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Animal performance and fatty acid composition of lambs fed with different vegetable oils

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ABSTRACT

Twenty-seven lambs were used to investigate the effects of the inclusion of 4% hydrogenated palm oil (HPO) or sunflower oil (SFO) in the concentrate on animal performance, carcass and meat quality and fat characteristics and fatty acid composition. Animals (16.2 ± 0.27 kg initial weight) were fed concentrate (Control, HPO or SFO) and barley straw ad libitum and slaughtered at 25 kg. SFO lambs tended to eat less concentrate than HPO animals ($P < 0.10$). Neither HPO nor SFO affected any of the carcass characteristics studied, meat pH and meat and fat colour ($P > 0.05$). SFO decreased proportions of C16:0, C18:1 *cis-11* and C18:3 ($P < 0.05$) and increased C18:1 *trans* ($P < 0.001$) and C18:2/C18:3 ratio ($P < 0.05$). Atherogenicity index was lower ($P < 0.05$) when SFO was included in the concentrate. HPO did not affected and SFO improved fatty acid composition of fattening lambs without affecting animal performance.

1. Introduction

In the Mediterranean area, intensively reared lambs are usually fed with barley straw and concentrate ad libitum in order to achieve great growth rates. Over the last decade, fat supplementation became a common practice to increase the energy density of the diet for ruminants (Bauman, Corl, & Peterson, 2003), palm oil supplements being the most used, since they do not have the negative effects on rumen fermentation as unsaturated oils (Jenkins, 1993). However, the type of fat in the ration is known to affect the composition of body fat (Bas & Morand Fehr, 2000).

Lamb fat is characterized by a high saturated fatty acid (SFA) content, and a low polyunsaturated fatty acid (PUFA) content (Enser, Hallett, Hewitt, Fursey, & Wood, 1996), due to the biohydrogenation of unsaturated fatty acids by rumen microflora (Doreau & Ferlay, 1994). Nevertheless, meat from ruminant animals (Pariza & Ha, 1990) is within the primary sources of conjugated linoleic acid (CLAs) for humans, which has been associated with a wide range of positive health benefits. One of the options of enhancing the beneficial effects of animal products is through diet manipulation, such as the use of finishing diets supplemented with sunflower oil with high purities of linoleic or oleic fatty acids to improve the concentration of CLAs and thus their health benefits (Kott et al., 2003). On the other hand, the use of such oil has been proposed as an alternative to increase the content of PUFA in lamb tissues (Yu et al., 2008). Studies appear to focus on a higher ruminal C18:1 *trans-11* production to enhance endogenous formation of CLA *cis-9*, *trans-11* both in beef and lamb and to investigate if production of the precursor, or the activity of the Δ9-desaturase, is the limiting factor for achieving a higher tissue CLA deposition (Raes, De Smet, & Demeyer, 2004). However, although several adverse effects of *trans*-fatty acids on human health have been reported, C18:1 *trans-11* (typically the major *trans*-fatty acid in ruminant fat) can serve as a precursor for endogenous CLA *cis-9*, *trans-11* synthesis in human tissues (Ryhänen et al., 2005). Nevertheless, there are no studies comparing the effects of the inclusion of fats with different level of saturation on lambs performance and fatty acid composition.

The present work was conducted to study the effects of 4% hydrogenated palm oil (HPO) or sunflower oil (SFO) supplementation in the concentrate for fattening lambs on feed intake, animal performance, carcass and meat characteristics and meat and subcutaneous fatty acid composition.

2. Materials and methods

2.1. Animals

Twenty-seven male Merino lambs (initial age 8–9 weeks) were allocated by stratified randomization on the basis of live body

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weight (LBW, 16.2 ± 0.27 kg) into three equal groups to study the effects of the inclusion of 4% hydrogenated palm oil (HPO) and 4% sunflower oil (SFO) in the concentrate offered during the fattening period.

The lambs were kept with their mothers until weaning, with free access to a commercial starter concentrate, barley straw and alfalfa hay until the commencement of the trial. They were dewormed by dosing with Ivomec (Merial Labs., Spain) and vaccinated against enterotoxaemia (Miloxan, Merial Labs., Spain).

Animals were housed individually and animal handling followed the recommendations of European Council Directive 86/609/EEC for protection of animals used for experimental and other scientific purposes.

2.2. Diets

After 5 days of adaptation to the control diet (barley straw and concentrate feed without oil added), lambs were fed barley straw and the corresponding experimental concentrate feed ad libitum. The ingredients and chemical composition of the concentrates are given in Table 1. Hydrogenated palm oil and sunflower oil were added to and mixed completely with the concentrate before feeding each lamb.

2.3. Experimental procedure

Concentrate and forage (in long form) were supplied in separate feeding troughs and fresh drinking water was always available. The amount of feed offered was adjusted daily on the basis of the previous day intake, allowing refusals of 20%. The amounts of feeds offered and of refusals were weighed daily, and samples were collected for subsequent analyses.

Animals were weighed before morning feeding twice a week to about 24 kg LBW and then every day until the slaughter LBW (25 kg).

Table 1
Ingredients and chemical composition of experimental concentrates (g/kg).

