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The use of faba bean and sweet lupin seeds in fattening lamb feed. 2. Effects on meat quality and fatty acid composition

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ABSTRACT

This study aimed to evaluate the effects of using faba bean and lupin seeds used singly or in association as protein sources in the diet of fattening lambs. The physical and chemical characteristics of the meat and its fatty acid composition were investigated.

Twenty-four "Gentile di Puglia" male lambs, weaned at 38 ± 2 days of age and at an average initial body weight of 15.8 ± 0.5 kg (mean ± sd), were divided into three homogeneous groups ($n = 8$) and fed for 8 weeks with three different experimental diets: FB containing 300 g/kg diet (on as fed basis) of faba bean seeds; FB + L containing 150 g/kg diet of faba bean seeds plus 150 g/kg diet of lupin seeds; L containing 250 g/kg diet of lupin seeds. Three types of pelleted total mixed rations were formulated to be isonitrogenous and isocaloric. Meat chemical composition, pH, colour and Warner-Bratzler Shear Force were not influenced by dietary treatment. Analysis of the intramuscular fat showed a higher percentage of the saturated fatty acid (SFA) myristic acid (C14:0) in the meat of L lambs than in FB and FB + L (7.13 *vs* 4.41–4.71%; $P < 0.05$); comparison of the polyunsaturated fatty acid (PUFA) percentages showed that the faba bean diet gave higher levels of linoleic acid (C18:2 *n*-6 *cis*9, *cis*12) than lupin (3.35 *vs* 2.44%; $P < 0.05$) and lower levels (0.31 *vs* 0.39%; $P < 0.05$) of linolenic acid (C18:3 *n*-3). The *n*-6/*n*3 ratio and the thrombogenicity index were not influenced by diet, whereas the atherogenicity index was lower, and therefore better, when lambs were fed the faba bean diet in comparison with the lupin diet (0.89 *vs* 1.29; $P < 0.05$). In general, for the parameters we studied, the use of lupin in association with faba gave intermediate values, without any significant differences compared to those for the protein sources used singly. In conclusion, the diet containing lupin had a negative effect on fatty acid composition of the intramuscular fat, while this effect was mitigated by the use of lupin + faba in association.

1. Introduction

In Europe, the main protein source in animal feeds consists mostly of imported GM soya meal.

Recent interest in the Mediterranean area has been directed at the use of alternative local protein sources, such as faba, lupin and protein pea, in order to reduce rearing costs and meet the requirements of sustainable farming, which bans GM products (Lanza et al., 2011; Scerra et al., 2011; Facciolongo et al., 2014).

Faba bean (*Vicia faba* L. var. *minor*) is an inexpensive and highly nutritious legume grown in the Mediterranean area. Faba seeds are a good source of starch (450–500 g kg^{-1} dry matter) and protein (230–300 g kg^{-1} dry matter) with a high lysine content (Palander et al., 2006), and are particularly suited for use as an alternative to soybean in organic livestock farming (Masoero et al., 2005). Faba bean is also rich in fiber, vitamins and minerals (Ofuya and Akhidue, 2005), and reduces blood cholesterol levels (Frühbeck et al., 1997; Macarulla et al., 2001; Facciolongo et al., 2014). Faba seed contain a low level of ether extract (approx. 2.0% of DM; Grela and Günter, 1995; Masoero et al., 2005) but useful levels of unsaturated fatty acids (18.4% oleic acid, 30.8% linoleic and 4.3% linolenic acid (Grela and Günter, 1995). The use of diets based on faba bean have given growth performances and meat quality similar to those obtained with traditional diets using soya meal as their main protein source (Caballero et al., 1992; Lanza et al., 1999).

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Sweet white lupin (*Lupinus albus* L.) is suited to the Mediterranean climate and agronomic conditions, and is also one of the few alternative crops with a high protein content similar to that of soybean: 38–42%. In addition, lupin seeds contain 9–14% oil, with fatty acids containing a high percentage of unsaturated fats (50–60% oleic acid, 16–23% linoleic acid and 8–9% α-linolenic acid; Boschin et al., 2008) and a ratio of *n*-3/*n*-6 fatty acids ranging 0.4–0.6 (Masucci et al., 2006; Boschin et al., 2008).

New feeding strategies for ruminants and monogastrics aim to reduce saturated fatty acids in their products destined for human consumption and to increase PUFAs, especially the *n*-3 series. There are proven benefits for human health when these characteristics are transferred to meat fat (D'Amicis and Turrini, 2002). It has also been shown that diet can have effects on the physical and chemical characteristics of meat, influencing both consumer acceptance and conservation properties (Liu et al., 1995; Hopkins and Fogarty, 1998; Harper, 1999).

However, few data are available about the effects of diets containing faba bean and/or lupin seeds on meat quality and on its fatty acid composition. Vicenti et al. (2009) reported that use of sweet lupin used in the feed of young Podolian cattle reduced the fat content of sirloin steak, improving the nutritive quality of the meat. Scerra et al. (2011) found increased levels of n-3 PUFA in the intramuscular fat of lambs fed a diet with faba bean (24% on as fed basis) in partial replacement of wheat.

