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EVALUATION OF DIFFERENT PROCESSING METHODS OF VELVET BEAN (*Mucuna pruriens*) FOR USE AS A FEED INGREDIENT FOR BROILERS

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SUMMARY

Velvet beans (*Mucuna pruriens*) (VB) are valuable in subsistence and sustainable agriculture but the very limited scientific literature indicates that they are toxic when fed to poultry in commercial-type rations. Our earlier work has indicated that incorporation of VB in broiler diets at low levels (10%) gave similar performance as the control diet. This study explored whether higher amounts of VB (20%) can be included in broiler diets if further processing is used. The first experiment focused on the impact of various VB processing methods on broilers grown through 42 d of age. The treatments were the control (corn-soybean based-diet) and five VB diets at 20% (1. raw and ground, 2. roasted whole and ground, 3. ground and roasted, 4. soaked 24 h, roasted and ground, and 5. soaked 24 h, heat dried and ground. Broiler body weights and feed intake were lower ($P<0.001$) for all the experimental diets that contained processed VB and little or no impact of VB processing no broiler performance was noted. Feed conversion rates were often not superior ($P<0.001$) for the control diet and except for the first week, no significant differences were observed for mortality. Pre-chill carcass weights differed among the treatments ($P<0.001$) and the weights with VB flour were 50.8-62.1% of those with control feed. Percentage carcass yield was not affected by treatment.

The second experiment focused on the supplementation of diets containing roasted VB with methionine and/or lysine as possible mechanisms to alleviate the negative effects of the anti-nutritional factors. No impact of methionine and/or lysine supplementation was found in any of the variables. For all VB diets, including the unsupplemented, roasted VB treatment similar to a treatment in Experiment 1, broiler body weights and feed intake were higher than in the Experiment 1. Differences in the results between Experiment 1 and 2 may be related to different initial content of anti-nutritional factors in the VB flour or factors related to experimental design. Content of L-Dopa in all VB flour utilized in Experiment 1 was high. More studies are needed to determine the presence of possible secondary anti-nutritional factors, as well as to examine the amino acid content of the VB and to find other processing methods.

Key words: Broiler feed, *Mucuna*, anti-nutrient, L-Dopa.

INTRODUCTION

Velvet beans (*Mucuna spp.*) were once a widely grown legume in the U.S. before being replaced by soybeans. Up to 1.5 million hectares were planted in the late 1910s (Coe, 1918). In developing countries such as Honduras, the velvet bean plant is increasingly being used as a cover crop and is usually intercropped with corn (Buckles, 1995). It is valuable in subsistence and sustainable agriculture because it is hardy, resistant to insects and drought, can be managed with minimal care, and improves soil fertility through nitrogen fixation. The foliage can be fed to ruminants or can be grazed. The velvet bean is prolific in seed production and velvet bean seeds (VB) are sometimes eaten both by humans and by non-ruminants animals such as pigs and chickens.

The very limited scientific literature indicates that VB are toxic when fed to poultry in commercial-type rations, causing reductions in growth, feed intake and egg production, as well as increased mortality (Harms *et al.*, 1961; Carew *et al.*, 2002). However, a study reported that autoclaving VB prior to consumption improves the growth of young chicks (under 454 g) to equal that of chicks who consumed roasted soybeans as the protein source; feed intake, however, was still low (Olaboro *et al.*, 1991).

Many anti-nutritional and potentially toxic factors are found in VB. Among them are antitrypsin factors, tannins and cyanide (Ravindran and Ravindran, 1988), anticoagulants (Houghton and Skari, 1994), analgesic, antipyretic and anti-inflammatory factors (Iauk *et al*., 1993) and others (Olaboro *et al.,* 1991). L-Dopa, a compound with neurological impacts, is also found in relatively large amounts (Bell and Janzen, 1971; Daxenbichler *et al*., 1971).

