Raw Pea (*Pisum sativum*), raw Faba bean (*Vicia faba* var. *minor*) and raw Lupin (*Lupinus albus* var. multitalia) as alternative protein sources in broiler diets

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Paper received July 30, 2004; accepted November 21, 2004

ABSTRACT

The ban of the meat and bone meal for entering animal diets and the concern of transgenic feeds poses a challenge to animal nutritionists in Europe. The challenge is to find homegrown protein-rich feedstuffs, making sure no antinutritional factors are present which could interfere in the animals' performance. The raw Pea (*Pisum sativum*) (RP), raw Faba bean (*Vicia faba*, variety *minor*) (RFb) and raw Lupin (*Lupinus albus*, variety *multitalia*) (RL) were evaluated as alternative protein sources into broiler diets. Six hundred thirty 1d-old Ross male chicks, Marek vaccinated, were randomly assigned to seven dietary treatments (5 pens per treatment/18 birds per pen). Chicks were floor housed, ad libitum fed isocaloric and isonitrogenous diets and had free access to water. Artificial light was provided 10 h/d. The bulk of the base diet (control diet) was corn (48.7%, 56.6% and 57%), solvent-extracted soybean meal (42.8%, 37.3% and 33.4%), corn oil (4.4%, 5.2% and 6.3%), plus synthetic amino acids, minerals, trace minerals and vitamins, respectively for the 1-10d-old, 11-28d-old and 29 to 42d-old growing periods. The RP, RFb and RL entered diets in substitution of the soybean and corn according to the cost optimization (P100, Fb100 and L100, respectively for RP, RFb and RL) and at half of the optimized quantity (RP50, RFb50 and RL50, respectively for RP, RFb and RL). The amount used as fed basis for the higher level of inclusion were: P100: 350 g/kg for all diets; Fb100: 480 g/kg (1-10d-old) and 500 g/kg (11-42d-old); L100: 360 g/kg (1-10d-old) and 300 g/kg (11-42d-old). The average daily gain (ADG) were lower ($P < 0.05$) in the RP group compared to the control group. Over the whole period of growth, the RFb group had similar ADG compared to the control group and for both levels of inclusion, whereas reduced ($P < 0.05$) ADG were observed in the RL100 group. Reduced ($P < 0.05$) ADG were also observed for the RFb100 and the RL100 groups when calculated over the first three weeks of growth. Birds performance was improved ($P < 0.05$) in the RL50 group. No effects were observed on dressing percentage and breast and leg quarter cuts. The RFb and RL could represent valuable protein feeds in broilers diet formulation.

Key Words: Broilers, Pea, Faba bean, Lupin, Protein sources.

RIASSUNTO

PISELLO, FAVA E LUPINO CRUDI COME FONTE PROTEICHE ALTERNATIVE IN DIETE PER BROILERS

Il divieto dell'utilizzo delle farine di carne nelle diete per animali e la preoccupazione legata agli alimenti transgenici rappresenta una problematica per i nutrizionisti in Europa. Un'alternativa potrebbe essere l'utilizzo di fonti proteiche non convenzionali di origine vegetale prive di fattori antinutrizionali intrinseci. Lo studio ha valutato la possibilità dell'utilizzo di Pisello

