Pakistan J. Zool., vol. 47(4), pp. 989-996, 2015.

The Use of Faba Bean and Sweet Lupin Seeds Alone or in Combination for Growing Lambs. 1. Effects on Growth Performance, Carcass Traits, and Blood Parameters

Antonia Lestingi,[1*] Francesco Toteda,[2] Arcangelo Vicenti,[2] Davide De Marzo[3] and Anna Maria Facciolongo[4]

[1]*Department of Veterinary Medicine, University of Bari Aldo Moro, Strada provinciale Casamassima Km. 3, Valenzano, Italy*

[2]*Department of Agro-Environmental and Territorial Sciences, University of Bari Aldo Moro, Via G. Amendola 165/A, Bari, Italy*

[3]*Department of Emergency and Organ Transplantation, Section of Veterinary Clinics and Animal Production, University of Bari Aldo Moro, Via G. Amendola 165/A, Bari, Italy*

[4]*CNR, Institute of Biosciences and BioResources (IBBR), Via G. Amendola 165/A, Bari, Italy*

Abstract.- The study investigates faba bean and lupin seeds when used alone or in combination as protein supplements for growing lambs, and their effects on growth, carcass characteristics, and hematological traits. Twenty-four *Gentile di Puglia* male lambs were weaned at 38 ± 2 days of age, and divided into three homogeneous groups, based on body weight (BW). For eight weeks before slaughter, the lambs were assigned to one of three isoenergetic and isonitrogenous dietary treatments, differing in the protein supplement: a faba bean diet (FB) containing 300 g/kg diet (on as fed basis) of faba bean seeds; a faba bean plus lupin diet (FB+L) containing 150 g/kg diet of faba bean seeds plus 150 g/kg diet of lupin seeds (both on as fed basis); a lupin diet (L) containing 250 g/kg diet of lupin seeds (on as fed basis). Individual body weights and feed intakes were recorded weekly to calculate average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio. In the 1st and 8th weeks of the trial, blood samples were taken in order to measure glucose, total cholesterol, NEFA, creatinine, urea and total protein concentration and respective electrophoresis fractions. Carcass traits and tissue composition of leg and loin were determined. Slaughter body weight was lower for lambs fed on diets containing lupin than for lambs fed on diets containing faba beans. In Group L, ADG was lower than FB and FB+L groups. Group L lambs had lower ADFI than the other two groups. For Group FB lambs, loin weight was a higher percentage of half carcass weight than for Groups L and FB+L lambs. Leg and loin dissection data showed Group L lambs to have a greater percentage of bone in the leg than Group FB+L lambs. Group L lambs had higher concentrations of urea than the other two groups at the end of the trial. The use of lupin alone was associated with lower growth performances whereas, when lupin is given with faba bean the results suggest positive effects.

Keywords: lamb, protein supplement, growth performance, carcass traits, blood parameters

INTRODUCTION

The advantage of using cereal-based diets in intensive feeding of growing lambs is that they give better animal production performances than forage-only diets, although cereal-based diets generally require additional protein supplementation to meet the animal's nutritional requirements (Jacques *et al*., 2011). The high protein content (42-54%) of imported soybeans, together with their excellent balance of amino acids and high energy levels, make them Europe's predominant protein supplement in commercial livestock rations (Turner *et al*., 2012). However, consumers are beginning to distrust the widespread use of genetically modified soybeans, and moreover high demand, rapid price increases and recent environmental concerns have increased interest in using locally-produced legumes in animal rations (Vasta *et al*., 2008). Homegrown legume seeds have been used primarily for their high protein and starch contents, despite the presence of some anti-nutritional factors (Masoero *et al*., 2005) that may limit their use.

In Mediterranean environments, faba beans and lupin seeds are potential alternative to soybean meal in organic breeding systems (Masoero *et al*.,

* Corresponding author: antonia.lestingi@uniba.it
0030-9923/2015/0004-0989 $ 8.00/0

2005; Facciolongo *et al.*, 2014); moreover they are legumes suitable for rotation with winter wheat.

