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Growth Response, Haematological Parameters and Carcass Characteristics of Broiler Chickens Fed Varied Levels of Bovine Blood Meal

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ABSTRACT
The price hikes of feed ingredients is one of the nightmares of poultry farmers in Ghana. A feeding trial was conducted to evaluate the effect of varied levels of bovine blood meal-based diets on growth response, haematological parameters and carcass characteristics of broiler chickens. Sixty, one week-old broiler chicks were randomly assigned to three treatments (T0, T1, and T2) in a Completely Randomized Design (CRD) with five replications and four birds per replicate. The experimental diets were, T0 (control diet, 0% bovine blood meal), T1 (1.5% blood meal and 4.5% fish meal) and T2 (3% bovine blood meal and 3% fish meal). Feed and water were offered *ad libitum*. At the end of experiment, five birds per treatment were randomly selected for carcass assessment. The chemical composition of blood meal showed that it contained 95.34 % dry matter, 84.74% crude protein, 7.21% ether extract and 1.92 % crude fibre. The results showed non-significant (P>0.05) differences in final body weight, average daily feed intake, body weight gain, average daily weight gain and feed conversion ratio except mortality. The results further revealed no significant (P>0.05) differences in all the haematological parameters studied. The results of the carcass examination showed that all the parameters assessed were not affected by dietary treatment with the exception of the back, heart and gizzard. The results showed that bovine blood meal can replace fish meal up to 50% in broiler diets without deleterious effects on growth performance, blood parameters, carcass quality and general well-being of the birds.

Keywords:
Growth response,
haematology,
carcass characteristics,
blood meal,
broiler chicken.

INTRODUCTION

Price hikes of feedstuff is one of the main challenges facing the poultry industry in Ghana. The cost of feeds and feeding generally ranged between 60-85% of the total cost of production (Khawaja *et al*., 2007; Shahidullah *et al*., 2008; Anoh & Akpet, 2013; Iji *et al*., 2017; Arabi & Adam, 2021; Swe *et al*., 2022). This high price of feedstuffs is a consequence of population growth, urbanization, high income levels, poor government policies implementation (e.g., planting for food and jobs) and natural disasters (Anoh & Akpet, 2013; Odukoya *et al*., 2019). These factors mentioned above have led to a decrease in the expansion of the poultry sector, resulting in low level of animal protein intake in a typical Ghanaian home. Reversing the trend of high cost of production via the use of cheaper and locally available alternative feed materials is an innovative way of increasing the supply of poultry products to the ordinary Ghanaian households. This will ultimately make them accessible and affordable to the citizenry, thus reducing the effect of kwashiorkor and malnutrition in children.Such locally available and cheaper alternative feed resource of animal origin is the blood meal which can be used in place of the traditional expensive feed ingredients like soya bean meal and fish meal.

Bovine blood is a waste product of the abattoir which provides a cheap and reliable alternative feed ingredient for compounding poultry feed. It provides readily available and an economic alternative protein source to address a wide variety of practical and nutritional needs of poultry. Blood meal (BM) is a dark coffee-coloured powder with a distinctive smell. It has 80-90% crude protein with a reasonable level of iron and copper (Shahidullah *et al.*, 2008; Odukoya *et al*., 2019). It also has high lysine content (6-8%) which meets the protein and lysine requirement of birds. Other amino acids such as arginine, methionine, leucine and cysteine are in blood meal in appreciable amounts, but glycine and isoleucine is very low in blood meal (Arabi & Adam, 2021). Encouraging large scale utilization of blood waste as an animal feed ingredient will not only increase the elasticity of feed formulation and conserve foreign exchange, but will also enhance the economic, nutritional, health and environmental benefits (Odukoya *et al.*, 2019; Arabi & Adam, 2021). There are some reports indicating that 1-4% BM can be used in poultry diet with improved growth response (Shahidullah *et al.*, 2008). However, other reports have shown that 10-15% inclusion levels of blood meal significantly improved the growth performance of chickens (Ekwe *et al*., 2020; Salifu *et al*., 2023) while inclusion rates exceeding 20% observed depressed performance and increased mortality rates.

The present study was conducted to evaluate the effects of using blood meal on growth performance, haematological parameters and carcass characteristics of broiler birds.