(Pisum sativum) (RP), Fava (Vicia faba, varietà minor) (RFb) e Lupino (Lupinus albus, varietà multitalia) (RL) crudi in diete per broilers. 630 pulcini maschi Ross di 1 un giorno di vita, vaccinati Marek, sono stati randomizzati a 7 trattamenti (5 box per trattamento/18 animali per box). I pulcini erano allevati a terra, alimentati ad libitum con diete isocaloriche ed isoproteiche ed avevamo libero accesso all'acqua di bevanda. Agli animali veniva fornita una luce artificiale per 10 h/d. La dieta di base (dieta di controllo) era costituita da, rispettivamente per i periodi crescita di 1-10, 11-28 e 29-42 giorni: mais (48.7%, 56.6% e 57%), farina di estrazione di soia (42.8%, 37.3% e 33.4%), olio di mais (4.4%, 5.2% e 6.3%), aminoacidi di sintesi, minerali e vitamine. RP, RFb e RL venivano utilizzati nelle diete in sostituzione della farina di soia e mais in base ad un processo di ottimizzazione della dieta (RP100, RFb100 and RL100, rispettivamente per RP, RFb e RL) ed in ragione del 50% della quantità ottimizzata (RP50, RFb50 e RL50, rispettivamente per RP, RFb e RL). Le quantità utilizzate erano: RP100: 350 g/kg per tutte le diete; RFb100: 480 g/kg (1-10 giorni) e 500 g/kg (11-42 giorni); RL100: 360 g/kg (1-10 giorni) e 300 g/kg (11-42 giorni). L'incremento medio giornaliero (ADG) è risultato inferiore (P < 0.05) nelle diete con RP rispetto alle diete di controllo. Nel periodo complessivo di crescita i gruppi alimentati con RFb hanno ottenuto, per entrambi i livelli di inclusione, ADG simili al gruppo di controllo mentre la dieta RL100 ha determinato una riduzione (P < 0.05) dell'ADG. L'analisi nelle prime tre settimane di crescita ha evidenziato una riduzione (P < 0.05) dell'ADG in animali alimentati con le diete RFb100 e RL100. La performance degli animali è migliorata (P < 0.05) nel gruppo RL50. Non si sono osservati effetti significativi sulla resa alla macellazione e sulla percentuale di petto e cosce. In conclusione, RFb e RL possono rappresentare una fonte proteica alternative interessante nella formulazione di diete per broilers.

Parole chiave: *Broilers, Pisello, Fava, Lupino, Fonti proteiche.*

Introduction

The outbreak of the bovine spongiform encefalophaty has lead to the ban of meat and bone meal utilization in animals diets. Additionally, the concern of genetically modified feeds poses challenges to nutritionists looking for feedstuffs as alternative protein sources in animal feeding. Field pea (*Pisum sativum*), faba beans (*Vicia faba*) and lupin (*Lupinus albus*) have been used in broilers (Brenes *et al.*, 2002; Cowieson *et al.*, 2003; Daveby *et al.*, 1998; Farrell *et al.*, 1999; Rubio *et al.*, 2003; Steenfeldt *et al.*, 2003) and hens (Perez-Maldonado *et al.*, 1999) diets. The use of grain legumes in animal diets could be impaired by the presence of one or more antinutritional factors. Some concerns were observed for high lupin inclusion into broiler diets, which might results in increased feces viscosity due to the high non-starch polysaccharide (NSP) contents. The NSP are not degraded by monogastric digestive enzymes impairing the gastro intestinal tract functions. The NSP contents vary accordingly to species and cultivars (Evans *et al.*, 1993; Gdala and Buraczewska, 1996; Gdala and Buraczewska, 1997; Kocher *et al.*, 2000). The attempt to reduce the negative effects of NSP involves enzymes addition to diets (Cowieson *et al.*, 2003; Gilbert *et al.*, 1999; Kocher *et al.*, 2000; Steenfeldt *et al.*, 2003), reduced level of inclusion (Farrell *et al.*, 1999; Gualtieri and Rapaccini, 1990; Quarantelli and Bonomi, 1991) and proper particle size and technological treatments (Daveby *et al.*, 1998; Gatel, 1993; Lacassagne *et al.*, 1991).

The objective of the study was to evaluate raw pea (*Pisum sativum*) (RP), raw faba beans (*Vicia faba*, variety minor) (RFb) and raw lupin (*Lupinus albus*, variety *multitalia*) (RL) as alternative protein sources in corn-soybean based broiler diets.

Material and methods

Six hundred thirty 1d-old Marek vaccinated ROSS male chicks were obtained from a commercial hatchery (Dal Verme Camillo e Filippo, Torre degli Alberi, Pavia). Thirty-five pens (18 birds per pen) were used (42d) and to each was randomly assigned 1 of 7 dietary treatments (5 pens/treatment). Chicks were floor housed (0.09 m^2/bird) in three conditioned rooms (24°C), *ad libitum* fed isocaloric and isonitrogenous diets and had free access to water. Artificial light was provided 10 h/d. Fluorescent lights with ultraviolet filters was provided 24 h/d for the first 14d in the experiment. Animals were raised according to the European Union (86/609/EEC) and Italian (D.lgs January 27, 1992 n. 116) directives on animal welfare for experimental and other scientific purposes. Diets were formulated according to the ROSS breeders requirements for starter (1-10d-old), growing (11-28d-old) and finishing (29-42d-old) periods. The bulk of the base diet (control diet - CTR) was corn

