LUPINS (Lupinus albus var.Ulta) REPLACE A PART OF SOYBEAN MEAL IN DIETS FOR GROWING CHICKENS

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SUMMARY

The gain in body weight of broilers fed diets containing up to 30% sweet raw lupins or 35% autoclaved lupins was not significantly different from that of broilers fed a corn-soybean meal diet. Lupin hulls did not appear to be deleterious for broilers.

INTRODUCTION

The main source of plant protein in poultry diets is soybean meal and the main suppliers are the U.S.A., Brazil and Argentine. Animal nutritionists are interested in alternative sources of plant protein from legumes which may be cultivated under more diverse conditions. Lupins could fill that role. Lupins have been cultivated in some Mediterranean countries and in some highlands of the Americas as a minor legume for food since ancient times. The commonly grown species (albus, L. angustifolius, L. luteus in Mediterranian region and L. mutabilis in Americas) have high crude protein (CP) content but may also contain alkaloids like lupanine and 13-hydroxyl upanine which impart a bitter taste. The alkaloid content may be 0.5 to 2% in bitter varieties (Gladstones, 1982). The alkaloids reduce the palatability of lupin-containing diets. The alkaloid content can be reduced by soaking and boiling the seeds in water for a long time and discarding the water (Johnson et al,, 1986.). However, plant breeders have developed sweet lupins with alkaloid content as low as 0.01% (Ruiz, 1976; Gladstone, 1982).

Satisfactory broiler growth was obtained by incorporating lupin meal from Uniwhite, a sweet variety of L. augustifolius in diets at levels of 15% (Smetana and Morris, 1972). A diet containing 24% lupin meal supported as good a growth of broilers as their wheat-safflower meal control diet (Yule and McBride, 1976). Bitter or sweet lupins were fed at levels of 40% in broiler diets and the broilers reached a body weight of 1.886 kg and 1.215 kg as compared to a weight of 2.046 kg on a corn-soybean diet (Guillaume et al., 1979). Erickson (1985) reported depressed daily gains in broilers by adding 10%, 20%, and 30% ground lupins to replace corn in their diets.

Autoclaving of lupin (L. albus var. multulupa) for 30 minutes at 120^{0} significantly improved the growth of broilers as compared to raw lupins. Lupins were used at levels of 6.4% and 12.8% to replace 20% and 40% protein from soybeans in broiler diets (Molina et al., 1983).

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Watkins et al. (1987) fed raw, autoclaved or extruded lupins (L. albus cv Ultra) in broiler diets and observed that growth and feed conversion of chicks fed more than 10% lupins were inferior to controls fed no lupins. However, chicks fed 10% extruded lupins were significantly heavier than the controls. The diet had to be supplemented with methionine and lysine.

Galactan content is high in lupin hulls but it is doubtful that they act as toxicants for chickens (Carre and Leclercq, 1985).

Halvorson et al. (1983) determined the true metabolizable energy (TME) of lupins for turkeys as 2.64 kcal/g. A value of 2.2 kcal TME/g was found for adult male chickens (Watkins et al., 1987).

Halvorson et al. (1983) observed no depression in growth of turkeys at 3 weeksofage when fed lupins (L. albus) at a level of 15% in a diet supplemented with lysine and methionine.

We have further studied lupins (L. albus var Ultra) for their usefulness in supporting the growth of chickens.

METHODS AND MATERIALS

Lupins grown in California were supplied by Mr. T.E. Kearney of the Coop. Extension of the University of California, Davis. The seeds were dissected and the hulls were separated manually to obtain endosperm for analysis. The proximate analyses of the ground lupins was carried out acording to AOAC (1975). Acid detergent fiber (ADF), neutral detergent fiber (NDF), cellulose and lignin were determined by the procedure of Goering and Van Soest(1975). Coarsely ground lupins were autoclaved for 15 minutes-at 121°C. During grinding, lupins tend to plug up fine screens. Amino acid profiles of a sample were determined after acid hydrolysis by ion-exchange chromatography.

Broiler (Hubbard) chicks (Experiments 1 and 2), and New Hampshire chicks (Experiment 3) were purchase from A and M Hatchery, Santa Rosa, CA. They were banded, weighed and distributed into groups of approximately an equal weight. The birds were housed in electrically heated battery cages. Water and feed were available all the time. The conventional system of management for this age of chickens were followed. The composition of the diets (or feeds) is given in Tables 4, 6, and 8. Each diet was fed to duplicate group of birds housed randomly in the battery. The individual body weights of birds and the group diet intakes were recorded two times each week. There is a waste of diet initially and this is the reason for not recording diet intakes from day one. The feed intake over the last 3 days of the Experiments 1 and 2 was measured, and the corresponding excreta were collected for AME determination. The birds were killed by cervical dislocation and liver and pancreas were collected and weighed.

The data on gain in body weight, feed intake/gain in body weight, and on liver or pancreas weights as % of body weight were subjected to analysis of variance to determine any significant differences. Least significant difference (LSD) values were calculated where applicable.