MATERIALS AND METHODS

Ethical Approval

The experimental procedures and guidelines were approved by the University's Research Ethics Committee**.**

Experimental Site and Duration of the Experiment

The study was carried out at the Livestock Section of the Department of Ecological Agriculture of the Bolgatanga Technical University, Bolgatanga. The mean environmental temperature ranges between 24°C and 36°C. High temperature intensities are mostly experienced from February to April and in November, with the heat peaking at 37.9°C which can sometimes rise to 45°C in March (Ayimbire *et al.*, 2018). The mean annual rainfall is about 1000 mm. The rainy season covers from May to mid-October peaking in August. The dry season lasts from November to April with the *harmattan* covering the months of December to January. The experiment lasted for eight weeks.

Collection and Processing of Blood Meal

Bovine Blood was collected from a slaughterhouse situated in Yorogo in the Bolgatanga municipality. It was collected into a clean 25-litre gallon and transported to the University campus for processing. The blood was poured into a head pan and placed on burning firewood and cooked for 45 minutes. The content in the head pan was constantly stirred to prevent lump formation. The cooked blood was sun-dried for three days on a clean aluminum sheet to a moisture content below 14%, pulverized, packaged and stored for feed formulation and laboratory analysis.

Dietary Treatments

The dietary treatments compounded to meet the nutritional requirements of the broiler birds is shown in Table 1. The treatment 1 (T1, 0 % BM), treatment 2 (T2, 1.5 % BM) and treatment 3 (T3, 3.0 % BM). Treatment 1 served as control diet. The three diets were compounded to be iso-nitrogenous and iso-caloric.

Table 1: Gross composition of dietary treatments containing varying levels of blood meal

Ingredient	Blood Meal Inclusion Level			Blood Meal Inclusion Level		
	Starter Diet (8-28 d)			Finisher Diet (29-63 d)		
	T0 (0.0%)	T1 (1.5%)	T2 (3.0%)	T0 (0.0%)	T1 (1.5%)	T2(3.0%)
Maize	60.00	60.00	60.00	60.00	60.00	60.00
Wheat bran	12.00	13.00	14.00	16.50	17.00	17.00
Soybean meal	19.00	18.00	17.00	14.20	13.50	12.50
Blood Meal	0.000	1.500	3.000	0.000	1.500	3.000
Fish meal	6.000	4.500	3.000	6.000	4.500	3.000
Oystershell	2.000	2.000	2.000	2.300	2.500	3.500
Premix	0.200	0.200	0.200	0.200	0.200	0.200
Lysine	0.200	0.200	0.200	0.200	0.200	0.200
Methionine	0.200	0.200	0.200	0.200	0.200	0.200
Salt	0.300	0.300	0.300	0.300	0.300	0.300
Toxin binder	0.100	0.100	0.100	0.100	0.100	0.100
Total (%)	100.0	100.0	100.0	100.0	100.0	100.0
Chemical analysis (%)						
Crude protein	20.00	20.02	20.04	18.13	18.22	18.10
Crude fibre	4.128	3.843	3.244	3.651	3.661	3.655
Crude fat	4.323	4.221	4.320	5.462	5.499	5.433
Calcium	2.067	1.958	1.641	2.033	2.001	2.029
Phosphorus	1.190	1.189	1.181	1.260	1.364	1.366

Laboratory Analysis

Compounded diet samples were sent to Ecological Agriculture laboratory of the Department of Ecological Agriculture, Bolgatanga Technical University for chemical analysis. The feed samples were examined for dry matter (DM), Crude fibre (CF), Ether extract (EE) and ash. The proximate analysis was carried out according to Horwitz& Latimer (2000).

Experimental Animals Management and Experimental Design

Sixty unsexed one-day-old commercial broiler chicks were fed commercial starter mash for the first one week and then randomly allotted to three (3) treatments designated as T0 (control diet with 0% BM), T1 (diet with 1.5 % BM) and T2 (diet with 3% BM) in a Completely Randomized Design (CRD). Each of the treatments was replicated five times with four (4) birds per replicate. Feed and water were given *ad libitum* during the experimental period. Birds were immunized against Gumboro and Newcastle diseases and mortality data recorded as it occurred.

Parameters Measured

Parameters assessed in the experiment were the initial body weight (IBW), final body weight (FBW) while weight gain (WG), average daily weight gain (ADG), average daily feed intake (ADFI), feed to gain ratio, and mortality. At the end of the experiment, the birds were denied feed for 18 h and only water were provided to empty their crops. Five broilers per treatment (i.e. one broiler per replicate) were selected at random, slaughtered by severing the jugular vein, exsanguinated, defeathered and eviscerated. The carcass parameters evaluated were carcass weight (hot and chilled), drumstick, thigh, breast, wing and back. Dressing percentage was calculated relative to live weight of birds before slaughter [DP %= (carcass weight / live weight) x100] and parts yield relative to carcass weight [Parts yield % = (parts weight/ carcass weight) x100]. The heart, liver, gizzard and intestine were excised, weighed and relative weights determined.