Faba bean (*Vicia faba* L.) is primarily used in animal feeding as grain, and to a lesser degree as fodder. Faba grain is a good source of starch (450-500 g kg^{-1} dry matter) and protein (230-300 g kg^{-1} dry matter) with a well balanced content of amino acids (Ortiz *et al.*, 1993). The use of a lamb fattening diet largely based on faba bean gave growth performances and meat characteristics similar to the most frequently used diets using soybean meal as their main protein source (Antongiovanni *et al.*, 2002; Lanza *et al.*, 2011).

Lupin seed is a legume with high crude protein (CP, 35-40%) content, which has a high degradability (RDP 665 g/kg of CP), and contains both low starch content and high content of non-starch polysaccharides (van Barneveld, 1999). The seeds of traditional varieties contain substantial amounts of alkaloids (5-20 g kg^{-1} DM; Guillaume *et al.*, 1987) that can reduce intakes (Kung *et al.*, 1991), but newer varieties of sweet lupin have low alkaloid contents (<0.05% DM), especially sweet white lupin (*Lupinus albus* L.). They also appear to be free of other anti-nutritional factors such as lecithin, antitrypsin and hemaglutinin (Guillaume *et al.*, 1987). However, the high ruminal degradability of protein make their use difficult as replacements for soybean meals in the ruminant rations (INRA, 1988), but this 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).

Sweet lupin and faba bean differ in their chemical composition, in rumen degradability (Masoero *et al.*, 2005) and in the amino acid composition (Degussa, 2006) of their proteins, and this may be reflected in animal performances. It is possible that combined use of the two legumes in animal feed could achieve a better balance and thus improve animal performances. Moreover, we are not aware of reports on the effect of the use of faba beans or lupin on lamb blood parameters, some of which are important indicators of the animal's nutritional state and welfare and may be useful to identify metabolic imbalances or disorders. Therefore, this study aimed to use faba bean and lupin seeds as protein supplements, both alone and in combination, and to evaluate their effects on the growth performances, carcass characteristics, and hematological parameters of growing lambs.

MATERIALS AND METHODS

Animals and diets

All procedures involving animals were conducted 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 di Puglia male lambs, weaned at 38±2 days of age and at an average initial body weight (BW) of 15.8±0.5 kg (mean ± standard error), were divided into three homogenous groups for BW and age. They were housed in individual pens (1 m^2 per head) with continuous access to water, and the temperature in the pens ranged from 7°C to 15°C. Lambs were assigned to one of three dietary treatments: FB group received 300 g/kg diet (on as fed basis) of faba bean seeds; FB+L group received 150 g/kg diet of faba bean seeds plus 150 g/kg diet of lupin seeds; L group received 250 g/kg diet of lupin seeds. The three pelleted total mixed rations (PTMR) (Table I) were formulated to be isocaloric and isonitrogenous to meet the nutritional requirements of lambs (INRA, 1988). Lambs were adapted to the ration during 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 analysis. Straw was offered on the rack as a source of roughage. Straw intake was very low and was not recorded. Individual body weights and feed intakes were recorded weekly to calculate average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR).

Slaughtering and carcass traits

At 98 days of age the lambs were slaughtered by exsanguination according to veterinary police rules (D.P.R. 320/54) after fasting for 12 h and recording of slaughter body weights. Hot carcass, skin, fleece, head, pluck and full and empty gastro-

intestinal tract (GIT) were weighed. Carcasses were then hung by the Achilles tendon and chilled at 4°C (80-82% relative humidity) for 24 h and reweighed. The weight of digestive content (full-empty GIT) was used to calculate the net dressing percentage (carcass weight after chilling/empty body weight). The cold carcasses were then divided into two symmetrical sides. The right side was separated into cuts (neck, steak, brisket, shoulder, abdominal region, loin, leg) according to ASPA methods (1996). Loins and legs were dissected into tissue components (lean, separable fat and bone).

Table I.- Ingredient and chemical composition of the experimental diets.