(48.7%, 56.6% and 57%), solvent-extracted soybean meal (42.8%, 37.3% and 33.4%), corn oil (4.4%, 5.2% and 6.3%), plus synthetic amino acids, minerals, trace minerals and vitamins, respectively for the 1-10d-old, 11-28d-old and 29 to 42d-old growing periods (Tables 1, 2 and 3). The RP, RFb and RL entered diets in substitution of the soybean meal and corn according to the cost optimization in diet formulation (RP100, RFb100 and RL100) and to the half of the optimized amount (RP50, RFb50 and RL50), respectively for RP, RFb and RL. The amount used as fed basis for the cost-optimized diets were: RP100: 350 g/kg for all diets; RFb100: 480 g/kg (1-10d-old) and 500 g/kg (11-42d-old); RL100: 360 g/kg (1-10d-old) and 300 g/kg (11-42d-old). The RP, RFb and RL and experimental diets were characterized for protein, crude lipids, total fiber, total sugar and ash contents (Martillotti *et al.*, 1987), ADF and NDF (Van Soest *et al.*, 1991). The starch content was measured by polarimetric method (Martillotti *et al.*, 1987). Amino acids were measured with amino acids analyser (Carlo Erba 3A29) according to published methods (Eggum, 1968; Moore, 1963; Moore *et al.*, 1980). The methionine content was determined after oxidation with performic acid. Feeds were analyzed for total phenols and tannins, fractioned by adsorption chromatography according to Carmona *et al.* (1991), daidzein and genistein were determined by gas chromatography-mass spectrometry (Liggins *et al.*, 1998) and by reverse-phase HPLC (Franke *et al.*, 1994). The antitripsin activity was analyzed by the method described by Smith *et al.* (1980). Pens were weighted at day 1, 21 and 42 and feed intake was monitored. The weight gain, feed intake and feed efficiency were calculated. Bird mortality was recorded daily and dead birds were removed and weight was recorded. At 42d old, after being weighted, two broilers per pen were randomly selected and litium-heparinized blood samples were obtained by wing puncture and centrifuged at 3000 rpm for 20 min. The plasma was collected and stored at -20°C until analyzed for urea, total proteins, bilirubin, albumin, albumin/globulin ratio, aspartate amino transferase (AST), alanine amino transferase (ALT) and gamma-glutamyl transferase (GGT) according to Bertoni *et al.* (1998). At 42d old animals were processed in a commercial processing plant (Avicola Valtidone S.R.L., 29015 Castel San Giovanni (PC) – 6a via del Montanino), eviscerated and weight were recorded. One animal per pen was randomly selected and part weights were recorded for breast meat (pectoralis major) and leg quarter (drumstick plus thigh). Data were analyzed by the GLM procedure of SAS (SAS, 1999). Differences among means were declared at $P < 0.05$.

Results and discussion

The alternative protein feeds had low levels of antinutritional factors (Table 4) and in average the mortality for the entire experiment was 1.4 %.

The amino acids profiles (Table 6) and the chemical composition (Table 5) of the grain legumes are reported. Values are in good agreement with previous published data (Perez-Maldonado *et al.*, 1999; Velmurugu *et al.*, 2002). The RP, RFb and RL had reduced essential amino acids (EAA) contents compared to the soybean, which is traditionally used in broiler diets. However, by adding synthetic amino acids RP, RFb and RL could still be partially used in broiler diet formulation in place of soybean.

The performance results are shown in Table 7. When feeding the RFb50 or the RL50 diets the ADG of birds for the first period of growth were not different than ADG of birds from the control diet. Because of the reduced feed intake, birds fed the RL50 diet improved ($P < 0.05$) the feed to gain ratio. However, when considering the whole period of growth birds performed similarly independently of the source of protein being fed. The enhancement in birds performance was previously reported when feeding 150, 231 e 469 g lupin (*Lupinus albus*) per kg of diet as substitute of soybean meal (Brenes *et al.*, 2002). The reported good amino acid availability of lupin compared to other alternative protein sources (Hew *et al.*, 1996) might explain the performance of young birds in our trial. However, because of the NSP content, the inclusion of lupin into poultry diets could also result in increased digesta viscosity and excreta stickiness (Perez-Maldonado *et al.*, 1999). Despite the reported good performance with inclusion levels over 400

Table 1. Ingredients (g/kg 'as fed basis') and chemical composition of diets fed from 1 to 10d-old.

