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Response of broiler chickens to the dietary inclusion of *Chromolaena odorata* leaf meal

A. Donkoh*, C.C. Atuahene, D.M. Anang, E.K. Badu-Botah and K.T. Boakye

Department of Animal Science,
Kwame Nkrumah University of Science and Technology
Kumasi, Ghana

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ABSTRACT

A study was carried out to determine the nutrient composition of the leaf meal of the tropical plant *Chromolaena odorata*, and its value as a feed ingredient and colouring agent in broiler chickens' diets. *Chromolaena odorata* leaf meal (COLM) contained (on dry matter basis) crude protein 218.0 g kg^{-1}, crude fibre 141.0 g kg^{-1}, and metabolizable energy 5.42 MJ kg^{-1}, tannic acid equivalent 143 g kg^{-1}. Two hundred and forty 2-week-old broiler chickens were used in a complete randomised design to evaluate the effect of diets containing varying amounts of COLM (0, 25, 50 and 75 g kg^{-1}) on growth performance and some physiological parameters. The diets were fed *ad libitum* for 6 weeks. The COLM addition had an adverse effect on the performance of broiler chickens by reducing feed intake (r=-0.97), body weight gain (r=-0.99), feed conversion efficiency (r=0.96), water consumption (r=-0.74) and carcass yield (r=-0.98). Mortality rates were, however, unaffected by dietary treatments. Body colour intensity increased with increasing levels of COLM. At dietary levels of 0, 25, 50 and 75 g kg^{-1}, the skin, beak and shank colour scores on Roche colour fan were 0, 4.6, 6.8 and 7.9, respectively. Haematological and blood biochemical indices and spleen, liver, heart, gizzard and intestinal weights were unaffected by the level of inclusion of COLM.

KEY WORDS: *Chromolaena odorata*, chemical analysis, growth performance, broilers

* Corresponding author: Tel.: +233-51-60325, e-mail address: armdonkoh@yahoo.co.uk

INTRODUCTION

There has been much interest over recent years in exploring alternative feedingstuffs for poultry because of rising costs conventional dietary ingredients. There are many crops of great feeding potential which are currently under-exploited. Plant leaf meals are appealing because they often contain considerable amount of protein and other nutrients. *Chromolaena odorata*, formerly known as *Eupatorium odoratum*, is a perennial tropical plant which is currently under-exploited and its possible use as a feed ingredient is being examined in diets for animals. Results of a study conducted (Apori et al., 2000) to evaluate the chemical composition of the dried leaves of *Chromolaena odorata* have been encouraging to warrant further research. Chemical analysis of the leaf fraction of an 8-week-old regrowth indicated a high crude protein (258 g kg^{-1}DM) and low neutral detergent fibre (331 g kg^{-1}DM) contents. The amino acid profile revealed that about 565 g kg^{-1} of the total protein consisted of amino acids. In addition, the dried leaves had low extractable phenolic (hydrolysable tannins, 0.72 g kg^{-1}DM and condensed tannins, 1.40 g kg^{-1}DM) contents. There is however, evidence that dietary tannins, at certain concentrations and regardless of the source, are deleterious to chick growth (Dale et al., 1980). There are no reports in the literature as to the utilization of *Chromolaena odorata* leaf meal as a feed ingredient for poultry.

A pilot trial, has therefore been conducted on the feeding potential of *Chromolaena odorata* leaf meal in relation to poultry.

MATERIAL AND METHODS

Preparation of leaf meal sample

Samples of green leaves were harvested from plants of *Chromolaena odorata* (COLM) which had not flowered. The leaves were air-dried, ground to pass a 100-mesh sieve and stored in polythene sacks until used in formulations.

Chemical analysis

Samples of COLM were analysed for dry matter, protein (N $\times$ 6.25), crude fibre, ether extract and ash (AOAC, 1990) and calcium, phosphorus, potassium and sodium concentrations (Fick et al., 1979). Fibre components were also estimated on the COLM (Goering and van Soest, 1970). The tannin content of COLM was determined using the Folin-Denis reagent as described by the AOAC (1990).