Toxic and anti-nutritional factors in feed ingredients may be destroyed by heat (Olaboro *et al.,* 1991); the well-known value of heating soybean meal is an example of this. In our earlier work we found that roasted VB, incorporated in broiler diets at low levels (10%), gave similar performance as the control diet (del Carmen *et al*., 2002). To explore whether higher amounts of VB (20%) can be included in broiler diets if further processing is used, the first study reported here was designed to determine the effect of various VB processing methods on the nutritional value of nutritionally balanced corn-soybean-VB diets for broilers grown through 42 d of age. A second study focused on supplementation of diets containing roasted VB with methionine and/or lysine as possible mechanisms to alleviate the negative effects of the anti-nutritional factors contained in VB.

MATERIALS AND METHODS

Experiment 1.

Treatments

Dried VB (*Mucuna pruriens*) were obtained locally in Honduras where these experiments were conducted at the Poultry Teaching and Research Unit at the Escuela Agricola Panamericana. The different treatments consisted of a corn-soybean based control diet (Treatment 1) and five VB diets. In all VB diets, inclusion level was 20%. Grinding was done in a hammer mill using a screen with 3/16" openings. The five VB treatments were: Treatment 2: raw and ground, Treatment 3: roasted whole and ground, Treatment 4: ground and roasted, Treatment 5: soaked 24 h (68 kg of bean in 135 L of water), roasted and ground, and Treatment 6: soaked (24 h), heat dried at 35°C for 3d and ground. Roasting was done in a gas-heated, hand-cranked, metal cylinder for 30 min at 130^{o} C. Analytical values (proximate analyses, amino acids, minerals and L-Dopa) shown for the different processing methods of VB (Table 1) were used to balance the experimental diets. A total metabolizable energy (TME) value of 2,370 kcal kg^{-1} was determined for the raw VB using the method of Sibbald (1976). L-Dopa was measured by HPLC of boiling water extracts of ground VB (Myhrman, 2002).

Experimental procedure

Day-old Arbor Acres® x Arbor Acres® straight-run chicks were used. The birds were housed in 2 x 3 m experimental floor pens in an open-sided, naturally ventilated house. Shavings were used for bedding and 24 h of light per day were used. Each pen was heated by a gas brooder and provided with a bell waterer and tube feeder. Feed and water were given *ad libitum*.

Starter, grower and finisher rations were formulated for use during 0-21, 22-35 and 36-42 days of age, respectively (Table 2, 3 and 4). The 20% VB substitution into the control diet was made using linear programming. Within each age period, all diets were kept iso-nitrogenous and iso-caloric. The chicks were divided into 24 pens of 72 each at a density of 12.0 birds per square meter. Four pens were assigned to each of the six treatments. Broilers and feed intake were weighed weekly and the birds were observed daily for mortality and unusual behavior. Body weight, feed consumption, feed conversion ratio, and mortality were determined for each pen on a weekly basis. Pre-chill carcass weights and carcass yield were determined for 25% of the population of each pen after feathers, head, neck, legs and internal organs were removed at processing.

A randomized complete block design with two replications was used in the study. Data from the two replications were pooled and analyzed using the General Linear Models (GLM) procedure of SAS® (SAS Institute, 1991) and the Student-Newman-Keuls test ($P < 0.05$).

Experiment 2.

Treatments

Dried VB (*Mucuna pruriens*) were obtained locally in Honduras where these experiments were conducted. As in Experiment 1, the control diet was based on corn and soybean, and VB substitution was at a 20% level. The roasting procedure was done as in Experiment 1. Methionine and lysine supplementations were done at a level that was 50% above the levels established by National Research Council (NRC) Poultry Nutrients Requirement Handbook (1994). The diets were: 1. Control, 2. Roasted VB, 3. Roasted VB with methionine, 4. Roasted VB with lysine, and 5. Roasted VB with methionine and lysine. Analytical values shown for the VB (Table 1) were used to balance the experimental diets. A true metabolizable energy (TME) value of 2370 kcal kg^{-1} was determined for the raw VB using the method of Sibbald (1976). L-Dopa was measured by HPLC using boiling water extracts of ground VB (Myhrman, 2002).

Table 1. Composition of velvet bean flour processed in different ways.