	CTR	RP		RFb		RL	
		100	50	100	50	100	50
Ingredients:							
Corn meal	487	297	386	250	373	451	465
Soybean meal	428	258	350	180	300	88	262
Pea	-	353	175	-	-	-	-
Faba beans	-	-	-	479	240	-	-
Lupin	-	-	-	-	-	360	180
Corn oil	44	50	48	45	44	50	47
L-Lysine hydrochloride	1.1	-	0.3	1.3	1.3	5	2.8
DL-Methionine	1.8	2.8	2.2	3.5	2.7	3.5	2.6
L-Threonine	-	0.3	-	0.7	0.3	1.1	0.3
L-Tryptophan	-	0.5	0.2	0.8	0.4	1.3	0.7
Calcium carbonate	4.9	1.4	3.8	0.5	2	-	1.5
Dicalcium phosphate	23.3	27.1	25.1	28.7	26.1	30.1	28
Sodium chloride	2.8	3	3	2.3	2.5	1.4	3.7
Sodium bicarbonate	1.5	0.8	1	1.6	1.6	3	3
Premix[1]	5	5	5	5	5	5	5
Coccidiostat[2]	1	1	1	1	1	1	1
Composition by analysis:							
Crude protein	227	227	229	227	227	227	225
Ether extract	66	67	72	66	64	96	81
Crude fiber	33	29	28	45	32	45	42
Ash	59	58	60	55	57	52	57
Starch	370	363	360	366	372	313	342
Total sugars	47	56	48	46	43	42	51
Lysine	13.7	14	13.6	14	13.7	13.8	13.3
Methionine + Cystine	9.4	9	9.6	9.4	9.2	9.7	9.1
Threonine	8.8	8.8	9.1	8.9	8.7	8.7	9.1
Tryptophan	2.7	2.8	2.9	2.5	2.8	2.7	2.4
Composition by calculation:							
ME (kcal/kg)	3008	3013	3022	2986	2987	3014	3017

[1]Premix supplied per kg of diet: vitamin A 4,000,000 U; vitamin D_3 800,000 U; vitamin E 4,000 mg; vitamin B_1 160 mg; vitamin B_2 1,020 mg; vitamin B_6 600 mg; D-phantotenic acid 2,400 mg; vitamin K_3 400 mg; vitamin PP 6,000 mg; vitamin B_{12} 4 mg; Folic acid 120 mg; Co 120 mg; Fe 7,600 mg; I 320 mg; Mn oxide 25,000 mg; Cu 8,000 mg; Se 120 mg; Zn oxide 20,000 mg.

[2]Content for kg of coccidiostat: Lasalocid 90 g

Table 2. Ingredients (g/kg 'as fed basis') and chemical composition of diets fed from 11 to 28d-old.

	CTR	RP		RFb		RL	
		100	50	100	50	100	50
Ingredients:							
Corn meal	536	306	402	250	392	482	482
Soybean meal	373	230	318	146	260	111	265
Pea	-	356	178	-	-	-	-
Faba beans	-	-	-	497	249	-	-
Lupin	-	-	-	-	-	300	150
Corn oil	52	67	63	64	59	61	61
L-Lysine hydrochloride	1.8	0.4	0.2	1.2	1.4	5	2.3
DL-Methionine	2.3	3.1	2.6	3.8	3.1	3.7	2.7
L-Threonine	0.4	0.6	0.2	0.9	0.6	1.2	0.4
L-Tryptophan	-	-	-	0.3	-	0.9	0.1
Calcium carbonate	9.1	10	10	8	7.2	8	8
Dicalcium phosphate	14.7	15	15	18	18	17	17
Sodium chloride	2.5	2	2	2	2	1	1.2
Sodium bicarbonate	1.9	3	3	3	3	4	4
Premix[1]	5	5	5	5	5	5	5
Coccidiostat[2]	1	1	1	1	1	1	1
Composition by analysis:							
Crude protein	222	215	214	217	216	215	212
Ether extract	74	76	82	84	90	83	88
Crude fiber	31	37	32	53	41	43	41
Ash	54	56	55	57	57	51	53
Starch	380	386	381	375	356	378	366
Total sugars	52	40	45	38	37	42	44
Lysine	13.1	12.9	12.8	12.7	12.9	13	12.8
Methionine + Cystine	8.9	8.9	9	9.1	8.7	9.2	9
Threonine	9	8.9	9	8.9	8.7	9.1	9.3
Tryptophan	2.6	2.6	2.7	2.6	2.7	2.7	2.5
Composition by calculation:							
ME (kcal/kg)	3108	3087	3123	3108	3070	3109	3099