Item	Diets[1]		
	FB	FB+L	L
Ingredient composition, % (as-fed basis)			
Barley	20.0	20.0	20.0
Corn	20.0	20.0	20.0
Corn gluten	2.2	-	-
Oats	12.0	14.0	18.0
Faba bean	30.0	15.0	-
Lupin	-	15.0	25.0
Straw	10.0	10.0	10.0
Wheat bran	2.0	2.2	3.2
Calcium carbonate	1.8	1.8	1.8
Dicalcium phosphate	1.0	1.0	1.0
NaCl	0.5	0.5	0.5
Vitamins	0.5	0.5	0.5
Chemical composition (dry matter basis)			
Moisture, % (as fed)	13.6	13.7	13.7
CP, %	14.9	15.4	15.7
Ether extract, %	3.2	3.4	4.0
Crude fiber, %	9.2	9.5	9.9
Ash, %	4.6	4.4	4.0
NDF, %	21.9	22.7	23.8
ADF, %	10.9	11.7	12.4
ADL, %	2.0	2.2	2.4
PDIN[2] (g/kg dry matter)	103.0	102.0	101.0
PDIE[3] (g/kg dry matter)	101.0	100.2	99.0
Meat Forage Units (*n*/kg DM)	0.90	0.92	0.93

[1]Diets: FB, Faba Bean; L, Lupin; FB + L, 50% Faba Bean + 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.

Feed chemical composition

Samples of each PTMR were ground in a hammer mill with a 1 mm screen and analysed using the following AOAC procedures (2004): dry matter (DM) (Method 934.01), ether extract (EE) (Method 920.39), ash (Method 942.05), crude protein (CP) (method 954.01), crude fibre (CF) (Method 945.18), acid detergent fibre (ADF) and acid detergent lignin (ADL) (Method 973.18), and amylase-treated neutral detergent fibre (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 (1988).

Blood parameters

In the 1st and 8th weeks of the trial, blood samples taken from the jugular vein of each animal with a Vacutainer® were used to analyse the energy (glucose, total cholesterol, NEFA) and protein (creatinine, urea, total protein and respective electrophoresis fractions) metabolism parameters. The blood samples were collected and centrifuged, within 30' at 3000 rpm for 15'; the serum obtained was divided into aliquots, transported at 4°C to the laboratory, and frozen at -20°C until analyses were performed. Serum concentration of parameters was assessed using Assel reagents and a SEAC photometer with interferential filters. Serum protein electrophoresis was performed on agarose gel according to the Helena BioSciences method.

Statistical analyses

Statistical analysis was performed using the GLM procedure of the SAS application package (SAS, 2000) with the model including diet treatment effect and experimental error. The statistical analysis of blood parameters was carried out using the ANOVA model for repeated measurements, which considered the diet (D), the sampling time (S) and the interaction (D x S). When the diet and the sampling time effects were significant ($P < 0.05$) means were compared using Student's *t* test.

RESULTS AND DISCUSSION

In vivo *performance and slaughtering data*

Slaughter body weight was lower ($P<0.05$) for lambs fed with lupin seeds than for lambs fed

with faba beans (Table II). There were no differences in slaughter body weights between lambs fed with lupin plus faba beans and those fed with the two protein sources alone. On the other hand, ADG in Group L was lower ($P<0.05$) than FB and FB+L (27.9% and 23.5% lower, respectively). There were also differences between dietary treatments in average daily feed intake (ADFI). Group L had lower ($P<0.01$) ADFI than the other two groups, while there were no differences in FCR between dietary treatments.

Lupin protein is highly degradable in the rumen and this may partly explain the poor animal performance observed in our trial. Masoero *et al*. (2005) reported that lupin meal is more N-soluble than faba bean meal (87.18% vs. 71.12%), and the same authors observed that *in vitro* rumen degradability of lupin protein is always greater than the faba bean degradation value (70.82% vs. 58.80% during the first 8 hours of incubation). The degree of lupin protein degradation in the rumen varies from 42 to 95%, based on work by Orskov and McDonald (1979), using a synthetic-fiber bag technique. The lower levels of rumen protein degradation were associated with ground whole seed at high fractional outflow rates (high feeding levels), while the high degradation rates (low by-pass values) were associated with fine grinding and/or low fractional outflow rates (low level feeding). Although the method of seed preparation can influence the proportion of lupin protein that ”by-passes” rumen fermentation, in most instances only a low proportion of lupin protein and amino acids reaches the abomasum intact (van Barneveld, 1999).