RESULTS AND DISCUSSION

The proximate composition of lupins and the endosperm is given in Table 1.

Table 1. Proximate composition of lupins

	DM %	CP %	EE %	CF %	Ash %	NFE %	Ca %	P %
Whole seed	90.53	33.32	8.71	13.53	3.84	31.13	0.21	0.52
Endosperm	92.38	44.10	10.36	1.90	4.18	31.84	0.13	0.64

The analysis of the carbohydrate complex is given in Table 2. The endosperm has much lower levels of NDF, ADF and cellulose which are mostly concentrated in the hulls. Pectic substances like galactans are solublized and lost during NDF measurements.

Table 2. Carbohydrate and lignin content of lupins

	NDF %	ADF %	Cellu-lose, %	Lignin %	AME kcal/g
Whole seed	19.96	15.85	13.55	2.47	2.20*
Endosperm	8.8	7.21	4.45	3.03	

* Determined by a fast method using non-starved roosters.

The amino acid profile (Table 3) indicates that lupin protein has a lower concentration of the amino acids isoleucine, lysine, methionine, phenylal anine and valine than the soybean protein. Cystine and arginine are more abundant in lupins than in soybeans. However, cystine only spares methionine but doe not replace it. For this reason, diets containing lupins need to be supplemented with methionine and lysine.

Table 3. Amino acid profile of lupins and soybeans (g/16g N)

Amino acid	Lupins	Soybean	Amino acid	Lupins	Soybean
Alanine	3.5		Leucine	7.2	7.85
Aspartic acid	10.1		Lysine	4.5	6.54
Arginine	10.6	7.97	Methionine	0.6	0.96
Cystine	1.2	0.58	Phenylalanine	3.6	5.11
Glutamic acid	20.3		Proline	3.6	
Glycine	3.9	3.92	Tyrosine	3.6	3.69
Histidine	2.3	2.50	Threonine	4.0	3.92
Isoleucine	3.0	5.47	Valine	3.3	5.23
Serine	5.1	6.3			

The diet in Experiment 1 was formulated to test the maximum incorporation of raw lupin meal in diets for broiler chicks. A value of 2.4 kcal AME/g for lupins was used as diets were formulated before AME has been determined. The composition of the diet is given in Table 4.

A corn-soybean meal diet served as control and the test diets contained 10%, 20%, 30% or 35% raw lupins.

Table 4. Composition of the control and lupin diets (Expt. 1)

Ingredient	Diet				
	Control	L-10	L-20	L-30	L-35
	g/kg				
Corn	571.0	532.7	464.5	429.2	392.7
Soybean meal (48% CP)	274.4	177.6	177.6	74.7	50.0
Lupins	-	100.0	200.0	300.0	350.0
Corn gluten	75.1	106.1	49.7	85.2	84.8
Soybean oil	33.0	34.0	57.7	57.2	63.0
DL-Methionine	1.1	0.8	1.6	1.6	1.7
Lysine	1.4	2.9	1.9	3.2	8.4
$CaHPO_4.2H_2O$	24.0	27.1	29.7	32.8	34.2
$CaCO_3$	10.0	8.8	7.2	6.0	5.3
Vitamin premix	5.0	5.0	5.0	5.0	5.0
NaCl	5.0	5.0	5.0	5.0	5.0
AME, kcal/g*	3.26	3.19	3.27	3.29	3.28
Calculated					
CP, %	23.0	23.11	22.27	22.48	22.56
Lysine, %	1.2	1.18	1.14	1.12	1.55
Met + Cys, %	0.93	0.91	0.89	0.86	0.84

* Determined values.

No significant difference ($P<0.05$) in gain in body weight of broilers was observed over a 21 day period when they were fed either the control diet or diets containing 10%, 20% or 30% raw lupins (Table 5). A level of 35% raw lupins significantly depressed the gain in body weights. Feed efficiency was poorest if the diets contained 30% or 35% lupins. Raw lupins can be safely used up to a level of 30% in broiler diets.

Table 5. Gain in body weight and feed efficiency of broilers fed raw lupin diets in Experiment 1

Diet	Gain in body weight over		Feed/gain over 4 to 21 days	Mortality out of 14 birds
	21 days	4 to 21 days		
	g	g		
Control	492.0	444.8	1.30	1
L-10	492.3	454.6	1.41	0
L-20	490.3	453.9	1.38	0
L-30	439.3	401.1	1.51	0
L-35	343.9	305.9	1.66	0
LSD ($P<0.05$)	80.7		0.09	

The effect of autoclaving of lupins was studied in Experiment 2 using the diets of the composition given in Table 6.