Four 6-week-old broiler chickens were used to determine the nitrogen-corrected true metabolizable (TME_n) content of COLM. Birds were fed *ad libitum* on a broiler finisher diet for 1 week prior to force-feeding (Sibbald, 1986). The birds were individually housed in cages with collection trays, fasted for 24 h and fed 30 g of the test ingredient through crop intubation. Four broilers were kept fasted during the assay to measure endogenous losses. Excreta were quantitively collected daily for 48 h after crop intubation, oven-dried at 60°C for 48 h, equilibrated to ambient conditions, weighed and ground (Dale and Fuller, 1983). Both COLM and feacal samples were analysed for gross energy by bomb calorimetry. ME_n values for the experimental diets were, however, calculated from the values given by the NRC (1994) and the determined TME_n content of COLM. The chemical composition of COLM is presented in Table 1 in comparison with data on wheat bran.

Dietary treatments, experimental animals and management

A control diet, containing no COLM and three other diets containing 25, 50 and 75 g COLM kg^{-1}, in substitution of wheat bran, were prepared (Table 2).

TABLE 1

Chemical composition of *Chromolaena odorata* leaf meal[a] and wheat bran, g kg^{-1} DM (except ME)

Component	COLM	Wheat bran
Proximate analysis		
dry matter	926.0	904.3
crude protein	218.0	157.0
ether extract	24.0	30.0
crude fibre	141.0	110.0
ash	83.0	49.5
nitrogen-free extract	534.0	653.5
Fibre components		
neutral detergent fibre	209.0	304.6
acid detergent fibre	201.0	182.4
hemicellulose	8.0	122.2
Mineral elements		
Ca	13.0	1.4
P	0.5	11.5
K	21.0	11.9
Na	10.6	0.5
Other organic components		
tannic acid equivalent	143.0	-
ME, MJ kg^{-1}[b]	5.42	5.44

[a] values are the means of four samples

[b] estimated by the method of Sibbald (1986)

TABLE 2

Composition of diets fed to 14-day-old broiler chickens

	Level of *C. odorata* leaf meal, g kg^{-1} diet			
	Diet			
	Control	25	50	75
Ingredients, g kg^{-1}				
maize	590	590	590	590
Chromolaena odorata	0	25	50	75
fish meal (630 g CP kg^{-1} DM)	190	190	190	190
soyabean meal	60	60	60	60
wheat bran	130	105	80	55
oyster shell (ground)	20	20	20	20
vitamin and mineral premix[a]	5	5	5	5
NaCl	5	5	5	5
Chemical analysis, g kg^{-1}DM				
crude protein	219.6	221.2	222.7	224.2
crude fibre	33.6	34.4	35.1	35.9
ether extract	36.3	36.2	36.0	35.9
Ca	15.2	15.5	15.8	16.1
P	8.2	8.0	7.8	7.6
ME, MJ kg^{-1}[b]	11.59	11.59	11.59	11.59

[a] premix supplied (kg^{-1} diet): vit. A, 10,000 IU; vit. D_3, 2000 IU; vit. E, 10 IU; vit. K, 3 mg; riboflavin, 4.4 mg; cobalamin, 0.05 mg; pantothenic acid, 8 mg; niacin, 16.5 mg; choline, 175 mg; folic acid, 0.5 mg; Mg, 2.3 mg; Fe, 30.5 mg; Zn, 50 mg; Co, 0.27 mg

[b] calculated from National Research Council (1994) and the ME value of *Chromolaena odorata* leaf meal estimated by the method of Sibbald (1986)

Two hundred and forty unsexed 14-day-old commercial broiler chickens were individually weighed and allocated randomly to the four dietary treatments. Each treatment was replicated three times. Starting weights of broiler chickens averaged 185 g. The birds were placed and reared in deep litter pens. Treatment diets were administered from 2-8 weeks of age. Feed (in mash form) and water were consumed free choice throughout the experimental period. Chickens were vaccinated against Gumboro and Newcastle diseases. They were protectively medicated against coccidiosis at 3 days of age and again during the third week.