Moreover, lupin seeds supply monogastric animals and ruminants with less methionine than other amino acids, and contribute excessive amounts of arginine (van Barneveld, 1999). The comparatively high levels of arginine are a problem when feeding lupin to livestock, because arginine and lysine are antagonists and compete for a common carrier at cell level (van Barneveld, 1999). The lower ADFI observed in lambs fed with lupin seeds may be attributed to the alkaloid content of lupin, although it has been reported that sheep are relatively more tolerant of alkaloids than monogastrics (Stanford *et al*., 1996). Although the variety of sweet lupine used in the present study is known to have such a low alkaloid content, ranging from 0.007 to 0.222% (Stanford *et al*., 1996) that we did not measure it, it is still possible that it negatively influenced ADFI and growth. In fact, some of the inconsistencies in the performance reported for lupin-fed lambs (Tracy *et al*., 1988) and cattle (Guillaume *et al*., 1987) may have been caused by these potential toxins, and reduced feed intake and growth of pigs have also been reported to occur with dietary alkaloid levels of 0.03% or greater (Pearson and Carr, 1977).

The section data are reported in Table III. FB lambs had a higher ($P<0.05$) percentage of loin weight in the half-carcass weight compared with the lambs fed with the other two experimental diets. The abdominal region was also a greater percentage of half-carcass weight in FB+L lambs than in FB and L lambs ($P<0.05$). The leg and loin dissection data (Table IV) showed that Group L had a larger ($P<0.05$) percentage of leg bone than FB+L lambs, while there were no significant differences between groups regarding loin dissection, or regarding bone, fat and lean ratios of leg and loin.

Blood parameters

The blood parameters shown in Table V are within the range reported for ovine species (El Barody *et al*., 2002; Abdel-Ghani *et al*., 2011). The protein source and timing of blood sampling did not affect glucose, total cholesterol and NEFA concentrations. However, at the end of the trial, the lambs in Group FB had tendentially higher plasma NEFA concentrations than the lambs fed on diets containing lupin alone. The lower energy requirements of the lambs with a lower weight gain could explain lower NEFA mobilizations from adipose tissue (Glukman *et al*., 1987).

Blood sampling time and feeding treatment both had a significant ($P<0.01$) effect on urea concentration. Group L lambs had higher ($P<0.05$) concentrations of urea than the other two groups at the end of the trial. Urea is an end-product of nitrogen (N) metabolism in many species, and its concentration reflects the level of ammonia production in the rumen (Lewis, 1957). The relatively high urea blood content observed in Group L could be due to the greater protein degradability of lupin compared with faba bean

Table II.- Effect of protein source on growth performances and carcass traits in growing lambs (% of empty body weight).

Item	Diets[1]			r.m.s.e.	P-value
	FB	FB+L	L		
Initial BW (kg)	15.97	15.93	15.80	2.20	0.984
Slaughter BW (kg)	25.98[a]	25.43[ab]	23.04[b]	2.80	0.050
Average daily gain (kg/day)	0.18[a]	0.17[a]	0.13[b]	0.04	0.013
Average daily feed intake (kg/d)	0.86[a]	0.86[a]	0.73[b]	0.03	< 0.001
Feed conversion ratio (kg/kg)	4.97	5.17	6.38	1.50	0.094
Empty BW (kg)	24.07	23.53	21.62	3.47	0.268
Skin	14.21	15.44	14.97	1.66	0.233
Omentum	0.97	0.96	1.00	0.39	0.987
Head	4.40	4.48	4.54	0.53	0.828
Pluck	5.64	5.51	5.32	0.92	0.746
Net dressing percentage	52.54	52.81	53.14	2.30	0.910

[1]Diets: FB, faba bean; L, lupin; FB + L = 50% faba bean + 50% lupin.
r.m.s.e., root mean square error; ADFI, Average daily feed intake.
Means within a row with no common superscript differ significantly (P < 0.05).

Table III.- Effect of protein source on percentage of carcass cuts (% of half carcass weight) in growing lambs.