Component	VB1	VB2	VB3	VB4	VB5
	- - - - - - - -	- - - - - - - -	(%)	- - - - - - - -	- - - - - - - -
Dry matter[1]	89.80	91.10	91.60	90.50	88.00
Ash[1]	3.20	3.50	3.60	3.30	3.20
Crude protein[1]	22.70	23.70	24.00	24.50	24.20
Ether extract[1]	3.40	3.90	3.90	4.30	3.60
Crude fiber[1]	13.60	14.50	12.90	15.00	13.30
Amino acids[1]					
Aspartic acid	2.58	3.05	2.80	2.78	2.78
Threonine	0.86	0.91	0.91	0.93	0.92
Serine	0.90	0.98	0.96	0.98	1.00
Glutamic acid	2.59	3.03	2.87	2.86	2.81
Glycine	1.01	1.14	1.08	1.08	1.07
Alanine	0.82	0.93	0.89	0.90	0.87
Cistine	0.42	0.45	0.45	0.44	0.43
Valine	1.16	1.45	1.26	1.26	1.25
Methionine	0.36	0.41	0.40	0.40	0.37
Isoleucine	1.06	1.29	1.18	1.18	1.16
Leucine	1.54	1.81	1.69	1.71	1.69
Tyrosine	0.96	1.40	1.03	1.05	1.05
Proline	1.36	1.45	1.42	1.38	1.40
Phenylalanine	1.02	1.20	1.11	1.12	1.11
Lisien	1.49	1.22	1.63	1.61	1.61
Histidina	0.54	0.62	0.59	0.59	0.58
Tryptophane	0.15	0.25	0.14	0.16	0.15
Arginine	1.65	1.97	1.81	1.82	1.82
L-Dopa (%)[2]	5.52	5.44	5.51	4.92	5.37
	- - - - - - - -	- - - - - - - -	(ppm)	- - - - - - - -	- - - - - - - -
P[1]	4447	4193	4496	4521	4233
K[1]	14251	11370	11248	11020	10486
Ca[1]	1036	968	1239	969	1318
S[1]	1445	1510	1721	1623	1617
Fe[1]	71.9	86.5	110	82.8	73.1

VB1= Raw, VB2= Roasted and ground, VB3= Ground and roasted, VB4= Soaked, roasted, and ground, VB5= Soaked, heat dried, and ground.

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Table 2. Starter phase (0-21 d) diets in Experiment 1.

Ingredients and analytical results	T1	T2	T3	T4	T5	T6
	(%)					
Ingredients:						
Corn	50.50	34.50	35.00	35.50	36.00	36.00
Soybean meal (48 % CP)	41.00	34.00	33.50	33.30	33.00	33.00
Velvet bean	0.00	20.00	20.00	20.00	20.00	20.00
Vegetable oil	4.50	7.50	7.50	7.50	7.50	7.50
Dicalcium monophosphate	1.10	1.10	1.15	1.15	1.15	1.15
Calcium carbonate	1.75	1.75	1.75	1.75	1.75	1.75
Premixes (vitamin + mineral)	0.30	0.30	0.30	0.30	0.30	0.30
SALT (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30
Oxytetracycline®	0.01	0.01	0.01	0.01	0.01	0.01
Sacox®	0.02	0.02	0.02	0.02	0.02	0.02
DL-Methionine	0.12	0.13	0.12	0.12	0.12	0.13
Analytical results:						
Crude protein	23.00	23.00	23.00	23.00	23.00	23.00
ME kcal kg^{-1}	3100.00	3100.00	3100.00	3100.00	3100.00	3100.00
Available P	0.38	0.30	0.30	0.30	0.30	0.30
Ca	0.90	0.90	0.90	0.90	0.90	0.90
Methionine	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	1.42	1.46	1.41	1.47	1.45	1.46

T1= Control, T2=Raw, T3= Roasted and ground, T4= Ground and roasted, T5= Soaked, roasted, and ground, T6= Soaked, heat dried, and ground.

