Small Ruminant Research 143 (2016) 15–23

Contents lists available at ScienceDirect

Small Ruminant Research

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

The use of peas and sweet lupin seeds alone or in association for fattening lambs: Effects on performance, blood parameters and meat quality

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ARTICLE INFO

Article history:
Received 19 October 2015
Received in revised form 1 August 2016
Accepted 10 August 2016
Available online 17 August 2016

Keywords:
Lamb
Protein source
Performance
Blood parameters
Meat quality
Fatty acid composition

ABSTRACT

The aim of this study was to evaluate the effects of using sweet lupin and pea seeds singly or in association as protein sources in the diet of fattening lambs. We investigated lamb growth performances, carcass characteristics, blood parameters, chemical and physical characteristics of the meat and its fatty acid composition.

Twenty-four "Gentile di Puglia" male lambs (body weight 15.8 ± 0.5 kg and age 38 ± 2 days) were divided into three homogeneous groups (n = 8) and fed for 7 weeks with three different experimental diets: L containing 250 g/kg diet (on as fed basis) of lupin seeds; P + L containing 150 g/kg diet of pea seeds plus 150 g/kg diet of lupin seeds; P containing 300 g/kg diet of pea seeds. Three types of pelleted total mixed rations were formulated to be isonitrogenous and isocaloric.

Group P had a higher average daily feed intake than the other two groups, while there were no differences in slaughter body weights, average daily gains and feed conversion ratio due to dietary treatment. Carcass traits and tissue composition of leg were not affected by the protein source. Group L lambs had higher concentrations of urea than the other two groups at the end of the trial. Meat chemical composition, pH, colour and tenderness were not influenced by the protein source. Group L meat contained higher proportions of saturated fatty acids (SFA), in particular myristic acid (C14:0), than meat from groups P and P + L; comparison of unsaturated fatty acid (UFA) percentages also showed that lupin-fed lamb contained lower levels of oleic acid (C18:1*n*-9, *cis*-9) than the other two groups. Meat of lupin-fed lambs had a lower *n*-6/*n*-3 ratio than group P, but worse atherogenicity and thrombogenicity indices than groups P and P + L. In conclusion, when lupin was used alone in lamb feed, it had a negative effect on intramuscular fatty acid composition, while the use of pea and lupin together eliminated the negative effects of lupin.

1. Introduction

Recently, leguminosae seeds have been considered as an alternative protein source to soybean meal in animal feed owing tothe controversy regarding the use of genetically modified organisms (GMOs) (Tudisco et al., 2010). In addition, seed legumes are strategically important, not only because they can be used to overcome the marked deficit of high-protein feed stuff, but also because they increase the sustainability of crop-livestock systems by safeguarding soil fertility, reducing greenhouse gas emissions and the use of nitrogenous fertilizers (Carrouée et al., 2003).

Lupin is an interesting and promising legume crop, since it is well suited to the Mediterranean climate. Lupin seeds are a valuable source of nitrogen and energy owing to their high contents of crude protein (300–500 g kg^{-1}) and oil (50–100 g kg^{-1}), which vary with species and variety (Calabrò et al., 2015).

The fatty acid composition of lupin includes about 50–60% oleic acid, 16–23% linoleic acid, and 8-9% α-linolenic acid (Boschin et al., 2008; Calabrò et al., 2015). Moreover, lupin contains both low levels of starch (42–101 g kg^{-1} dry matter; Jezierny et al., 2010) and high levels of non-starch polysaccharides (van Barneveld, 1999). Lupin does not contain the many anti-nutritional factors found in soybean, although some varieties that are not genetically selected are high in alkaloids that can reduce feed intake (Kung et al., 1991). Unlike most lupins, however, sweet white lupin (*Lupinus albus* L.) has a low alkaloid content, and the increased selection of sweet

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http://dx.doi.org/10.1016/j.smallrumres.2016.08.006
0921-4488/

varieties with very low alkaloid contents has increased the possibility of using white lupin seed in human or livestock nutrition.

Pea (*Pisum sativum* L.) is a legume seed with a lower crude protein content than lupin (25–26% of dry matter), but it contains relatively higher levels of lysine and methionine than lupin (Hove and King, 1978; Brand et al., 2004; Saastamoinen et al., 2013). Pea contains a remarkably large proportion of starch (over 40% of dry matter), that is highly soluble and easily degradable (Nocek and Tamminga, 1991). The crude fat content of pea ranges from 15 to 20 g kg-1dry matter, and is therefore in a lower range than the crude fat content of lupin (Masoero et al., 2005). Moreover, pea contains good levels of unsaturated fatty acids (12.7% oleic acid, 35.3% linoleic and 5.4% linolenic acid; Grela and Günter, 1995). Worldwide, pea is the second most important feed legume grain after soybean (Mikić et al., 2009), and its low number of anti-nutritional factors gives good palatability (Liponi et al., 2006).