Item	Diets[1]			r.m.s.e.	*P*-value
	FB	FB+L	L		
Half carcass (kg)	6.08	6.02	5.80	1.03	0.500
Half carcass composition (%)					
Neck	9.55	9.51	9.55	0.66	0.985
Steaks	14.40	14.68	14.82	0.94	0.586
Brisket	10.79	11.27	11.24	0.93	0.366
Shoulder	16.62	16.70	16.79	0.49	0.739
Loin	7.42[a]	6.92[b]	6.86[b]	0.49	0.033
Abdominal region	5.79[b]	6.17[a]	5.36[b]	0.45	0.002
Leg	31.55	30.99	31.26	0.93	0.465

For abbreviations and statistical detail, see Table II.

(92.7 *vs* 86.3%; Masoero *et al*., 2005). In fact, lower blood urea levels were observed in lambs receiving protected protein (Abdel-Ghani *et al*., 2011). As reported by Otto *et al*. (2000), a lower urea concentration may be related to higher amino acid and protein synthesis allowing greater growth performances also confirmed by the higher growth rate of the lambs receiving faba bean. Moreover, the urea concentration reflects the changes in protein metabolism (Hammond, 1998) and other studies have also reported a rise in blood urea concentration during growth (Abdel-Ghani *et al*., 2011). This may be linked to increasing ability of the lamb rumen to degrade proteins and carbohydrates as the lambs grow (Grunwaldt *et al*., 2005).

The timing of blood sampling had a significant (P<0.01) effect on creatinine concentration, and a significant interaction (P<0.01) was found between dietary treatment and blood sampling times. Moreover, at the end of the trial, blood creatinine values were significantly higher (P<0.01) in Group L lambs than in the other two groups. Other studies have reported an increase in blood creatinine levels during growth (Abdel-Ghani *et al*., 2011); this is probably due to growth and the consequent increase in muscle mass. Istasse *et al*. (1990) found a positive correlation between creatinine, carcass weight and lean tissue in cattle. The significant increase in creatinine of Group L lambs might also be due in this case to the higher rumen degradability of lupin proteins in comparison

Table IV.- Effect of protein source on leg and loin tissue composition in growing lambs.

Item	Diets[1]			r.m.s.e.	*P*-value
	FB	FB+L	L		
Leg (kg)	1.92	1.82	1.74	0.32	0.462
Leg composition (%)					
Lean	72.70	74.45	70.94	3.75	0.132
Fat	6.78	6.44	6.79	2.57	0.994
Bone	20.52^{ab}	19.11^{b}	22.28^{a}	2.67	0.043
Lean/bone	3.55	4.42	3.20	1.55	0.213
Lean+fat /bone	3.88	4.77	3.51	1.60	0.211
Lean /fat	12.07	12.98	12.87	5.27	0.915
Loin (kg)	0.45	0.42	0.39	0.08	0.267
Loin composition (%)					
Lean	62.60	62.71	62.63	2.41	0.944
Fat	14.40	15.03	13.81	3.26	0.723
Bone	23.00	22.26	23.56	1.93	0.365
Lean /bone	2.73	2.81	2.68	0.24	0.433
Lean + fat /bone	3.37	3.52	3.28	0.37	0.365
Lean /fat	4.52	4.35	4.87	1.20	0.633

For abbreviations and statistical detail, see Table II.

Table V.- Effects of protein source and time sampling on blood parameters in growing lambs.

Item	Diets[-1]						r.m.s.e	P-value		
	FB		FB+L		L					
	Sampling time (week)		Sampling time (week)		Sampling time (week)					
	1	8	1	8	1	8		D	T	D x T
Glucose (mg/dl)	68.10	68.90	65.50	65.40	66.10	72.90	7.22	0.191	0.154	0.325
Total cholesterol (mg/dl)	53.00	49.67	53.70	50.50	55.90	52.80	9.58	0.607	0.204	0.993
NEFA (mEq/l)	1.34	1.48	1.30	1.37	1.30	0.97	0.49	0.234	0.687	0.296
Urea (mg/dl)	21.24^{ab}*	25.58^{b}	23.27^{ab}*	27.32^{b}	23.72^{ab}*	32.37^{a}	3.97	0.002	< 0.001	0.132
Creatinine (mg/dl)	0.95^{ab}	1.10^{b}	0.99^{ab}	1.08^{b}	0.90^{ab}*	1.35^{a}	0.18	0.153	< 0.001	0.006
Total protein (g/dl)	6.14	6.34	6.06	6.27	6.15	6.58	0.63	0.605	0.072	0.845
Albumin (%)	55.42*	48.22	55.93*	47.40	55.81*	50.60	4.79	0.562	< 0.001	0.549
Albumin/Globulin	1.24*	0.96	1.27*	0.91	1.29*	1.04	0.20	0.468	< 0.001	0.694
α_1-globulin (%)	6.18*	8.48	6.66	7.98	5.94*	7.45	1.72	0.458	< 0.001	0.655
α_2-globulin (%)	15.74^{ab}	15.82^{ab}	16.08^{ab}	16.68^{a}	14.30^{ab}	14.25^{b}	1.84	0.002	0.658	0.845
β-globulin (%)	7.18^{ab}	6.97^{b}	7.47^{ab}	6.67^{b}	7.67^{ab}	8.45^{a}	1.21	0.017	0.812	0.128
γ-globulin (%)	15.73*	20.56	14.14*	21.22	16.35	19.24	3.83	0.069	0.001	0.230