Experimental procedure

The experiment was conducted with broilers from 1 to 21 d of age. Arbor Acres® x Arbor Acres® male chicks were used in the study. The birds were housed in two five-tier experimental battery brooders with individual pen dimensions of 1.18 x 0.93 m. Each individual pen was heated by a gas brooder and provided with a trough waterer and feeders. Feed and water were given freely. Starter ration was formulated for use during 0-21 d of age (Table 5). The chicks were divided into 5 pens of 20 birds each in both battery brooders. Five pens were assigned to each of five treatments that were previously mentioned. VB substitution, diet formulation, and data collection was as in Experiment 1. A randomized complete block design was used in the study. Three replications were conducted using the same experimental procedures. Data were pooled and analyzed as in Experiment 1.

Table 3. Grower phase (22-35 d) diets in Experiment 1.

Ingredients and analytical results	T1	T2	T3	T4	T5	T6
	(%)					
Ingredients:						
Corn	59.70	43.80	44.42	44.64	44.92	36.00
Soybean meal (48 % CP)	30.92	23.82	23.28	23.11	22.84	33.00
Velvet bean	0.00	20.00	20.00	20.00	20.00	20.00
Vegetable oil	5.76	8.77	8.68	8.73	8.60	7.50
Dicalcium monophosphate	1.13	1.13	1.16	1.16	1.16	1.15
Calcium carbonate	1.70	1.69	1.69	1.67	1.69	1.75
Premixes (vitamin + mineral)	0.30	0.30	0.30	0.30	0.30	0.30
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30
Oxytetracycline®	0.01	0.01	0.01	0.01	0.01	0.01
Sacox®	0.02	0.02	0.02	0.02	0.02	0.02
DL-Methionine	0.16	0.16	0.16	0.16	0.16	0.13
Analytical results:						
Crude protein	19.00	19.00	19.00	19.00	19.00	19.00
ME (kcal kg^{-1})	3250.00	3250.00	3250.00	3250.00	3250.00	3250.00
Available P	0.34	0.26	0.26	0.26	0.25	0.26
Ca	0.85	0.85	0.85	0.85	0.85	0.85
Methionine	0.48	0.48	0.48	0.48	0.48	0.48
Lysine	1.12	1.15	1.10	1.16	1.15	1.15

T1= Control, T2=Raw, T3= Roasted and ground, T4= Ground and roasted, T5= Soaked, roasted, and ground, T6= Soaked, heat dried, and ground.

Table 4. Finisher phase (36-42 d) diets in Experiment 1.

Ingredients and analytical results	T1	T2	T3	T4	T5	T6
	(%)					
Ingredients:						
Corn	59.70	43.80	44.42	44.64	44.92	36.00
Soybean meal (48 % CP)	30.92	23.82	23.28	23.11	22.84	33.00
Velvet bean	0.00	20.00	20.00	20.00	20.00	20.00
Vegetable oil	5.76	8.77	8.68	8.63	8.60	7.50
Dicalcium monophosphate	1.13	1.13	1.16	1.16	1.16	1.15
Calcium carbonate	1.70	1.69	1.69	1.67	1.69	1.75
Premixes (vitamin + mineral)	0.30	0.30	0.30	0.30	0.30	0.30
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30
Oxytetracycline®	0.01	0.01	0.01	0.01	0.01	0.01
Sacox®	0.02	0.02	0.02	0.02	0.02	0.02
DL-Methionine	0.16	0.16	0.16	0.16	0.16	0.13
Analytical results:						
Crude protein	19.00	19.00	19.00	19.00	19.00	19.00
ME (kcal kg^{-1})	3250.00	3250.00	3250.00	3250.00	3250.00	3250.00
Available P	0.34	0.26	0.26	0.26	0.25	0.26
Ca	0.85	0.85	0.85	0.85	0.85	0.85
Methionine	0.48	0.48	0.48	0.48	0.48	0.48
Lysine	1.12	1.15	1.10	1.16	1.15	1.15

T1= Control, T2=Raw, T3= Roasted and ground, T4= Ground and roasted, T5= Soaked, roasted, and ground, T6= Soaked, heat dried, and ground.

Table 5. Starter phase (1-21 d) diets in Experiment 2.