[1]*Premix supplied per kg of diet: vitamin A 4,000,000 U; vitamin D_3 800,000 U; vitamin E 4,000 mg ; vitamin B_1 160 mg; vitamin B_2 1,020 mg ; vitamin B6 600 mg ; D-phantotenic acid 2,400 mg ; vitamin K_3 400 mg; vitamin PP 6,000 mg; vitamin B_{12} 4 mg; Folic acid 120 mg; Co 120 mg; Fe 7,600 mg; I 320 mg; Mn oxide 25,000 mg; Cu 8,000 mg; Se 120 mg; Zn oxide 20,000 mg.*

[2]*Content for kg of coccidiostat: Lasalocid 90 g.*

Table 3. Ingredients (g/kg 'as fed basis') and chemical composition of diets fed from 29 to 42d-old.

	CTR	RP		RFb		RL	
		100	50	100	50	100	50
Ingredients:							
Corn meal	570	378	486	291	432	536	556
Soybean meal	334	172	246	109	223	64	200
Pea	-	350	175	-	-	-	-
Faba beans	-	-	-	500	250	-	-
Lupin	-	-	-	-	-	300	150
Corn oil	63	64	58	65	60	61	58
L-Lysine hydrochloride	0.6	0.1	0.1	0.1	0.1	3.3	1.9
DL-Methionine	1.7	3	2.2	3.2	2.4	3	2.3
L-Threonine	-	0.4	0.1	0.3	0.1	0.5	0.1
L-Tryptophan	-	0.3	-	0.2	-	0.6	0.1
Calcium carbonate	3.9	1.4	4.4	4.1	4.7	-	1.1
Dicalcium phosphate	20.5	23.2	20.6	20.2	20.3	25.2	22.8
Sodium chloride	3.6	2	2	2	2	2	1.3
Sodium bicarbonate	0.3	3	3	3	3	2.3	4
Premix[1]	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Coccidiostat[2]	-	-	-	-	-	-	-
Lysine	11.3	11.4	10.9	11.3	11.1	11.1	10.7
Methionine + Cystine	8.4	8	8.7	8.6	8.3	8.7	8.4
Threonine	8.1	8.8	8.4	8.6	8.3	8.4	8.6
Tryptophan	2.3	2.4	2.6	2.8	2.5	2.4	2.3
Composition by analysis:							
Crude protein	199	195	195	204	205	194	192
Ether extract	87	80	78	83	81	88	82
Crude fiber	31	36	33	52	36	46	32
Ash	51	51	52	53	52	45	46
Starch	426	427	439	420	417	433	442
Total sugars	33	35	36	33	36	31	29
Composition by calculation:							
ME (kcal/kg)	3245	3188	3226	3213	3196	3263	3238

[1]*Premix supplied per kg of diet: vitamin A 4,000,000 U; vitamin D_3 800,000 U; vitamin E 4,000 mg; vitamin B_1 160 mg; vitamin B_2 1,020 mg; vitamin B_6 600 mg; D-phantotenic acid 2,400 mg; vitamin K_3 400 mg; vitamin PP 6,000 mg; vitamin B_{12} 4 mg; Folic acid 120 mg; Co 120 mg; Fe 7,600 mg; I 320 mg; Mn oxide 25,000 mg; Cu 8,000 mg; Se 120 mg; Zn oxide 20,000 mg.*

[2]*Content for kg of coccidiostat: Lasalocid 90 g*

Table 4. Antinutritional content in protein sources.