Our aim was to study faba and lupin seeds used singly or in association as protein supplements in the feed of growing lambs, and to evaluate the effects on the physical and chemical characteristics of meat and on the fatty acid composition of its intramuscular fat.

2. Material and methods

2.1. Animals and diets

All procedures involving animals were performed according to the Italian government guidelines (Directive 91/629/EEC, received in Italy by D.L. 533/92 and modified by D.L. 331/98).

The study was conducted in a farm in southern Italy (latitude: 41°5′54″24 N; longitude:16°46′43″68 E) at 50 m above sea level, during 8 weeks, from December 2011 to February 2012. Twenty-four Gentile of Puglia male lambs, weaned at 38 ± 2 (mean ± sd) days of age and at an average initial body weight (BW) of 15.8 ± 0.5 kg (mean ± sd), were divided into three homogeneous groups ($n = 8$). Lambs were assigned to one of three dietary treatments: FB received 300 g/kg diet (on as fed basis) of faba bean seeds; FB + L received 150 g/kg diet of faba bean seeds plus 150 g/kg diet of lupin seeds; L received 250 g/kg diet of lupin seeds. Ingredient and chemical composition of the experimental diets, as well as animal management, are reported in a previous note (Lestingi et al., 2015).

2.2. Slaughtering and rheological parameters

At the end of the trial, the lambs were slaughtered by exsanguination according to veterinary police rules (D.P.R. 320/54). A portable instrument (Model HI 9025; Hanna Instruments, Woonsocket, RI) with an electrode (FC 230C; Hanna Instruments) was used to measure the pH values of the *Longissimus dorsi* (*Ld*) muscle at slaughter (pH_0), and then the carcasses were refrigerated for 24 h at 4 °C (pH_{24}). The refrigerated carcasses were divided into left and right halves, and samples of *Ld* muscle were taken from the right side in order to measure meat color and tenderness. Instrumental colorimetric characteristics (L^*, a^*, b^*) were measured using a colorimeter (Minolta CR-300, illuminant D65 and 0° observer; Minolta Camera Co., Osaka, Japan,) with the Hunter-Lab method by repeating the measurement 3 times, in different places. 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 coordinates a^* and b^* were used for the determination of Chroma = $(a^{*2} + b^{*2})^{1/2}$ and Hue = $\tan^{-1}(b^*/a^*)$. Two samples with a diameter and thickness of 1 cm were taken from *Ld* muscle and subjected to the Warner-Bratzler Shear Force (WBSF) system using an Instron 5544 Instrument. Shear forces were determined perpendicular to the fiber direction. Each sample was sheared 3 times.

Table 1
Fatty acid composition of the diets (% of total fatty acid methyl esters).

Fatty acids	Diets[a]		
	FB	FB + L	L
C16:0	16.17	16.30	14.90
C18:0	1.73	1.80	1.70
C18:1 *n*-9	25.17	29.70	30.50
C18:2 *n*-6	50.87	44.72	44.50
C18:3 *n*-3	4.54	5.51	5.50

[a] Diets: FB = faba bean; L = lupin; FB + L = 50% faba bean + 50% lupin.

Table 2
Effects of protein source on chemical composition of the meat from *Longissimus dorsi* muscle (%).

	Diets[a]				
	FB	FB + L	L	r.m.s.e.	*P*-value
Moisture	74.84	74.70	74.60	0.78	0.814
Crude protein	18.62	20.20	20.16	2.10	0.254
Crude fat	2.91	2.75	2.96	0.60	0.764
Ash	1.45	1.50	1.47	0.11	0.668

r.m.s.e. = root mean square error.
[a] Diets: FB = faba bean; L = lupin; FB + L = 50% faba bean + 50% lupin.

2.3. Chemical analysis

Samples of *Ld* muscle were taken to measure moisture, crude fat, protein and ash according to AOAC procedures (AOAC, 1995).

Total lipids were extracted from the homogenized *Ld* meat samples (100 g) using the chloroform/methanol method by Folch et al. (1957). Fatty acids were methylated using BF3-methanol solution (12% v/v) (Christie, 1982). The fatty acid profile was assessed using a Chrompack CP 9000 gas chromatograph, with a silicate glass capillary column (70% Cyanopropyl Polysilphenylene-siloxane BPX 70 of SGE Analytical Science, length = 50 m, internal diameter = 0.22 mm, film thickness = 0.25 μm). Temperature programme: 135° for 7 min, followed by increases of 4 °C per minute up to 210 °C. The Atherogenic Index (AI) and Thrombogenic Index (TI) were calculated according to Ulbricht and Southgate (1991).

Samples of each concentrate mixture were used for fatty acid analysis according to the method reported for meat fatty acid profile (Table 1).

Fatty acids were expressed as a percentage (wt/wt) of total methylated fatty acids.

2.4. Statistical analysis

Statistical analysis was performed using the GLM procedure of the SAS application package (SAS, 2000). The statistical model included diet treatment effect and experimental error. When the diet effect was significant ($P < 0.05$) means were compared by a Student's *t*-test.