneous FA compositions of their suckling lambs, without detrimentally affecting animal performance. Calcium soap of palm oil was used as a control because it is a saturated fat commonly used in sheep feeding (Castro, Manso, Jimeno, Del Alamo, & Mantecón, 2009; Gargouri, Caja, Casals, & Mezghani, 2006).

2. Material and methods

2.1. Animal and experimental diets

Twenty-four pregnant Churra ewes (mean BW 58.56 ± 1.685 kg) were selected before lambing and fed the same Control diet that they received during the experimental period but without added fat. Two days after lambing, each ewe based on their milk production, age, BW and parity in randomisation was assigned to one of two experimental diets (12 ewes per treatment).

Each ewe was individually fed and a total of 2.1 kg DM of the corresponding experimental diet was supplied twice a day, plus 210 g of barley straw/ewe/day and fresh water ad libitum. Each ewe consumed the whole amount of TMR supplied daily.

Samples of diets were taken once a week during the whole experimental period for the determination of chemical composition using the AOAC (2003). The ingredients and chemical composition of the experimental diets are given in Table 1.

The newborn lambs (12 per treatment), covered by the protected geographical indication 'Lechazo de Castilla y León', were housed with their respective mothers all day long and were fed exclusively by suckling throughout the experimental period. All animal handling practices followed the Directive 2010/63/EU of the European Parliament and of the Council on the protection of animals used for scientific purposes.

2.2. Milk sampling and composition

The ewes were milked once a day in a 2 × 24 low-line Casse system milking parlour, with twelve milking units and two milkers. The milking machine (Alfa-Laval Iberia, S.A., Madrid, Spain) was set to provide 180 pulsations per minute in a 50:50 ratio at a vacuum level of 36 kPa.

Table 1
Ingredients and chemical composition of experimental diets.

	Control	Lin
Ingredients, % as fed		
Dehydrated alfalfa	39.38	36.95
Soybean meal	13.77	12.92
Corn grain	11.83	11.10
Oat grain	10.38	9.74
Barley grain	7.86	7.37
Beet pulp	7.86	7.37
Molasses	4.95	4.64
Calcium soap of palm oil[a]	3	–
Extruded linseed[b]	–	9
Vitamin mineral premix	1.00	0.91
Chemical composition, % DM		
DM, %	88.87	88.81
Ash	9.07	8.87
NDF	28.34	26.59
ADF	17.56	16.48
Crude protein	16.86	17.69
Ether extract	5.30	5.16
ME[c]	11.6	11.6

[a] Calcium soap of palm oil (Magnapac®, Norel Animal Nutrition, Madrid, Spain) contained (% of identified fatty acids) C12:0 (0.26), C14:0 (1.20), C16:0 (46.9), C18:0 (40.7) and C18:1 (9.70).
[b] Extruded linseed (Tradilin®, S.A.S. Valorex, La Messayais, Combourtille, France). Product consisted of 30% wheat middlings and 70% extruded linseed. Fatty acid composition (% of identified fatty acids): C12:0 (0.05), C14:0 (0.10), C16:0 (6.40), C18:0 (4.00), C18:1 (15.10), C18:2 (18.20) and C18:3 (54.30).
[c] ME: metabolisable energy (MJ/kg DM) estimated using FEDNA (2003).

Once a week, individual ewe milk production was recorded and samples were taken in milk collection jars. One sub-sample of milk was kept at 4 °C until analysed for fat and protein, in accordance with the International Dairy Federation (IDF, 2000), using a MilkoScan-400 analyser (Foss Electric, Hillerød, Denmark). Aliquots from weeks 2 to 4 of the experimental period were stored at −80 °C for FA analysis.

2.3. Slaughter procedure, carcass and meat measurements

Lambs were weighed twice a week until they reached the intended body weight (11 kg). At the conclusion of the trial, 2 or 3 suckling lambs from each group were transported to a commercial EU-licensed abattoir on 4 different days and slaughtered (26.6 ± 4.60 days of age). At the abattoir, the live weight of the suckling lambs was recorded, the lambs were slaughtered and carcasses were immediately transferred to a cooler at 4 °C. After 24 h, carcasses were weighed again (cold carcass weight, CCW) and chilling losses were calculated as the difference between hot carcass weight (HCW) and CCW expressed as a proportion of the initial HCW. Dressing percentage was calculated as the ratio of CCW to slaughter live weight. Sample tissues of the *m. Longissimus dorsi* (dissected from between the 6th and the 13th rib) and subcutaneous dorsal fat (dissected from the rump) were frozen at −80 °C until FA analyses.

2.4. Fatty acid analysis

Milk fat was extracted following the method described by Luna, Juárez, & De la Fuente (2005) and intramuscular fat using the method described by Bligh & Dyer (1959). Subcutaneous fat was extracted by fusion of individual samples.

Milk FA composition (individual samples from weeks 2 and 4 of the suckling period) and fat depots (intramuscular and subcutaneous) were determined by gas–liquid chromatography. Fatty acid methyl esters (FAME) were prepared according to ISO-IDF (2002). Analysis of FAME was performed on a gas–liquid chromatograph (Agilent 6890 N Network System) onto a CP-Sil 88 fused silica capillary column (100 m × 0.25 mm, Varian, Middelburg, Netherlands) under similar conditions to those reported by Luna, Bach, Juárez, & De la Fuente