	Control	HPO	SFO
Barley grain	520	500	500
Corn grain	153	147	147
Soybean meal	214	205	205
Sunflower meal	29	28	28
Hydrogenated vegetable fat[a]	–	40	–
Sunflower oil[b]	–	–	40
Molasses	42	40	40
Sodium bicarbonate	10	10	10
Vitamin mineral premix[c]	31	30	30
Dry matter	887	888	894
Ash	63	61	61
Neutral detergent fibre	127	123	120
Crude protein	164	157	157
Ether extract	16	55	54
Fatty acids (% of total fatty acids)			
C16:0	16.7	50.6	8.8
C18:0	1.5	1.9	3.4
C18:1	20.0	12.6	26.7
C18:2	57.1	15.3	60.0
C18:3	4.5	1.2	1.2

[a] Hidrogenated vegetable fat (NUCLEOVIT-99®, Lechavit S.A., León, Spain). Analysis: 990 g ether extract/kg of DM. Fatty acid composition (g/kg fatty acids): C14:0, 12; C16:0, 625; C18:0, 257, C18:1, 98.
[b] Sunflower oil (C.C. Carrefour S.A., Spain). Analysis: 990 g ether extract/kg of DM. Fatty acid composition (g/kg fatty acids): C16:0, 60; C18:0, 40; C18:1, 288; C18:2, 605.
[c] Vitamin mineral premix (NUTEMIX®, NUTEGA, Madrid, Spain).

2.3.1. Slaughter and carcass measurements

When an animal reached the intended LBW (approximately 25 kg), feed and water were withdrawn, and after 1 h the lamb was weighed again, stunned, bled, skinned and eviscerated.

Dressed carcass and non-carcass components (as defined by Colomer-Rocher, Delfa, & Sierra, 1988) were obtained from the whole body of each lamb and weighed separately. Carcass was chilled at 4 °C for 24 h and then weighed again, so that chilling losses were calculated as the difference between hot (HCW) and cold carcass weight (CCW) expressed as a proportion of the initial HCW. Killing-out percentage was calculated as CCW expressed as percent of slaughter body weight.

Thoracic wall thickness (mm), subcutaneous fat thickness (mm), fatness score and consistency of fat were determined as described by Colomer-Rocher et al. (1988).

The left side of each carcass was jointed into commercials cuts (shoulder, breast-flank, leg, scrag end, best end, loin-rib and tail) according to Colomer-Rocher et al. (1988). Each cut was weighed to assess its proportion in the carcass. Thereafter, the shoulder was dissected into bone, lean and fat depots according to the procedure of Fisher and De Boer (1994) to determine tissular composition of the carcass.

2.3.2. Meat measurements

At 24-h post-mortem, loin-rib joint (from 6th rib-onwards) was cut at the level of 13th rib, and pH and colour were measured at the 6th rib site. pH was also measured in *m. semimembranosus* and colour was also measured in *m. rectus abdominis* and dorsal subcutaneous fat. A Metrohm® pHmeter (Metrohm, Switzerland), equipped with penetrating electrode and temperature probe was used for pH determination. Colour measurements were performed according to the $L^*a^*b^*$ system (Commission International de l'Eclairage, 1976) using a Minolta CM-2002 chromameter (Konica-Minolta Sensing, Japan). Fat colour was evaluated in subcutaneous dorsal fat.

A sample of *m. longissimus thoracis* was taken to determine water holding capacity as described by Grau and Ham (1953) and modified by Sañudo, Sierra, López, and Forcada (1986), and samples of this muscle and subcutaneous fat (fat sample from a point situated 4 cm from last rib and 4 cm from medium line) were taken and frozen at −30 °C for fatty acid composition determination.

The chemical composition of the meat was determined on *m. longissimus lumborum* samples, which were analyzed for dry matter (AOAC official method 950.46), ash (AOAC official method 920.153), crude protein (AOAC official method 981.10) and fat (AOAC official method 960.39).

In situ transesterification of fatty acids were performed following the method described by Carrapiso, Timón, Petrón, Tejeda, and García (2000), using 300 mg of freeze dried and minced *m. longissimus lumborum*. Anhydrous HCl/methanol was used for the methylation of the fatty acids and tridecanoic acid (C13:0) was used as internal standard (4 mg/ml). Methyl esters of fatty acids were quantified by GC (HP 5890 GC, Hewlett–Packard, USA) using a capillary column (HP 88, 100 m × 0.25 mm, Agilent Technologies, USA). The injector and detector temperatures were of 200 and 300 °C, respectively, and the helium flow ratio was 1 ml/min. An automatic split/splitless injector as used with a ratio 30:1 split and pressure of 16 psi. After injection (1 μl), the column temperature was held at 50 °C for 1 min and then increased to 180 °C at 10 °C/min. The temperature was kept at 180 °C for 25 min, followed by an increase of 2 °C/min to 220 °C and, finally, held at 260 °C for 5 min.

The identification of peaks was made by comparison of retention times with the ones obtained for fatty acid methyl ester (FAME) standard mixtures acquired from Un-Check-Prep Inc. (Elysian, MN, USA) and from Supelco Inc. (Bellefonte, PA, USA).