	T1	T2	T3	T4	T5
Ingredients:	- - - - - - - -	- - - - - - - - -	(%) - - - - - -	- - - - - - -	- - - - - - - -
Corn	51.0	35.5	35.00	35.00	34.00
Soybean meal (48 % CP)	40.0	33.0	33.50	33.50	34.00
Velvet bean	0.0	20.0	20.0	20.0	20.0
Dicalcium monophosphate	1.15	1.15	1.15	1.15	1.15
Calcium Carbonate	1.75	1.75	1.75	1.75	1.75
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30
Premixes (vitamin + mineral)[1]	0.30	0.30	0.30	0.30	0.30
Vegetable oil	4.50	7.50	7.50	7.50	8.00
Oxytetracycline®	0.06	0.06	0.06	0.06	0.06
DL-Methionine	0.12	0.13	0.38	0.13	0.38
L-Lysine	0.00	0.00	0.00	0.37	0.37
Analytical results:					
ME (kcal kg^{-1})	3,100	3,100	3,100	3,100	3,100
Crude protein	23.00	23.00	23.00	23.00	23.00
Ca	1.00	1.00	1.00	1.00	1.00
Available P	0.50	0.50	0.50	0.50	0.50
Lysine	1.20	1.20	1.20	1.80	1.80
Methionine	0.50	0.50	0.75	0.50	0.75

T1= Control, T2= Roasted VB, T3= Roasted VB and methionine, T4= Roasted VB and lysine, and T5= Roasted VB and methionine and lysine.

RESULTS

Experiment 1.

Throughout the entire growth period, body weights were lower (P<0.001) for all the experimental diets that contained processed VB (Table 6). Remarkably, raw and processed VB flour often resulted in a similar performance. At the end of the experimental period, broiler body weights with feeds containing VB were only 53.5-61.9% of those with the control diet, and the diets with VB did not differ among each other. A decrease in weekly feed consumption (P<0.001) was observed for all diets containing VB but commonly, feed intake was higher with feeds containing VB that had been soaked or that had been ground before roasting (Table 7). As with body weights, differences among treatments containing VB were remarkably small. Feed conversion rates were often not superior (P<0.001) for the control diet (Table 8). Except for the first week, no significant differences were observed for mortality (Table 9) between the treatments. Mortality was erratic, with a high coefficient of variation (CV=67.26%). During the first week, group consuming soaked, roasted, and ground VB had the highest mortality, and the group consuming roasted and ground VB had no mortality. There were differences in pre-chill carcass weights among the treatments (P<0.001) and the weights among the groups consuming VB flour were only 50.8-62.1% of those found for the groups consuming the control feed (Table 10). However, % carcass yield was not affected by treatment.

Table 6. Effect of different processing methods of velvet bean on broiler body weights in Experiment 1.

Days of age	T1	T2	T3	T4	T5	T6
			(g)			
7	124.9^{a}	87.0^{d}	98.4^{b}	90.8^{cd}	92.7^{bcd}	94.6^{bc}
14	278.1^{a}	162.7^{b}	168.4^{b}	168.4^{b}	170.3^{b}	170.3^{b}
21	557.5^{a}	300.0^{b}	295.9^{b}	323.7^{b}	316.5^{b}	316.5^{b}
28	996.6^{a}	506.9^{d}	525.5^{cd}	566.5^{bc}	583.8^{b}	583.8^{b}
35	1492.4^{a}	757.6^{b}	820.1^{b}	812.5^{b}	825.8^{b}	825.8^{b}
42	2028.4^{a}	1085.2^{b}	1255.7^{b}	1227.3^{b}	1198.9^{b}	1198.9^{b}

CV % = 8.02.
T1= Control, T2=Raw, T3= Roasted and ground , T4= Ground and roasted , T5= Soaked, roasted , and ground, T6= Soaked, heat dried, and ground.
Means within a row with different superscripts are significantly different ($P < 0.001$).

Table 7. Effect of different processing methods of velvet bean on broiler feed consumption during the experimental period in Experiment 1.