For other details and abbreviations, see Table II.
NEFA, non esterified fatty acids.
Means within a row and the same sampling time (T) with no common superscript differ significantly ($P < 0.05$);
between sampling times within the same diet (D), *: $P < 0.05$.

with faba bean proteins. In fact, Abdel-Ghani *et al*. (2011) found lower concentrations of blood creatinine and urea when lambs were fed diets containing ruminally protected proteins. Nozad *et al*. (2012) reported a positive correlation between blood urea and creatinine in cattle.

Total protein values were not affected by dietary treatment and sampling times. Albumin concentration was affected by the sampling time and was significantly (P<0.01) lower at the end of

the trial. The A/G ratio was also affected by the sampling time and was also lower ($P<0.01$) at the end of the experiment. The α_1-globulin and γ-globulin percentages were higher ($P<0.01$) at the end of the trial. Dietary treatment had a significant ($P<0.01$) effect on the α_2-globulin percentage, which was higher in the Group FB+L than in L at the end of the trial. Kaneko *et al*. (1989) also reported decreases in albumin concentrations and increases in globulin fractions in older animals. It has been reported that the protein sources used in this study have nutraceutical properties (Duranti, 2006) and can reduce blood cholesterol levels. The anticholesterolemic action of these legume grains seems to depend on mechanisms which include their effect on the serum levels of HDL, VLDL and LDL lipoproteins, known to migrate respectively into the α_1, α_2 and β fractions of serum protein electrophoresis (Kaneko, 1989). The results of the present study show that the protein sources did not affect blood total cholesterol concentrations despite significant increases in the α_1-protein fractions. This α_1-globulin increase could confirm the mechanism reported in rats by Sirtori *et al*. (2004) for lupin, and by Macarulla *et al*. (2001) for faba bean. Since El Barody *et al*. (2002) showed an increase in cholesterol levels of lambs (of 4 different genotypes) from weaning to four months of age, it could therefore be assumed that the two protein sources have acted to reduce cholesterol.

In conclusion, the use of lupine and faba bean seeds in association as the main protein source provides lamb growth performances and slaughtering data comparable to those obtained when faba bean seeds are used alone. However, when faba been seeds were the sole protein source in the diet, the half-carcasses presented a higher percentage of loin than the half-carcasses of lambs fed with the two protein supplements in association. Use of the two protein sources together improved lamb growth performances and decreased the leg bone percentage compared to lupin used alone. Blood parameters were little affected by dietary treatments. On the whole, our results suggest that association of the two protein sources in lamb feed has a positive effect on lamb growth and slaughtering data.

REFERENCES

ABDEL-GHANI, A.A., SOLOUMA, G.M.A., ABD ELMOTY, A.K.I., KASSAB, A.Y. AND SOLIMAN, E.B., 2011. Productive performance and blood metabolites as affected by protected protein in sheep. *Open J. Anim. Sci*., **1**: 24-32.

ANTONGIOVANNI, M., ACCIAIOLI, A., FRANCI, O., PONZETTA, M.P., PUGLIESE, C., BUCCIONI, A. AND BADII, M., 2002. Field bean (Vicia faba var. minor) as a protein feed for growing lambs with and without protected lysine and methionine supplementation. *Ital. J. Anim. Sci*., **1**: 229-238.