Lupin and pea seeds have been studied mostly as replacements for soybean meals in ruminant rations. Some studies have reported poor animal performances with the use of lupin, but the issue is controversial (Guillaume et al., 1987; Tracy et al., 1988; Kung et al., 1991; Murphy and McNiven, 1994; Stanford et al., 1996; Vicenti et al., 2009).The replacement of soybean meal with pea in lamb diets does not significantly affect growth and slaughter performances (Lanza et al., 2003, 2011; Scerra et al., 2011; Facciolongo et al., 2014). The use of pea as a protein supplement in lamb diets does not significantly affect the physical and chemical characteristics of meat compared to soybean meal (Lanza et al., 2003, 2011; Scerra et al., 2011). With regard to the fatty acid profile, Lanza et al. (2011) and Scerra et al. (2011) both reported that feeding with pea increased C18:3 *n*-3 muscle content compared to soybean meal or faba bean. However, in studies by Turner et al. (2012) and Facciolongo et al. (2015), the use of peas did not result in a preferential deposition of C18:3 *n*-3 in muscle, suggesting that there is no advantage in the use of pea in lamb diet. Recently, Lestingi et al. (2015a) have reported a worse atherogenic index and a lower percentage of *n*-6 PUFA in the meat of lupin-fed lambs compared to those fed on faba bean alone or in combination with lupin (50% on as fed basis).

However, at present there are few reports on the effect of pea and lupin use on blood parameters (Facciolongo et al., 2014), some of which are important indicators of the animal's nutritional state and may be useful for identification of metabolic imbalances or disorders (Ravarotto et al., 2000 Pavlík et al., 2010).

Information on the effects of lupin and/or pea on lamb meat quality and its fatty acid profile is also very limited. Nutritional guidelines for human beings recommend reducing fat intake, especially of saturated fatty acids, and optimizing the intake of foods containing high amounts of *n*-3 fatty acids with a favorable *n*-6/*n*-3 fatty acid ratio (Department of Health, 1994; Brasseur et al., 2004). Since consumers attach great importance to meat's sensory qualities in addition to its dietetic properties, other aspects such as tenderness, flavor and colors should also be considered (Geay et al., 2001).

Since sweet lupin and pea differ in their chemical composition, rumen degradability (Masoero et al., 2005) and amino acid composition, it is possible that combined use of the two legumes in animal feed could achieve a better balance and thus improve animal performances and meat quality.

This study therefore aimed to use pea and lupin seeds as protein sources, both alone and in association, in order to evaluate their effects on growth performances, carcass characteristics, hematological traits, chemical and physical characteristics, and fatty acid composition of the meat of fattening lambs.

Table 1
Ingredient, chemical and fatty acid composition of the experimental diets.

	Diets[1]		
	L	P + L	P
Ingredient composition, % (as-fed basis)			
Barley	20.0	20.0	20.0
Corn	20.0	20.0	18.0
Corn gluten	–	–	5.2
Oats	18.0	14.0	10.0
Peas	–	15.0	30.0
Lupin	25.0	15.0	–
Straw	10.0	10.0	10.0
Wheat bran	3.2	2.2	3.0
Calcium carbonate	1.8	1.8	1.8
Dicalcium phosphate	1.0	1.0	1.0
NaCl	0.5	0.5	0.5
Vitamin mineral premix	0.5	0.5	0.5
Chemical composition (dry matter basis)			
Moisture, % (as fed)	13.7	13.4	14.0
Crude protein, %	15.7	15.3	15.4
Ether extract, %	4.0	3.3	2.2
Crude fiber, %	9.9	9.5	8.6
Ash, %	4.0	3.4	3.2
Neutral detergent fiber, %	23.8	21.5	20.3
Acid detergent fiber, %	12.4	11.7	10.8
Acid detergent lignin, %	2.4	2.3	2.1
Starch	32.4	36.3	40.2
PDIN[2] (g/kg dry matter)	101.0	101.9	106.2
PDIE[3] (g/kg dry matter)	99.0	96.8	102.7
Meat Forage Units (*n*/kg DM)	0.93	0.91	0.90
Fatty acid composition (% fatty acid methyl esters)			
C16:0	15.16	14.20	14.30
C18:0	1.56	1.60	1.64
C18:1 *n*-9	30.50	27.66	24.16
C18:2 *n*-6	44.86	47.96	52.45
C18:3 *n*-3	5.80	5.82	5.90

[1] Diets: L = Lupin; P = Pea; P + L = 50% Pea + 50% Lupin.
[2] PDIN = protein digested in the small intestine allowed by the nitrogen.
[3] PDIE = protein digested in the small intestine allowed by the energy.

2. Materials and methods

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

2.1. Experimental design, animals and diets

The study was conducted on a farm in southern Italy (latitude: 41°5′54“24N; longitude: 16°46′43′68E) at 50 m above sea level, during a period of 7 weeks from December 2012 to February 2013. Twenty-four "Gentile di Puglia" male lambs, weaned at 38 ± 2 days of age and with an average initial body weight (BW) of 15.8 ± 0.5 kg (mean ± standard error), were divided into three groups of eight homogeneous for BW and age. Lambs were housed in individual pens (1 m^2 per head) with continuous access to water, and a temperature in the pens ranging from 8 °C to 16 °C. Lambs were assigned to one of three dietary treatments: Group L received 250 g/kg diet (on as fed basis) of lupin seeds (*Lupinus albus* cv Multitalia); P + L received 150 g/kg diet of pea seeds (*Pisum sativum*) plus 150 g/kg diet of lupin seeds; P received 300 g/kg diet of pea seeds. The three different pelleted total mixed rations (PTMR) (Table 1) were formulated to be isocaloric and isonitrogenous and to meet the lambs' nutritional requirements (INRA, 1988). Lambs were adapted to the ration during a period of 10 days. Feed was offered daily each morning at a rate of 110% of *ad libitum* intake calculated by weekly weighing-back of refusal. Feed samples were taken weekly and stored at −20 °C until analysis. Straw was offered on the rack as a source of roughage; intake was very low and was not recorded. Individual body weights and feed intakes were recorded