Blood Collection and Assays

The birds were held with back against the palm and the wing extended. The collection site was selected with most common sites employed in this experiment are the right jugular vein or the brachial (wing) vein. The site was then prepared by moistening the area with a cotton swab dipped in 70% alcohol and feathers moved aside to expose the vein. Twenty- three (23) gauge needle attached to 5mL syringe was gently inserted into the vein and minimal negative pressure was applied to draw the blood 2 mL. The drawn blood was discharge into an EDTA tube and mixed gently to prevent clotting. Cotton swab with 70% ethanol was used to apply gentle pressure to the punctured site until bleeding stopped. Samples were labelled appropriately on all the tubes, stored on ice and transported to the Bolgatanga Technical University's Laboratory for further processing.

Statistical Analysis

Data gathered were analyzed using one-way analysis of variance (ANOVA) via GenStat 18.2 edition and means were separated using Turkey's test as a post hoc analysis tool at 5%.

RESULTS AND DISCUSSION

Chemical Composition of Bovine Blood Meal (BBM)

The chemical composition of the bovine blood meal is shown in Table 2. The chemical composition of BBM showed that it contained 95.34 % DM, 84.74% CP, 7.21% EE and 1.92 % CF. The results showed that BBM contains an appreciable concentration of protein. The values presented here are similar to the proximate composition values reported by Donkor *et al.* (1999). Donkor *et al.* (1999) reported 90.35, 85.23, 1.49 and 3.51 % for DM, CP, EE and CF, respectively, for solar dried blood meal. Similarly, Sarkar *et al*. (2021) reported 95.77 % dry matter, 89.68% crude protein and 1.28% ether extract for sun dried bovine. The similarity or otherwise of the chemical components of the blood meals could be attributed to the breed, sex and the analytical method used.

Table 2: Chemical Composition of the Bovine Blood Meal

Parameter*	Results
Dry Matter, %	95.34
Crude Protein, %	84.74
Ether Extract, %	7.21
Crude Fiber, %	1.92
Calcium, %	1.13
Phosphorus, ug/g	1955.51
Sodium, ug/g	5442.83
Potassium, ug/g	1740.405

*Values are means of two determinations

Growth Performance

The results on growth performance parameters are shown in Table 3.

Table 3: Growth response of broiler chicken fed the experimental diets

	Bovine Blood Meal Inclusion Level				
Parameter	T0 (0.0%)	T1 (1.5%)	T2 (3.0%)	SED	P. value
IBW (kg)	0.392	0.368	0.382	0.022	0.464
FBW (kg)	2.554	2.617	2.226	0.221	0.193
ADFI (g)	86.90	94.10	89.70	8.600	0.712
BWG (kg)	2.142	2.278	1.840	0.213	0.150
ADG (g)	51.00	54.20	43.80	5.060	0.150
FCR (ADFI/ADG)	1.539	1.614	1.856	0.196	0.277
Mortality rate, %	5.560^{b}	7.110^{ab}	11.11^{a}	2.000	0.044

^{a,b}Means of different superscripts in the same row differ significantly at 5%. IBW- Initial body weight, FBW- Final body weight, ADFI-Average daily feed intake, BWG-Body weight gain, FCR-Feed conversion ratio.

There were non-significant differences among the treatment means in FBW, ADFI, BWG, FCR, with the exception of mortality. The T1 birds recorded highest value for the FBW (2.617 kg) > T0 (2.554 kg) > T2 (2.226 kg), respectively. The BBM was most effective when supplied at 1.5 % (25% substitution of fish meal) of the diet while 50% substitution of fish meal in the diet resulted in a depression of growth though not significant. In contrast, Seifdavati *et al*. (2008) reported significant improvement in performance with blood inclusion in the diet peaking at 75% substitution of fish meal in Cobb 500 broiler chickens. The differences could be as a result of the nutrient composition of the blood, diet composition and breed or strain of the birds.

The ADFI values were 94.10, 89.70 and 86.90 g for T1, T2 and T0, respectively. The birds that were on T2 had lower body weight gain than birds that were on T0 and T1 with the same trend observed in ADG. However, the birds on T0 (1.539) had the better FCR than birds that were on T1 (1.614), and T2 (1.856) though not significantly different.