Days of age	T1	T2	T3	T4	T5	T6
			(g)			
7	93.1^{a}	69.7^{c}	72.4^{bc}	70.3^{c}	73.1^{bc}	76.3^{b}
14	355.3^{a}	224.9^{b}	232.3^{b}	235.2^{b}	231.1^{b}	250.5^{b}
21	826.6^{a}	530.0^{b}	533.6^{b}	550.3^{b}	550.1^{b}	586.9^{b}
28	1543.4^{a}	979.6^{c}	989.9^{c}	1052.3^{c}	1053.1^{c}	1142.1^{b}
35	2552.4^{a}	1608.2^{c}	1653.9^{c}	1723.5^{bc}	1788.4^{b}	1832.3^{b}
42	3496.3^{a}	2429.8^{c}	2442.5^{c}	2579.4^{bc}	2652.2^{b}	2638.3^{b}

CV % = 3.51.
T1= Control, T2=Raw, T3= Roasted and ground, T4= Ground and roasted , T5= Soaked, roasted , and ground, T6= Soaked, heat dried, and ground.
Means within a row with different superscripts are significantly different ($P < 0.001$).

Table 8. Effect of different processing methods of velvet bean on feed conversion ratio in broilers in Experiment 1.

Days of age	T1	T2	T3	T4	T5	T6
7	0.75^{ab}	0.80^{a}	0.74^{b}	0.77^{ab}	0.79^{ab}	0.81^{a}
14	1.28^{b}	1.39^{ab}	1.38^{b}	1.40^{ab}	1.36^{ab}	1.47^{a}
21	1.48^{b}	1.77^{a}	1.81^{a}	1.70^{a}	1.67^{a}	1.86^{a}
28	1.55^{b}	1.93^{a}	188^{a}	1.86^{a}	1.87^{a}	1.95^{a}
35	1.71^{b}	2.13^{ab}	2.02^{ab}	2.18^{a}	1.99^{ab}	2.22^{a}
42	1.73^{b}	2.26^{a}	2.25^{ab}	2.11^{ab}	2.04^{ab}	2.22^{a}

CV % = 10.07.
T1= Control, T2=Raw, T3= Roasted and ground , T4= Ground and roasted , T5= Soaked, roasted , and ground, T6= Soaked, heat dried, and ground.
Means within a row with different superscripts are significantly different ($P < 0.001$).

Table 9. Effect of different processing methods of velvet bean on broiler mortality in Experiment 1.

Days of age	T1	T2	T3	T4	T5	T6
	(%)					
7	1.37[ab]	1.71[ab]	0.00[b]	0.34[ab]	3.08[a]	2.06[ab]
14	2.05	2.74	1.71	1.37	4.11	3.42
21	2.40	3.08	2.74	1.71	4.80	3.77
28	3.42	3.08	3.08	2.70	5.48	4.11
35	4.45	3.43	3.08	3.43	5.48	4.80
42	4.80	3.77	3.77	4.45	5.82	5.14

CV % = 67.26.
T1= Control, T2=Raw, T3= Roasted and ground , T4= Ground and roasted , T5= Soaked, roasted , and ground, T6= Soaked, heat dried, and ground.
[ab]Means within a row with different superscripts are significantly different ($P < 0.05$).

Table 10. Effect of different processing methods of velvet bean on carcass weight and yield in Experiment 1.

Variable	T1	T2	T3	T4	T5	T6
Carcass weight (g)[1]	1409.1[a]	715.9[b]	840.9[b]	812.5[b]	875.0[b]	795.5[b]
Carcass yield (%)[2]	69.4	65.9	67.0	66.2	67.0	66.4

[1]CV %.= 9.35; [2]CV %.= 2.02.
T1= Control, T2=Raw, T3= Roasted and ground , T4= Ground and roasted , T5= Soaked, roasted , and ground, T6= Soaked, heat dried, and ground.
Means within a row with different superscripts are significantly different ($P < 0.001$).

Experiment 2.

No significant differences were found for body weight (Table 11), feed consumption (Table 12), feed conversion ratio (Table 13), and mortality (Table 14) between any of the treatments during the three weeks the birds were being fed the experimental diets. For all VB diets, including the unsupplemented, roasted VB treatment (that was similar to T3 in Experiment 1), broiler body weights and feed intake were higher than in the Experiment 1.

