Small Ruminant Research 159 (2018) 11–17

Contents lists available at ScienceDirect

Small Ruminant Research

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

Effect of diet lipid source (linseed vs. soybean) and gender on performance, meat quality and intramuscular fatty acid composition in fattening lambs

A.M. Facciolongo[a,*], A. Lestingi[b], M.A. Colonna[c], F. Nicastro[d], D. De Marzo[c], F. Toteda[c]

[a] CNR, Institute of Biosciences and BioResources (IBBR), Via G. Amendola 165/A, 70121 Bari, Italy
[b] Department of Veterinary Medicine, University of Bari "Aldo Moro", Strada provinciale Casamassima Km. 3, 70010 Valenzano, BA, Italy
[c] Department of Agro-Environmental and Territorial Sciences, University of Bari "Aldo Moro", Via G. Amendola 165/A, 70121 Bari, Italy
[d] Department of Emergency and Organ Transplantation, Section of Veterinary Clinics and Animal Production, University of Bari "Aldo Moro", Via G. Amendola 165/A, 70121 Bari, Italy

ARTICLE INFO

Keywords:
Lambs
Linseed
Gender
Meat quality
Fatty acids

ABSTRACT

This research aimed to evaluate the effect of diet lipid source and sex on meat quality and lipid fatty acid composition in fattening lambs. Twenty-eight Gentile di Puglia breed lambs were weaned at about 35 days of age and included in a 2 × 2 factorial scheme of two sexes (males vs. females) and two diets (soybean meal vs. extruded linseed).

Lambs fed linseed diet had a higher carcass fat score than lambs fed soybean diet. The linseed diet gave a higher ($P < 0.05$) PUFA content and a lower n-6/n-3 ratio than the soybean diet. The females had lower ($P < 0.01$) daily growth rates, higher ($P < 0.01$) feed conversion ratio, greater ($P < 0.01$) dressing percentages and fatter carcasses ($P < 0.01$); while, the meat of the males showed higher values of final pH, brightness and yellow index. The males showed a lower PUFA n-6:n-3 ratio in comparison with females.

In conclusion, the diet influenced fewer variables compared to sex. The fatty acid composition of meat resulted more satisfying in males than females.

1. Introduction

Consumption of ruminant meat is declining in Europe and North America, also due to health concerns for its high content of saturated fatty acids (SFA) (Vahmani et al., 2015). In order to provide benefits for human health, the target is to produce leaner meat with lower saturated and higher monounsaturated (MUFA) and polyunsaturated fatty acid (PUFA) contents particularly n-6 and n-3 PUFA, because the latter fatty acids contribute to the prevention of various cancers, atherosclerosis and coronary heart disease (Scollan et al., 2006); in addition to anticarcinogenic effects, these fatty acids also affect the immune system and lipid metabolism, and ultimately enhance human health (Moloney et al., 2008).

Recent study has therefore focused on increasing the n-3 PUFA content and conjugated linoleic acid (CLA) in ruminant products (Atti et al., 2013; Toteda et al., 2011).

Attempts to increase the PUFA content of ruminant meat, by diet supplementation, is limited due to the fatty acid rumen biohydrogenation (Lunn and Theobald, 2006) which, also, is influenced by several factors, including the forage:concentrate ratio, the level and type of lipid supplementation, ruminal pH and ionophores (Bessa et al., 2000).

The fatty acid composition of muscle lipids, moreover, is affected by the activity of enzymes involved in fatty acid synthesis, such as Δ^4, Δ^5, Δ^6, Δ^9 desaturase and elongase (Bressan et al., 2011; Enser et al., 2008; Malau-Aduli et al., 1998; Wood et al., 2008). Strategies for n-3 PUFA enrichment of lamb meat have included diets supplemented with fish products or with linseed (Toteda et al., 2011; Urrutia et al., 2015). Linseed has a high PUFA content, especially of linolenic acid, and meat from lambs fed with a linseed supplement was found to contain a higher level of n-3 PUFA (Bas et al., 2007; Elmore et al., 2000).