AOAC, 2004. *Official methods of analysis*, 18th ed. Association of Official Analytical Chemists, Arlington, VA, USA.

ASPA, 1996. *Metodiche per la determinazione delle caratteristiche qualitative della carne (Procedures for meat quality evaluation).* Scientific Association of Animal Production, Perugia, Italy.

DEGUSSA, 2006. Amino Dat 3.0®. *The amino acid composition of feedstuffs*, 5th rev. ed. Degussa AG, Feed Additives, Hanau, Germany.

DURANTI, M., 2006. Grain legume proteins and nutraceutical properties. *Fitoterapia*, **77**: 67-82.

EL-BARODY, M.A.A., ABDALLA, E.B. AND EL-HAKEAM, A., 2002. The changes in some blood metabolites associated with the physiological responses in sheep. *Livest. Prod. Sci.*, **75**: 45-50.

FACCIOLONGO, A.M., RUBINO, G., ZARRILLI, A., VICENTI, A., RAGNI, M. AND TOTEDA, F., 2014. Alternative protein sources in lamb feeding 1. Effects on productive performances, carcass characteristics and energy and protein metabolism. *Progr. Nutr*., **16**: 105-115.

GLUCKMAN, P.D., BREIER, B.H. AND DAVIS, S.R., 1987. Physiology of the somatotropic axis with particular reference to the ruminant. *J. Dairy Sci.,***70**: 442–466.

GRUNWALDT, E.G., GUEVARA, J.C., ESTÉVEZ, O.R., VICENTE, A., ROUSSELLE, H., ALCUTEN, N., AGUERREGARAY, D. AND STASI, C.R., 2005. Biochemical and haematological measurements in beef cattle in Mendoza plain rangelands (Argentina). *Trop. Anim. Hlth. Progr.*, **37**: 527-540.

GUILLAUME, B., OTTERBY, D.E., LINN, J.G., STERN, M.D. AND JOHNSON, D.G., 1987. Comparison of sweet white lupin seeds with soybean meal as protein supplements for lactating dairy cows. *J. Dairy Sci*., **70**: 2339-2348.

HAMMOND, A.C., 1998. Use of BUN and MUN as a guides for protein and energy supplementation in cattle. *Rev. Corpoica*, **2**: 44-48.

INRA, 1988. *Alimentation des bovines, ovins et caprins*. INRA, Paris.

ISTASSE, L., VAN EENAEME, C., EVRARD, P., GABRIEL, A., BALDWIN, P., MAGHUIN-ROGISTER, G. AND

BIENFAIT, M., 1990. Animal performance, plasma hormones and metabolites in Holstein and Belgiam Blue growing-fattening bulls. *J. Anim. Sci.*, **68**: 2666-2673.

JACQUES, J., BERTHIAUME, R. AND CINQ-MARS, D., 2011. Growth performance and carcass characteristics of Dorset lambs fed different concentrates: Forage ratios or fresh grass. *Small Rumin. Res.*, **95**: 113-119.

KANEKO, J.J., 1989. Serum proteins and the dysproteinemias. In: *Clinical biochemistry of domestic animals* (eds. J.J. Kaneko), Academic Press Inc., San Diego, CA, USA. pp. 142-165.

KUNG, L., JR., MACIOROWSKI, K., POWELL, K.M., WEIDNER, S. AND ELEY, C.L., 1991. Lupin as a protein supplement for growing lambs. *J. Anim. Sci.*, **69**: 3398-3405.

LANZA, M., FABRO SCERRA, M., BELLA, M., PAGANO, R., BROGNA, D.M.R. AND PENNISI, P., 2011. Lamb meat quality and intramuscular fatty acid composition as affected by concentrates including different legume seeds. *Ital. J. Anim. Sci.*, **10:e18**: 87-94.

LEWIS, D., 1957. Blood-urea concentration in relation to protein utilization in the ruminant. *J. agric. Sci.*,, **48:** 438-446.