Table 11. Effect of roasted velvet bean supplemented with methionine and lysine on broiler body weights in Experiment 2.

Days of age	T1	T2	T3	T4	T5
	(g)				
7	104.9	95.4	100.3	96.8	104.1
14	251.3	225.1	232.8	222.1	243.7
21	465.0	412.3	433.7	400.1	439.3

CV % = 14.21.
T1= Control, T2= Roasted VB, T3= Roasted VB and methionine, T4= Roasted VB and lysine, and T5= Roasted VB and methionine and lysine.

Table 12. Effect of roasted velvet bean supplemented with methionine and lysine on daily broiler feed intake in Experiment 2.

Days of age	T1	T2	T3	T4	T5
	--------------------------------(g)--				
7	105.5	100.3	109.9	106.2	104.2
14	341.0	334.3	366.0	331.0	341.6
21	794.0	750.6	832.3	799.9	864.7

CV %= 18.01.
T1= Control, T2= Roasted VB, T3= Roasted VB and methionine, T4= Roasted VB and lysine, and T5= Roasted VB and methionine and lysine.

Table 13. Effect of roasted velvet bean supplemented with methionine and lysine on broiler feed conversion ratio in Experiment 2.

Days of age	T1	T2	T3	T4	T5
7	1.00	1.05	1.09	1.09	1.00
14	1.35	1.48	1.54	1.49	1.40
21	1.70	1.82	1.91	1.99	1.96

CV %= 21.33.
T1= Control, T2= Roasted VB, T3= Roasted VB and methionine, T4= Roasted VB and lysine, and T5= Roasted VB and methionine and lysine.

Table 14. Effect of roasted velvet bean supplemented with either methionine and or lysine on broiler mortality in Experiment 2.

Days of age	T1	T2	T3	T4	T5
	-------------------------------------(%)-------------------------------------				
7	0.95	1.10	1.10	1.15	1.06
14	1.05	1.34	1.40	1.25	1.14
21	1.22	1.35	1.41	1.47	1.43

CV %= 54.00.
T1= Control, T2= Roasted VB, T3= Roasted VB and methionine, T4= Roasted VB and lysine, and T5= Roasted VB and methionine and lysine.

DISCUSSION

Relatively little difference was found in the nutritional composition of the VB flour processed in different ways (Table 1). Remarkably, very little impact of the different processing methods was found on the content of L-Dopa, which remained high in both the processed (4.92-5.51%) and raw VB flour (5.52%). Even the treatment where VB was first soaked (24 h) and then roasted prior to grounding resulted only in a slight decrease in L-Dopa (to 4.92%).

In Experiment 1, all processing methods containing VB resulted in greatly decreased feed intake, broiler body weight, and carcass weight. The high content of L-Dopa in the VB flour may partly explain the deleterious impact of even the processed VB. In addition, VB constituted 20% of the broiler diets. Earlier, we found that incorporation of roasted VB at 10% level resulted in broiler performance that was similar to that with control diet (del Carmen *et al*., 2002). Clearly, even soaking together with roasting or heat drying did not improve the nutritional quality of VB.

The results of Experiment 2 are contrary to those found in Experiment 1. With all VB diets, starter phase performance was similar to that with the control diet. These results are difficult to explain, and may be related to different initial content of anti-nutritional factors in the flour or factors that had to do with experimental design. No beneficial impact of methionine and lysine was found in this Experiment.

More studies need to be done in order to determine the presence of possible secondary anti-nutritional factors that may interact with L-Dopa to diminish growth performance in broilers. However, more detailed studies of the nutritional contributions of VB based on amino acids may be necessary in order to properly balance the deficiencies of the diets that contain VB. Many factors remain uninvestigated regarding the potential use of VB in animal diets, such as heating conditions, water extraction, nutrient modifications and other processing methods. These factors need to be investigated in much greater detail and further studies of the nutritional and toxic properties of VB could lead to promising results.

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