Lamb performance and meat quality are influenced by several factors, including sex (Dransfield et al., 1990; Sañudo et al., 1998a, 1998b; Sañudo et al., 1998b). Many reports show that male lambs have a greater daily body gain (Bas et al., 2007; Fernández et al., 2000), a better feed convertion ratio (Rodríguez et al., 2008) and a lower carcass fat (Bas et al., 2007) than females. On the contrary, there are conflicting evidences about the sex influence on the meat physical characteristics (Tejeda et al., 2008; Yarali et al., 2014) and on the fatty acid composition of muscle lipid (Diaz et al., 2003; Tejeda et al., 2008).

The current study investigated the effects of linseed diet supplementation on in vivo performance, carcass traits, meat quality and

* Corresponding author.
E-mail address: annamaria.facciolongo@ibbr.cnr.it (A.M. Facciolongo).

https://doi.org/10.1016/j.smallrumres.2017.11.015
Received 4 April 2017; Received in revised form 29 November 2017; Accepted 30 November 2017
Available online 02 December 2017
0921-4488/

muscle fatty acid composition in male and female lambs fed with pelleted feed during finishing.

2. Materials and methods

2.1. Experiental design, animals and diets

The study was carried out in a farm situated in the Province of Bari (Italy) (41° N, 16° E, 50 m above sea level), in accordance with animal welfare regulations (Directive 91/629 EEC, ratified in Italy by D. Lgs. 533/92 and modified by D. Lgs. 331/98).

Twenty-eight Gentile di Puglia lambs, born in November, were weaned at 35 ± 2 days of age (mean ± s.d.), and divided into four homogeneous groups according to age and body weight (n. = 7) in a 2 × 2 factorial design to study the effects of feeding (soybean vs. extruded linseed) and sex (male vs. female).

Lambs were kept in individual pens (1 m^2 per head) at a temperature ranging from 10 °C to 15 °C and they had continuous access to water. Lambs were assigned to one of two dietary treatments: L) linseed feed containing 3% extruded linseed; S) soybean feed containing 4% soybean meal.

The two-pelleted total mixed rations (PTMR) (Table 1) were formulated as isocaloric and isonitrogenous to meet the nutritional requirements of lambs (INRA, INRA, 1988). Lambs were adapted to the ration over 10 days. Feed was offered daily at 08:00 h at a rate of 110% of ad libitum intake calculated by weighing-back refusal weekly. Feed samples were taken weekly and stored at −20 °C until analysed. Straw was offered on the rack as a source of roughage, but its intake was very low (< 30 g/head/day) and was not recorded. Individual body weights and feed intakes were recorded to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed conversion ratio (FCR, kg food ingested daily/kg daily body growth).

Table 1
The ingredient, chemical and fatty acid compositions of experimental diet.

	Diets	
	Linseed	Soybean
Ingredient% (as-fed basis)		
Soybean	–	4.00
Corn	27.00	30.00
Barley	27.00	27.00
Wheat bran	5.00	5.00
Faba bean	30.00	26.00
Extrude linseed	3.00	–
Molasses	3.50	3.50
Vitamin mineral premix	4.50	4.50
Chemical composition (dry matter basis)		
Moisture, % (as fed)	10.00	10.00
Crude protein, %	15.32	15.33
Ether extract, %	3.10	2.91
Crude fiber, %	4.85	4.63
Starch, %	46.97	47.02
Ash, %	2.65	2.59
Neutral detergent fiber, %	17.72	16.77
Acid detergent fiber, %	7.60	7.20
Acid detergent lignin, %	0.85	0.90
Meat Forage Units (n/kg dry matter)	0.94	0,98
PDIN[a] (g/kg dry matter)	94.18	94.60
PDIE[b] (g/kg dry matter)	89.44	88.91
Fatty acid composition (% fatty acid methyl esters) (% of total fatty) acid).		
C16:0	11.00	22.61
C16:1n-7	0.11	0.19
C18:0	2.40	4.31
C18:1n-9cis (oleic acid)	21.14	29.54
C18:1n-7 trans11 (vaccenic acid)	0.60	1.13
C18:2 n-6 cis9cis12 (linoleic acid)	38.69	26.05
C18:3 n-3 (linolenic acid)	23.06	9.08

[a] PDIN = protein digested in the small intestine allowed by the nitrogen.
[b] PDIE = protein digested in small intestine allowed by the energy.