MACARULLA, M.T., MEDINA, C., DE DIEGO, M.A., CHÁVARRI, M., ZULET, M.A., MARTÍNEZ, J.A., NÖEL-SUBERVILLE, C., HIGUERET, P. AND PORTILLO, M.P., 2001. Effects of the whole seed and a protein isolate of faba bean (Vicia faba) on the cholesterol metabolism of hypercholesterolaemic rats. *Brit. J. Nutr.*, **85**: 607-614.

MASOERO, F., PULIMENO, A.M. AND ROSSI, F., 2005. Effect of extrusion, expansion and toasting on the nutritional value of peas, faba beans and lupins. *Ital. J. Anim. Sci.*, **4**: 177-189.

MURPHY, S.R. AND MCNIVEN, M.A., 1994. Raw and roasted lupin supplementation of grass silage diets for beef steers. *Anim. Feed Sci. Technol.*, **46**: 23-35.

NOZAD, S., RAMIN, A.G., MOGHADAM, G., ASRI-REZAEI, S., BABAPOUR, A. AND RAMIN, S., 2012. Relationship between blood urea, protein, creatinine, triglycerides and macro-mineral concentrations with the quality and quantity of milk in dairy Holstein cows. *Vet. Res. Forum*, **3**: 55-59.

ØRSKOV, R.E. AND MCDONALD, I., 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *J. agric. Sci.*, **92**: 499-503.

ORTIZ, L.T., CENTENO, C. AND TREVINO, J., 1993. Tannins in faba bean seeds: effects on the digestion of protein and amino acid in growing chicks. *Anim. Feed Sci. Technol.*, **41**: 271-278.

OTTO, F., VILELA, F., HARUN, M., TAYLOR, G., BAGASSE, P. AND BOGIN, E., 2000. Biochemical blood profile of Angoni cattle in Mozambique. *Israel Vet. Med. Assoc.*, **55**: 95-102.

PEARSON, G. AND CARR, J.R., 1977. A comparison between meals prepared from the seeds of different varieties of lupin as protein supplements to barley-based diets for growing pigs. *Anim. Feed Sci. Technol.*, **2**: 49-58.

SAS, 2000. *SAS/STAT Users Guide*: Statistics. SAS Institute Inc., Cary, NC, USA.

SIRTORI, C.R., LOVATI, M.R., MANSONI, C., CASTIGLIONI, S., DURANTI, M. AND MAGNI, C., 2004. Proteins of white lupin seed, a naturally isoflavone-poor legume, reduce cholesterolemia in rats and increase LDL receptor activity in HepG2 cells. *J. Nutr.*, **134**: 18-23.

STANFORD, K., MCALLISTER, T.A., LEES, B.M., XU, Z.J. AND CHENG, K.J., 1996. Comparison of sweet white lupin seed, canola meal and soybean meal as protein supplements for lambs. *Can. J. Anim. Sci.*, **76**: 215-219.

TRACY, V.A., BARTON, B.A., ANDERSON, G.W. AND WILLIAMS, M.S., 1988. Comparison of sweet white lupin seeds with soybean oil meal as a protein supplement for sheep. *J. Anim. Sci.*, **66**(Suppl): 499 (Abstr.).

TURNER, T.D., KARLSSON, L., MAPIYE, C., ROLLAND, D.C., MARTINSSON, K. AND DUGAN, M.E.R., 2012. Dietary influence on the m. longissimus dorsi fatty acid composition of lambs in relation to protein source. *Meat Sci.*, **91**: 472-477.

VAN BARNEVELD, R.J., 1999. Understanding the nutritional chemistry of lupin (*Lupinus* spp.) seed to improve livestock production efficiency. *Nutr. Res. Rev.*, **12**: 203-230.

VASTA, V., NUDDA, A., CANNAS, A., LANZA, M. AND PRIOLO, A., 2008. Alternative feed resources and their effects on the quality of meat and milk from small ruminants. *Anim. Feed Sci. Technol.*, **147**: 223-246.

VICENTI, A., TOTEDA, F., DI TURI, L., COCCA, C., PERRUCCI, M., MELODIA, L. AND RAGNI, M., 2009. Use of sweet lupin (*Lupinus albus* L. var. Multitalia) in feeding for Podolian young bulls and influence on productive performances and meat quality traits. *Meat Sci.*, **82**: 247-251.

(Received 12 January 2015, revised 15 April 2015)