The similarity in performance among all groups may be attributed to comparable chemical composition, physical form and balanced nature of the diets (Choct & Hughes, 1999; Shabani *et al*., 2015). Apart from genetics, efficiency of nutrient utilization and growth rate of birds, performance is determined by balanced diet (Khan *et al*., 2016). Insufficient diet may affect the growth performance of birds and efficiency of nutrient utilization (Bregendahl *et al*., 2002). However, there was significant effects (P<0.05) among treatments in mortality rate of the birds. It was observed that mortality increased with increasing inclusion levels of BBM. The mortality reported in this study may not have been triggered by the dietary treatments as T0 treatment without BBM also recorded mortality, hence mortality could be ascribed to adverse environmental factors (Anoh & Akpet, 2013).

Haematological Parameters

The haematological parameters of the broiler chicken fed the experimental diets are shown in Table 4.

Table 4: Haematological Parameters of broiler chicken fed the experimental diets

	Bovine Blood Meal Inclusion Level				
Parameter	T0 (0.0%)	T1 (1.5%)	T2 (3.0%)	SED	P. value
WBC, 10^3/L	40.50	20.69	31.51	15.70	0.473
RBC, 10^6/L	2.370	2.322	2.348	0.135	0.939
HB, g/dl	6.681	6.282	6.340	0.353	0.712
HCT,%	30.42	29.52	30.06	1.528	0.841
LYMPH, %	17.97	8.881	12.87	6.380	0.390
MCH, pg	28.18	27.12	27.18	1.383	0.698
NEUT, %	15.72	8.730	16.13	10.00	0.714
MCV, f/L	128.5	127.3	128.2	3.290	0.931
MCHC, %	21.96	21.30	21.14	0.908	0.643
BASO, %	4.420	2.514	1.978	1.059	0.091
EOS, %	0.002	0.000	0.000	0.002	0.397

WBC-White blood cell, RBC-Red blood cell, HB-hemoglobin, HCT-Haematocrit, MCHC- Mean corpuscular hemoglobin concentration, MCV-Mean corpuscular volume, NEUT-Neutrophils, LYMPH- lymphocyte, BASO- basophiles, EOS- Eosinophils

The white blood cell (WBC) count was ranged between 40.50 x10^{12}/L and 31.51 x 10^{12}/L for the broiler birds. The highest value (40.50 x10^{12}/L) was found in T0, the lowest value (20.69 x10^{12}/L) in T1 (1.5% BBM) and the intermediary value (31.51x 10^{12}/L) in birds fed T2 diet, respectively. The Red Blood Cell (RBC) values range from 2.370 x10^{12}/L-2.348x 10^{12}/L following the trend of the WBC parameter. The values of hemoglobin, mean corpuscular hemoglobin concentration, mean cell volume, neutrophils, and lymphocyte took the same trajectory as the WBC and RBC respectively. Basophiles and Eosinophil with the ranges of 1.978 % - 4.420 % and 0.00% - 2.00% respectively, declined gradually with the increasing BBM inclusion levels.

The results presented in Table 4 showed that BBM had no significant (P>0.05) effect on the blood parameters of the broiler chickens. This is an indication that the test ingredient did not adversely impact on the blood parameters. The current report here collaborates with the results of Donkoh *et al*. (1999), Odunsi *et al*. (1999) and Salifu *et al*. (2023) who reported similar nonsignificant differences (P>0.05) in haematological parameters with blood protein-based diets. The results recorded in this study also is in agreement with Ekwe *et al*. (2020) who recorded nonsignificant differences in the WBC, PCV, RBC, monocytes and eosinophil of broiler chickens fed diets having varying level of bovine blood meal (BBM).

On the other hand, the results contradicted the findings of Shahidullah *et al.* (2008), Ogunwole *et al.* (2017), Onunkwo & Ekine (2020) and Eko *et al.* (2024) who recorded significant (P<0.05) variations in the blood parameters of birds fed BBM-supplemented diets. The WBC values (20.6 x 10^3/L-40.50 x 10^3/L) were higher than the results of Eko *et al.* (2024) who reported a range of 9.94 x 10^3/L-17.71 x 10^3/L of birds fed diets with bovine blood meal. The NEUT, BASO, and EOS were within the normal ranges reported by Baudouin *et al.* (2021), Eko *et al.* (2024, Osho *et al.* (2024) except that of LYMPH which were lower than normal values. The LYMPH are essential in the immune defense system of both animals and humans (Anoh *et al*., 2025). A lower lymphocyte count shows the animals' poor immune reaction to stress and disease conditions. This poor immune response was exhibited in the significant mortality rates in T1 and T2 treatment diets (Table 3).