Parameters measured

Broilers were individually weighed on a weekly basis. Weight gain, feed intake and feed conversion efficiency (adjusted for mortality) were measured for the 2-8 week period. Water consumption was recorded daily. These daily values were summed up for a 7-day period and the means were calculated. Records of mortality were also kept. All sick and dead chickens were sent to the Veterinary Laboratory for post-mortem examination. Body colour intensity score was assessed at 6 and 8 weeks of age by visual comparison of the skin, beak and shank with a Roche colour fan. At the end of the experiment (56 days of age), four broilers from each of the 12 replicates were randomly selected, starved of feed for 18 h, killed by cutting the jugular vein, exsanguinated, defeathered and eviscerated. Carcass yield was calculated from eviscerated weight and liveweight.

Blood collection and assays

To avoid a macrocytic hypochromic anaemia (Christie, 1978) caused by repeated bleeding, the birds were bled only at 6 and 8 weeks of age between 09.00 and 11.00 h. The birds were fasted for 12 h prior to collection of blood specimens to avoid post-prandial lipaemia (Kirk et al., 1990). Blood was analysed for red blood cell count (RBC), haemoglobin, hematocrit (packed cell volume, PCV) and blood protein. The series of blood tests were performed on blood drawn from the wing or jugular vein using dipotassium salt of EDTA (1.5 mg ml^{-1}) as anticoagulant. Erythrocyte (RBC) counting method was similar to that described by Maxwell (1981). Two separate counts were made for each blood sample and the mean of the two counts calculated. The quantity of haemoglobin and the haematocrit (PCV) values were respectively determined by the cyanmet-haemoglobin (Henry et al., 1974) and microhematocrit methods (Dacie and Lewis, 1975) using the average of duplicate samples. Total plasma protein concentration was measured in duplicate by the Biuret method outlined by Oser (1965).

Organ weights and histological studies

At 56 days of age, the possible effects of COLM on the weight of some body organs were also assessed. Four chickens from each treatment were randomly selected and killed by cervical dislocation. The spleen, liver, heart, gizzard and intestine were excised, weighed immediately and expressed as g kg^{-1} body weight. The spleen, liver, heart, gizzard and intestine were examined to determine whether the diets had resulted in gross pathological changes. Liver sections were cut before staining with haematoxylin and eosin (Humason, 1979) and examined microscopically for any abnormalities in the cells.

Statistical analysis

The dietary treatment effects for all the variables measured were analysed using the general linear models procedure of SAS (1987). The data were subjected to regression analysis to show the effect of including COLM on performance. Differences between means were determined by the use of the Duncan's multiple range test (Steel et al., 1997).

RESULTS AND DISCUSSION

The general performance of the experimental population is shown in Table 3. Feed intake for the 6-week period was significantly influenced by the level of COLM in the diets. Feed intake tended to decrease as the level of COLM in the diet increased. Regression of feed intake against level of COLM in the diet yielded the equation: Y (feed intake) = 3.98-0.013x ($r = -0.97$; $P<0.01$) where x is the level of COLM in the diet. The results obtained in this study with respect to feed intake is in agreement with that of phenolic-related studies by Barnes et al. (1974), Shenk et al. (1974) and Jung and Fahey (1983). Chemical analyses of the leaves of *Chromolaena odorata* in the present study and that of Apori et al. (2000) indicate that it contains tannins. Phenolic compounds, including tannins, reportedly affect feed intake because of unpalatability. A study by Shenk et al. (1974) indicated that meadow voles ingested less feed with as little as 15% phenolic-containing crownvetch in the diet. Prior extraction of crownvetch with ethanol removed the factor responsible for reduced intake by voles (Barnes et al., 1974). Jung and Fahey (1983) also reported that simple phenolics depress feed intake by rats.

There was little difference in average chicken weight after selection at 2 weeks of age, for birds fed diets containing 0, 25, 50 and 75 g COLM kg^{-1} diet. In general, increasing the levels of COLM in the diet decreased body weight gain during the period of 2-8 weeks of age. Compared with birds fed the COLM-free diet, birds fed the COLM-containing diets weighed significantly ($P<0.01$) less. The following correlation between the level of COLM in the diet and weight gain of broiler chickens was found: Y (weight gain) = 1.85-0.011x ($r=-0.99$; $P<0.01$).