2.2. Feed chemical composition

Samples of each PTMR were ground in a hammer mill with a 1 mm screen and analysed using the following AOAC (2004) procedures: dry matter (DM) (Method 934.01), ether extract (EE) (Method 920.39), ash (Method 942.05), crude protein (CP) (method 954.01), crude fiber (CF) (Method 945.18), acid detergent fiber (ADF) and acid detergent lignin (ADL) (Method 973.18), and amylase-treated neutral detergent fiber (NDF) (Method 2002.04). The protein value (PDIE – protein digested in the small intestine allowed by the energy, and PDIN – protein digested in the small intestine allowed by the nitrogen) was estimated using the equations proposed by INRA (1INRA (1988).

Samples of each concentrate mixture were used for fatty acid analysis according to the method described below for the meat fatty acid profile, and the results are shown in Table 1.

2.3. Slaughtering and carcass traits

Sixty-five days after the beginning of the trial, the lambs (100 days old) were slaughtered, by exsanguination, according to veterinary police rules (D.P.R. 320/54) after fasting for 12 h, with free water access, and recording of body weights. The carcass fatness was classified according to the EU scale (EEC Regulation 1278/94, 1994) for light lamb carcasses. The hot carcass, skin, fleece, head, pluck, and full and empty gastro-intestinal tract (GIT) were weighed. Carcasses were hung by the Achilles tendon, chilled at 4 °C (80–82% relative humidity) for 24 h and then reweighed. The weight of the digestive content (full-empty GIT) was used to calculate the net hot dressing percentage (carcass weight/empty body weight) and net cold dressing percentage (carcass weight after chilling/empty body weight).

2.4. Physical analyses of meat

The pH values were measured on the longissimus lumborum (Ll) muscle at the time of slaughter (pH_0) and after that the carcasses were refrigerated at 4 °C (pH_{24}) for 24 h, using a portable instrument (Model HI 9025; Hanna Instruments, Woonsocket, RI) with an electrode (FC 230C; Hanna Instruments) and performing a two-point calibration (pH 7.01 and 4.01).

Ll samples from the right carcass were used to measure meat colour and tenderness. The colorimetric indexes (L* = lightness, a* = redness, b* = yellowness) were determined using a Hunter Lab Miniscan™ XE Spectrophotometer (Model 4500/L, 45/0 LAV, 3.20 cm diameter aperture, 10° standard observer, focusing at 25 mm, illuminant D65/10; Hunter Associates Laboratory Inc., Reston, Virginia, USA) by taking three readings for each sample. The instrument was normalized to a standard white tile provided with the instrument before performing analysis (Y = 92.8, x = 0.3162, and y = 0.3322). The reflectance measurements were performed after the samples had oxygenated in air for atleast 30 min, by which time the measurements were stable (Šicklep and Čandek-Potokar, 2007).

Two *Ll* raw samples (1.25 cm diameter and thick) were tested for tenderness assessment by the Warner-Bratzler Shear Force (WBSF) system using an Instron 5544 Universal Testing Machine (Instron Corp. Canton, MA, USA). Shear forces were determined perpendicular to fiber direction (load cell: 50 kg; shearing speed: 100 mm/min). Peak force was expressed as kg/cm^2. Each sample was sheared 3 times.

2.5. Chemical analysis of meat

AOAC (1995) procedures were used to measure moisture, crude fat, protein, and ash contents of Ll raw samples. Total lipids were extracted from the homogenized Ll samples (100 g) using the chloroform/methanol method by Folch et al. (1957). Fatty acids were methylated using