Analysis		Soybean	RP	RFb	RL
Tannins	mg/g	0.39	0.14	0.47	0.61
Polyphenols	"	2.09	11.19	2.49	6.39
Genisteine	ppm	0.7	< 0.05	< 0.05	< 0.05
Daidzeine	"	1.6	0.1	0.1	< 0.05
Trypsin inhibiting activity		1.3	0.89	0.78	0.72

RP: raw Pea; RFb: raw Faba bean; RL: raw Lupin

Table 5. Chemical composition (g/kg 'as fed basis') of the grain legumes.

Parameter	Soybean	RP	RFb	RL
Dry matter	885.9	880.1	883.1	911.2
Crude protein	451	212.5	259	350.5
Ether extract	13	12.3	16.1	77.4
Crude fiber	-	68.2	77.7	95.8
Ash	60.7	32.6	33.8	38.1
Starch	-	436.6	327.2	114.1
Total sugars	92.6	38.4	40.3	65.6
Neutral Detergent Fiber	179.3	162.8	276.4	183.7
Acid Detergent Fiber	66.7	87.5	114.2	118

RP: raw Pea; RFb: raw Faba bean; RL: raw Lupin

g/kg (Olver and Jonker, 1997), when using 300 g RL/kg (RL100) the ADG was negatively affected ($P < 0.05$) compared to the control group with no differences of the feed to gain ratio (Table 7). Similarly to RL, birds fed the RFb100 diet had a reduced ADG compared to the control group, however, the effect was limited to the first period of growth (Table 7). Previous reports indicate faba bean meal can be used into broiler diets up to 35% as a partial substitute of maize (Farrell *et al.*, 1999; Joon *et al.*, 1998). The level of inclusion in our study ranged between 25% and 50%. The reduced level of EAA (Table 4), the lower amino acids availability (Hew *et al.*, 1996) of RFb compared to RL and the reduced ability of young birds to cope with alternative protein sources other than soybean (Farrell *et al.*, 1999) could in part explain the lower performance of birds fed the RFb100 diet (Table 7). When feeding the RP the ADG were reduced ($P < 0.05$) compared to the control diet at both levels of inclusion. No differences were reported for the F:G ratio (Table 7). Among the alternative protein sources, the RP had the lowest amount of EAA. Additionally, the higher level of RP inclusion in our trial was 17% over the suggested level of inclusion for broilers (Farrell *et al.*, 1999).

No effects on dressing percentage, breast and leg quarter weights were observed (Table 8). Data agree with previous works on broilers fed diets with 5% to 15% of Pea (Quarantelli and Bonomi,

Table 6. Amino acid content of the grain legumes (g/kg 'as fed basis').

Amino acid	Soybean	RP	RFb	RL
Alanine	19.8	8.9	10.6	11.6
Arginine	34.6	14.2	23.1	35
Aspartic Acid	48.9	26.5	24.7	41.6
Cystine	6.7	3	3.3	5
Glutamic acid	85.6	34.6	42.9	80.7
Glycine	19.1	8.5	10.6	13.6
Histidine	11.9	3.8	6.3	8.2
Isoleucine	22.7	8.7	11.1	16.3
Leucine	35.2	14.1	18.8	26.1
Lysine	28.4	13	15.9	14.9
Methionine	6.5	1.8	2.1	2.4
Phenylalanine	23.5	9.5	10.9	14.7
Proline	24.5	8.5	11.8	15
Serine	25.4	11.3	13.2	21.8
Threonine	18	8.1	9	13
Tyrosine	17.3	6.2	7.5	16
Valine	22.8	9.1	12.2	13.8
Tryptophan	6.1	1.8	2.3	2.1

RP: raw Pea; RFb: raw Faba bean; RL: raw Lupin

Table 7. Influence of alternative protein sources on the average daily intake (ADI), average daily gain (ADG) and feed to gain ratio (F:G) of broiler chickens.