Table 6. Composition of the control and lupin diets (Expt. 2)

Ingredient, g/kg	Diets				
	Control	L-20	L-30 Auto.	L-30 Raw	L-35
Corn	500.0	410.7	384.7	384.7	349.7
Soybean meal (48% CP)	400.0	300.0	224.5	224.5	200.0
Lupins	-	200.0	300.0	300.0	350.0
Soybean oil	40.0	40.0	41.0	41.0	50.0
$CaHPO_4.2H_2O$	22.0	22.0	22	22.0	22.0
$CaCO_3$	10.0	10.0	10.0	10.0	10.0
NaCl	5.0	5.0	5.0	5.0	5.0
DL-Methionine	2.0	2.0	2.5	2.5	3.0
Vitamin premix	10.0	10.0	10.0	10.0	10.0
$MnSO_4.H_2O$	0.2	0.2	0.2	0.2	0.2
ZnO	0.1	0.1	0.1	0.1	0.1
Sand	10.7	-	-	-	-
AME, kcal/g*	3.07	2.84	2.93	2.83	2.95
Calculated					
CP, %	23.7	24.7	24.1	24.1	24.2
Lysine, %	1.39	1.33	1.22	1.22	1.20
Met + Cys, %	0.96	0.91	0.90	0.90	0.94

* Determined values.

No significant difference was observed in the gain in body weight or feed efficiency of broilers fed either raw lupins at a level of 30% or autoclaved lupins at levels of 20%, 30% or 35% (Table 7). Autoclaving of lupins appears to improve their nutritional value.

Table 7. Gain in body weight of broiler chicks fed lupin diets and their feed eficiency

Diet	Gain in body weight over days		Feed/gain over	Mortality out of 12	Wt. as % of body wt.	
	24	11-21	11-21	birds	Liver	Pancreas
	g	g	days			
Control	528.8*	385.2	1.82*	0	2.90*	0.38*
L-20, auto.	533.6	370.4	1.92	2	2.57	0.33
L-30, auto.	527.4	359.2	1.94	1	2.91	0.33
L-30, raw	528.8	319.5	2.08	0	3.06	0.35
L-35, auto.	480.0	355.3	1.91	0	2.67	0.30

* Differences were nonsignificant ($P<0.05$) in a column.

Lupins contain a high level of galactans in the hulls which can be hydrolyzed with the enzyme hemicellulase. If galactans caused any growth depressi on, it should be overcome by suplementing the lupin diets with hemicellulase. This hypothesis was tested in Experiment 3 using diets of the composition given in Table 8. Both raw and autoclaved lupins were tested at a level of 65% in the diet.

Table 8. Composition of the diets to test the role of lupin hulls on the growth of chickens

Ingredient	Control	Control + E	Diet g/kg L-65	L-65 + E
Corn	500.0	490.0	204.2	194.2
Soybean meal, 48% CP	400.0	400.0	-	-
Lupins, autoclaved	-	-	650.0	650.0
Soybean oil	40.0	40.0	91.0	91.0
$CaHPO_4.2H_2O$	22.0	22.0	22.0	22.0
$CaCO_3$	10.0	10.0	10.0	10.0
Vitamin premix	10.0	10.0	10.0	10.0
Hemicellulase (E)	-	10.0	-	10.0
$MnSO_4.H_2O$	0.2	0.2	0.2	0.2
ZnO	0.1	0.1	0.1	0.1
NaCl	5.0	5.0	5.0	5.0
DL-Methionine	2.0	2.0	2.0	2.0
Sand	10.7	-	-	-
Calculated				
AME, kcal/g	3.06	3.07	2.99	3.00
CP,%	23.7	23.6	23.1	23.0
Lysine, %	1.39	1.38	1.21	1.21
Met + Cys	0.96	0.96	0.93	0.93

A level of 1% hemicellulase did not significantly improve the gain in body weights of the birds fed the control diet (Table 9). A level of 65% raw or autoclaved lupins significantly reduced the gain in body weight of New Hampshire chickens which was not overcome by the addition of hemicellulase enzyme. This suggests that galactans in hulls do not have any growth depressing effect confirming the observtion of Carre and Leclercq (1985).

Table 9. Gain in body weight (g), liver and pancreas weights of chickens fed raw and autoclaved (auto.) lupins diets with and without hemicellulase (E)

Diet	Weight gain over 33 days	14-33 days	F/G 14-33 days	Mort. out of 12	As % of Liver	Body wt. Pancreas
Control	380.6	295.1	1.94	0	2.6	0.33
Control + E	367.2	286.1	1.89	1	2.6	0.31
L-65, raw	286.9	233.1	2.10	0	3.0	0.29
L-65, raw + E	301.2	244.6	2.11	0	2.5	0.30
L-65, auto.	300.9	242.7	2.06	1	2.7	0.26
L-65, auto. + E	328.7	267	1.97	0	3.0	0.27
LSD ($P<0.05$)	58.6		0.07			

F/G = Feed/Gain; Mort. = mortality.

It may be concluded that raw lupins can be incorporated in broiler diets up to levels of 30% and after autoclaving, the level may be increased to 35%. Lupin hulls do not appear to be involved in growth dpression of chickens. Liver and pancreas weights were not significantly increased on various dietary treatments implying a lack of toxicants in sweet (low alkaloid) lupins.

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