The efficiency with which feed was converted to gain (feed:gain ratios) showed a consistent deterioration with increasing dietary COLM content. Regression of feed conversion ratio against the level of COLM yielded the linear regression equation: Y (feed:gain) = 2.11 + 0.011x ($r=0.96$; $P<0.01$). The decrease in weight gain and the reduced ability to efficiently utilize COLM-based diets for growth was mainly caused by the negative effect of COLM as indicated by the high indices of correlation for weight gain and feed conversion efficiency ($r=-0.99$ and 0.96, respectively). The results are in agreement with those of other tannin-related studies with a number of animal species (Price and Butler, 1980; Hale and McCormick, 1981; McBrayer et al., 1983; Okai et al., 1984; Atuahene et al., 1989). Jung and Fahey (1983) reported that phenolic compounds including tannins, bind with enzymes and also form nutritionally unavailable polymers with dietary proteins. Tan-

TABLE 3

Effect of *Chromolaena odorata* leaf meal on broiler chicken performance 14 to 56 days of age and blood components[a] and organ weights determined at 56 days of age

Indices	Level of *Chromolaena odorata* leaf meal				SEM	r values and level significance
	0	25	50	75		
Feed intake, kg	3.89	3.80	3.33	3.00	0.04	0.97^{**}
Weight gain, kg	1.86	1.55	1.32	1.01	0.02	-0.99^{**}
Feed conversion ratio, feed/kg weight gain	2.09	2.45	2.52	2.97	0.07	0.96^{**}
Water intake, ml	4000	3942	3701	3059	48.9	-0.74^{*}
Carcass yield, % LBW	0.74	0.72	0.71	0.69	0.27	-0.98^{**}
Mortality, %	1.66	1.66	1.66	0	0.24	-0.54
Body colour score	0	4.60	6.80	7.90	0.51	-0.96^{**}
Red blood cell count, millions m^{-3}	2.52	2.48	2.50	2.51	0.01	-0.08
Haemoglobin, g 100 ml^{-1}	13.80	13.60	13.70	13.70	0.04	-0.32
Haematocrit, %	33.80	33.90	33.80	33.80	0.02	-0.26
Total plasma protein, g 100 ml^{-1}	4.53	4.46	4.50	4.45	0.02	-0.59
Weight of, g kg^{-1}LBW						
spleen,	1.45	1.52	1.48	1.45	0.01	-0.16
liver	23.30	24.20	23.80	23.00	0.23	-0.32
heart	6.90	7.10	6.90	6.95	0.04	-0.07
gizzard	21.50	20.92	21.45	21.50	0.12	0.24
intestinal	118.08	117.05	119.35	118.60	0.42	0.32

[a] determined at 6 and 8 weeks of age

SEM - standard error of means

r - correlation coefficient

$^{**}P<0.01$; $^{*}P<0.05$

LBW - live body weight

nins reportedly combine with protein *via* hydrogen bonding and irreversibly through oxidation followed by covalent oxidation (Loomis and Battaile, 1966). Oh et al. (1980) suggested that the majority of the complex formation between tannins and proteins was due to hydrophobic interactions. It may also be suggested that the effects on feed intake may be one of the major mechanisms by which tannins depress growth. Modern broilers must consume large quantities of food in order to attain maximal growth. However, the reduction in feed intake induced by tannins in the diet might have created deficiencies of most, if not all, nutrients essential for optimum performance. Thus, the inferior growth rates and feed utilization observed among birds fed on diets containing COLM might be attributed to the reduced amount of protein available for growth.

