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Intramuscular fatty acid composition of lambs fed diets containing alternative protein sources

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ABSTRACT

Thirty male *Merinizzata italiana* lambs were divided into three groups after weaning according to live weight. The diet of the three groups differed in the main protein source used in the concentrate, soybean meal for treatment SBM, faba bean for treatment FB and peas for treatment PEA.
Lambs were fed ad libitum and slaughtered at about 160 days of age. Meat from the PEA group had higher proportions of the essential fatty acids C18:2 ω-6 and C18:3 ω-3 than from FB and SBM lambs and consequently its derivatives, C20:4 ω-6 and C20:5 ω-3 respectively, were higher in meat from PEA animals, compared to SBM and FB ones.
The total n-3 fatty acids were highest in meat from PEA lambs and consequently PEA lambs showed a more favourable n-6/n-3 ratio. In conclusion the use of legume seeds such as peas in lamb diets positively affected intramuscular fatty acid composition.

1. Introduction

In recent years an important objective of Mediterranean farmers has been to promote the use of alternative protein sources, preferably from local feedstuffs, in animal feeding to try to reduce costs. Soybean meal is the main protein source used in animal feeding in Europe and it is largely imported.

The effect of the use of alternative legume seeds in lamb nutrition has been considered. Several studies showed that their use did not negatively affect growth, slaughter performances or meat quality (Hadjipanayiotou, 2002; Lanza, Bella, Barbagallo, et al., 2003b; Lanza, Pennisi, & Priolo, 1999; Purroy, Echaide, Muñoz, Arana, & Mendizabal, 1992; Surra, Purroy, Munoz, & Treacher, 1992).

Faba bean (*Vicia faba* var. *minor*) is a legume seed available in the Mediterranean area and is comparatively cheap despite its relatively high nutritional value. Its crude protein content is high (30–32% of dry matter) and the aminoacidic profile has a high lysine content (Palander, Laurinen, Perttil, Valaja, & Partanen, 2006).

The use of diets based largely on faba bean for lamb fattening gave similar growth performance and meat characteristics as traditional diets based on soybean meal as the main protein source (Caballero, Rioperez, Fernandez, Marin, & Fernandez, 1992; Lanza et al., 1999).

The pea (*Pisum sativum* L.) is a legume seed high in crude protein (25–26%), which has a high degradability (RDP 780 g/kg of CP; NRC, 1989; Goelema, Spreeuwenberg, Hof, Van der Poel, & Tamminga, 1998). The starch content is 540 g/kg (McLean, Sosulski, & Youngs, 1974); appears to be highly soluble and easily degradable (Nocek & Tamminga, 1991) and the reported net energy for gain (NEg) is 6.19 MJ/kg (NRC, 1989). Lysine is particularly high at 1.6%.

New feeding strategies in animal nutrition in both ruminants and monogastric animals, have as principal objectives to increase polyunsaturated fatty acids, especially the ω-3 series, conjugated linoleic acid level and reduce saturated fatty acids in animal products (Scollan et al., 2006; Wood et al., 2008).

There is little data available on the effects of feeding faba bean (*Vicia faba* var. *minor*) or peas (*Pisum sativum*) on lamb intramuscular fatty acid composition.

The objective of the present trial was to evaluate the effect of totally replacing dietary soybean meal by peas or faba bean in the concentrate fed to lambs on the intramuscular fatty acid composition of their meat.

2. Materials and methods

2.1. Experimental design, animals and diets

The feeding trial was conducted at an experimental farm of the University of Reggio Calabria (Italy).

The experiment was conducted on thirty male *Merinizzata italiana* lambs, born on the same farm. After weaning, at 60 days of age, the lambs were divided into 3 groups balanced according to their weights

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(average live weight 10.45 kg ± S.D. 1.15 kg), with 10 animals per treatment. Treatments included:

Lambs fed with concentrate where soybean meal was the main protein source (SBM group); lambs fed with concentrate where faba bean was the main protein source (FB group) and lambs fed with concentrate where peas were the main protein source (PEA group).

The lambs, after 10 days of adaptation to the experimental diet, were fed for a further 90 days. The diets were based on polyphite hay and concentrate (30/70). In detail, the SBM lambs received a concentrate that comprised mainly barley, wheat, dehydrated lucerne and soybean meal. The FB and PEA lambs received diets in which all soybean meal and part of the wheat were replaced by 24% of faba bean and peas respectively (Table 1). Moreover the concentrate fed to the FB and PEA groups contained small quantities of gluten corn, to obtain isoproteic and isoenergetic diets.

The animals were slaughtered at about 160 days of age (60 days of weaning, 10 days adaptation and 90 days of experimental period).

Twenty-four hours after slaughter carcasses were split in left and right sides and from the right side samples of *longissimus dorsi* muscle were taken between the 6th thoracic rib and 4th lumbar rib to measure moisture, crude fat, protein and ash according to AOAC procedures (AOAC, 1995).

Subsamples of each concentrate mixture were collected weekly and mixed to give a final sample for NDF analysis, according to Van Soest, Robertson, and Lewis (1991), crude protein (method 984.13), ether extract (method 920.39) and ash (method 942.05) according to AOAC (Association of Official Analytical Chemists) (1995).