Parameter	CTR	RP		RFb		RL		SEM
		100	50	100	50	100	50	
[1]ADI, 1-21d	54.7[c]	50[ab]	47.7[a]	54.3[bc]	52.7[bc]	47[a]	47.5[a]	1.55
[2]ADI, 1-42d	109.9	108.8	105.5	111.1	109.8	104.1	110.4	2.76
ADI, 22-42d	165.5	168	162.5	167.8	167.2	161.2	173.2	4.59
[1]ADG, 1-21d	36[e]	33.6[bc]	30.9[a]	33.8[c]	34.8[ce]	31.8[ab]	36[e]	0.70
[1]ADG, 1-42d	63.3[c]	60.5[ab]	60.6[ab]	62[bc]	61[abc]	59.3[a]	63.3[c]	0.89
[1]ADG, 22-42d	90.5	87.4	90.3	90.2	87.3	86.9	90.7	1.79
[1]F:G, 1-21d	1.51[b]	1.49[b]	1.52[b]	1.60[b]	1.52[b]	1.48[b]	1.31[a]	0.05
[3]F:G, 1-42d	1.74	1.78	1.76	1.82	1.78	1.76	1.75	0.05
F:G, 22-42d	1.84	1.9	1.85	1.91	1.88	1.86	1.93	0.06

[1]P of the model < 0.0002; [2]P of the model: 0.052; [3]P of the model: 0.085

Table 8. Influence of alternative protein sources on dressing percentage, breast muscle percentage and leg quarter percentage of broiler chickens.

Parameter	CTR	RP		RFb		RL		SEM
		100	50	100	50	100	50	
Dressing	79.1	80.9	81	79.3	81.4	82.3	81.8	1.35
Breast	19.6	19.2	19.4	19.6	20.8	18.8	19.3	0.55
Leg quarter	27.1	26.8	26.7	24.9	26.7	27.3	26.2	0.90

[1]P of the model < 0.0002; [2]P of the model: 0.052; [3]P of the model: 0.085

Table 9. Some blood parameters from broilers eating diets with different protein sources.

Parameter		CTR	RP		RFb		RL		SEM
			100	50	100	50	100	50	
Urea	mmol/L	0.66^{bc}	0.55^{a}	0.59^{ab}	0.75^{c}	0.63^{ab}	0.67^{bc}	0.67^{bc}	0.03
[1]Total protein	g/L	27.97	26.94	26.91	25.97	27.87	25.05	27.86	0.87
[1]Bilirubin	mmol/L	6.94	8.98	9.32	7.84	10.06	12.90	8.18	1.93
[1]Albumin	g/L	13.58	13.74	13.34	13.14	13.58	13.74	14.28	0.38
[2]A/G		0.96^{a}	1.07^{a}	1.02^{a}	1.04^{a}	0.95^{a}	1.31^{b}	1.07^{a}	0.08
Aspartate amino transferase	U/L	299.62	269.56	261.06	285.36	261.02	248.66	285.62	22.51
[1]Alanine aminotransferase	"	4.51	5.94	5.54	5.64	5.21	5.74	5.01	0.45
Gamma-Glutamyltransferase	"	42.51^{a}	42.04^{a}	44.04^{ab}	38.54^{a}	42.01^{a}	50.74^{b}	44.71^{b}	2.64

[1]P of the model: > 0.05
[2]Albumin to globulin ratio

1991) or 5% to 30% of Lupin (Gualtieri and Rapaccini, 1990). However, the latter observed a reduced performance of broilers fed the 30% Lupin diet, particularly within the first three weeks of growth, yielding a 1.7% reduction of the dressing percentage compared to the control group.

Plasma analysis parameters are reported in Table 9. The urea levels were similar among treatments except the RP50 diet ($P < 0.05$). The urea plasma concentration is a crude estimate of the glomerular filtration rate (renal activity). Normal values indicate that at least one-third of renal mass is functional. Although differences among treatments were observed concerning indicators of the liver activity, parameters values were always within the normal range (Table 9).

Conclusions

The RL, at the lower level of inclusion, and the RFb could be valuable alternative protein sources in broiler diet when used over a six weeks period of growth. The higher level of inclusion should be avoided during the first three weeks of growth where birds might be more sensitive to limiting amino acids.

Considering the growing concern in Europe about using genetically modified soybean in animal feeding and the need of replacing proteins from meat and bone meal, the implement of RL and RFb into broilers diets could be an interesting alternative to soybean meal.

Work supported by the ALBIO project Safe feeds for improving animal welfare and food from animal products (D.M. MiPAF n. 441/7303/01)

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