The amount of water consumed by birds during the experimental period was significantly ($P<0.05$) correlated with the level of COLM in the diet. Water intake decreased very little as the level of COLM in the diet increased from 0 to 25 g kg^{-1}. However, the water intake decreased ($P<0.05$) at a dietary COLM level of 50 g kg^{-1} and also decreased greatly ($P<0.01$) at a level of 75 g kg^{-1}. Water intake of birds fed on diets containing 75 g COLM kg^{-1} was 24% lower than that consumed by birds fed COLM-free diet. The decrease in the amount of water consumed might be attributed to the decrease in feed intake as the level of COLM in the diet increased. This is in agreement with studies which have shown a relationship between feed and water intake under *ad libitum* conditions (Patrick and Ferrise, 1962; Ibarbia, 1968). These studies and this herein reported confirm the observation that the absolute water intake of birds is positively correlated with feed intake.

The level of COLM in the diet gave a correlation of -0.98 when linearly regressed against carcass yield indicating COLM exerted influence on this parameter. The significantly lower carcass yields were mainly a reflection of the lower performance recorded by birds fed on the COLM-containing diets.

The diet did not significantly affect mortality. A total of three (3) mortality cases were recorded during the experimental period. Out of this, one each occurred among birds fed on the COLM-free diet, 25 and 50 g COLM kg^{-1} diets. Post-mortem autopsies indicated no specific causes for death attributable to inclusion of COLM in broiler diets.

Body colour intensity increased from a score of 0 on the Roche colour fan for the control to 4.6 at 25 g COLM kg^{-1} dietary level, 6.8 at 50 g COLM kg^{-1}dietary level and 7.9 at 75 g COLM kg^{-1} dietary level in white maize-based diets.

The levels of COLM in the diet did not affect red blood cell count, haemoglobin, haematocrit and total plasma protein values. The spleen, liver, heart, gizzard and intestinal weights for birds fed on diets containing COLM were not significantly different from those fed the control diet. At the termination of the 6-week study, examination of several organs (spleen, liver, heart, gizzard and intestine) obtained from all sacrificed birds revealed no macroscopic deviation from the normal in terms of gross tissue changes. The histological characteristics of the liver from birds on the control diet were similar to those from birds on the COLM-containing diets.

In conclusion, it is clear that COLM addition to broiler diets negatively affects the performance of the bird as shown by decreased feed intake, growth, water consumption and carcass yield. The feeding value of COLM may be increased if the antinutritional factor, tannins could be eliminated or at least neutralised.

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STRESZCZENIE

Reakcja kurcząt brojlerów na podanie w diecie mączki z liści *Chromolaena odorata*

Celem doświadczenia było oznaczenie składu chemicznego mączki z liści rośliny tropikalnej *Chromolaena odorata* oraz jej wartości pokarmowej i właściwości barwnikowych jako składnika diety dla kurcząt brojlerów. Skład mączki z liści (COLM) był następujący (w s.m): białko ogólne 218,0 g kg^{-1}, włókno surowe 141,0 g kg^{-1}, energia metaboliczna 5,42 MJ kg^{-1} oraz ekwiwalent kwasu taninowego 143 g kg^{-1}. Doświadczenie przeprowadzono na dwustu czterdziestu dwutygodniowych kurczętach brojlerach, w układzie losowym, celem określenia wpływu różnych ilości COLM w diecie (0, 25, 50 i 75 g kg^{-1}) na wzrost i niektóre wskaźniki fizjologiczne. Diety były podawane do woli przez 6 tygodni. Dodatek COLM wpłynął ujemnie na wyniki produkcyjne kurcząt poprzez zmniejszenie pobrania paszy (r=-0,97) i wody (r=-0,74), przyrostów (r=-0,99), wykorzystania paszy (r=0,96), oraz wydajności rzeźnej (r=-0,98). Nie stwierdzono wpływu COLM na liczbę upadków kurcząt w grupach. Intensywność barwy tuszki zwiększała się wraz z wzrastającym udziałem COLM w diecie. Ocena punktowa zabarwienia skóry, dziobu i skóry na nogach w skali Roche wynosiła odpowiednio 0, 4,6; 6,8 i 7,9. Hematologiczne i biochemiczne wskaźniki krwi oraz ciężar śledziony, wątroby, serca, żołądka mięśniowego i jelit nie zależały od udziału COLM w diecie.