2.2. Fatty acid determination

Samples of *longissimus dorsi* muscle were taken at the level of the 13th thoracic rib, minced and vacuum-packed (50 g for each animal) and stored at −25 °C until needed. Lipid was extracted according to Folch, Lees, and Stanley (1957). Briefly, a 5 g homogenised *longissimus dorsi* sample was blended with chloroform/methanol (2:1, v/v) twice, filtered, placed in a separator funnel and mixed with saline solution (0.88% KCl). After separation into two phases, the aqueous methanol fraction was discarded and the chloroform lipid fraction was washed with distilled water/methanol (1:1, v/v). After a further filtration and evaporation by means of a rotary evaporator, lipid extracts were transferred to test tubes for subsequent gas chromatographic analysis. Duplicates of 100 mg of lipid were methylated using 1 ml of hexane and 0.05 ml of 2 N methanolic KOH (I.U.P.A.C., 1987). Gas chromatographic analysis was performed on a Varian model Star 3400 CX instrument equipped with a CP 88 capillary column (length 100 m, internal diameter 0.25 mm, film thickness 0.25 ml). Operating conditions were: a helium flow rate of 0.7 ml/min, an FID detector at 260 °C, a split–splitless injector at 220 °C with an injection rate of 120 ml/min, an injection volume of 1 ml. The temperature programme of the column was: 4 min at 140 °C and a subsequent increase to 220 °C at 4 °C/min. Retention times and area of each peak were computed using the Varian Star 3.4.1. software. The individual fatty acid peaks were identified by comparison of retention times with those of known mixtures of standard fatty acids (FAME, Sigma) run under the same operating conditions.

Subsamples of each concentrate mixture were collected weekly and mixed to give a final sample of each diet for fatty acid (FA) analysis as reported by Gray, Rumsby, and Hawke (1967).

Fatty acids were expressed as percent of total methylated fatty acids.

2.3. Statistical analysis

Data were subjected to analysis using the general lineal model procedure of Minitab statistical software (Minitab, 1995) using the group treatment as experimental factor. Differences between treatments were determined by a Student's *t*-test. Significance was inferred at the $P<0.05$ level. Single animals were considered as experimental units.

3. Results

3.1. Chemical composition of the diets

The ingredients and chemical composition of the diets are reported in Table 1. The three diets had similar crude protein contents.

With regard to dietary fatty acid composition (Table 2), FB and SBM diets had higher C16:0 and C18:0 contents compared to the PEA diet, the PEA diet had higher contents of the two essential fatty acids, linoleic (C18:2) and linolenic (C18:3) compared to the FB and SBM diets.

3.2. Animal growth performances and meat proximate analyses

The growth performances data are reported in Table 3. No significant differences were found between treatments. Average daily gain was over 130 g/day in all groups resulting in a final weight of around 28–30 kg with small differences among groups.

The proximate analyses of the meat samples are presented in Table 4. No statistical differences between groups were found for any parameter measured.

3.3. Intramuscular fatty acid composition

The intramuscular fatty acid composition data are presented in Table 5. Among the saturated fatty acids, there was a significant

Table 1
Ingredients and chemical composition of the diets[a].

Ingredient (g/kg as fed)	Group SBM	Group FB	Group PEA
Barley	380	368	358
Lucerne dehydrated	175	160	160
Soybean mail 44	159	–	–
Wheat	200	130	130
Faba bean	–	240	–
Peas	–	–	240
Corn gluten	–	40	50
Sunflower mail	20	20	20
Cane molasses	40	20	20
Calcium carbonate	16	12	12
Sodium chloride	5	5	5
Vitamin mineral premix[b]	5	5	5
Chemical composition[c]			
Dry matter (%)	87.73	87.87	87.86
Crude protein (% DM)	19.50	19.92	19.56
Ether extract (% DM)	2.21	2.50	2.72
Ash (% DM)	8.59	7.97	7.56
NDF (% DM)	25.66	24.06	24.33
UFV/kg DM	10.28	100.14	100.14

[a] All the analyses were performed in triplicates.
[b] The mineral vitamin premix consisted of vitamin A = 6750 μl; vitamin D3 = 1000 μl; vitamin E = 2 mg; vitamin B12 = 0.01 mg; vitamin B1 = 1 mg; folic acid = 0.2 mg; D-pantotenic acid = 5 mg; Co = 0.05 mg; Mn = 12.5 mg; Zn = 15 mg; and Mo = 0.5 mg.
[c] DM, dry matter; NDF, neutral detergent fiber.

Table 2
Fatty acid composition of the diets (g/100 g of fatty acid methylesters).

	Diets		
Fatty acid	PEA	FB	SBM
C14:0	0.252	0.705	0.704
C16:0	12.450	17.348	18.441
C18:0	2.680	3.393	3.813
C18:1 *n*-9	23.618	26.521	25.433
C18:2 *n*-6	49.210	48.012	46.490
C18:3 *n*-3	11.790	4.020	5.119