The RBC (2.322-2.370x10^6/L, HCT (29.52-30.43%), HB (6.282-6.681 g/dL), MCH (27.12-28.18 pg) and MCHC (21.14-21.96%) values in this present study are lower than values reported in previous studies (Onunkwo and Ekine, 2020; Baudouin *et al*., 2021; Hagan *et al*., 2022; Onunkwo *et al*., 2022; Kareem *et al*., 2024; Osho *et al*., 2024). Generally, low values of RBC, HCT, HB, MCH and MCHC indicates iron deficiency in the diets (Onunkwo & Ekine, 2020) which adversely affect haematopoiesis leading to anemic condition farm animals including chickens (Baudouin *et al*., 2021). The MCV (127.3-128.5 fl) values in this report were higher than those reported by Egbewande (2019), Onunkwo & Ekine (2020), Hagan *et al*. (2022), Kareem *et al*. (2024), Osho *et al*. (2024) and Anoh *et al*. (2025) but lower than that of Al-Aufi *et al*. (2023), Eko *et al*. (2024) and fell within the normal reference values of broilers (Abdulazeez *et al*., 2016; Baudouin *et al*., 2021). The blood indices are important in animals farming as these parameters give an indication of disease condition, stress levels, nutritive value of diet and metabolic state of the experimental animals (Baudouin *et al*., 2021).

Carcass Evaluation

The effects of dietary treatments on live bird weight, carcass weight, chilled carcass weight, dressing percentage, cut yields and their relative weights and the relative weights of the intestines, heart liver and gizzard are presented in Table 5.

Table 5: Carcass Characteristics and relative organ size of broiler chicken fed the experimental diets

	Bovine Blood Meal Inclusion Level				
Parameter	T0 (0.0%)	T1 (1.5%)	T2 (3.0%)	SED	P. value
Live weight (Kg)	2.382	2.248	2.156	0.127	0.237
Carcass weight (Kg)	1.857	1.773	1.853	0.099	0.647
Child carcass weight (kg)	1.825	1.692	1.745	0.111	0.498
Dressing Percentage	77.89	78.86	81.98	1.592	0.059
Drumstick (g)	275.9	250.0	245.2	17.59	0.214
Drumstick (%)	11.53	11.15	11.57	0.918	0.881
Thigh (g)	308.7	293.9	295.4	20.61	0.738
Thigh (%)	12.90	13.07	13.85	0.808	0.479
Wing (g)	200.5	195.4	185.2	9.780	0.317
Wing (%)	8.410	8.721	8.703	0.629	0.859
Breast (g)	502.0	497.5	475.6	45.90	0.830
Breast (%)	21.10	22.16	22.49	2.530	0.850
Back (g)	370.2^{a}	289.6^{b}	344.4^{ab}	24.60	0.019
Back (%)	15.49^{ab}	12.86^{b}	16.23^{a}	1.221	0.041

Head (%)	2.573	2.986	2.466	0.195	0.048
Feet (%)	4.395	4.370	4.289	0.411	0.964
Organ relative weights					
Intestine (%)	2.630	2.491	2.814	0.251	0.460
Heart (%)	0.444^{b}	0.373^{c}	0.546^{a}	0.024	<.001
Liver (%)	1.344	1.461	1.519	0.124	0.389
Gizzard (%)	1.400^{b}	1.392^{b}	1.840^{a}	0.131	0.007

$^{a,b,\,c}$ Means of different superscripts in the same row differ significantly at 5%.

The live bird weight, carcass weight, chilled carcass weight, dressing percentage were statistically (P>0.05) similar among dietary treatment means. The drumstick, thigh, breast, wing and their corresponding relative weights were also not affected by the diets. The back values were 370.2, 289.6 and 344.4 g with their corresponding relative weights values of 15.49, 12.86 and 16.23 % for T0, T1 and T2 respectively. The diets had an influence on the back and its relative weights. Birds on T0 diet recorded significantly (P<0.05) higher back weight than T1 but statistically similar to T2 (Table 5). The internal organs were not influenced by the diets except the heart and the gizzard. T2 heart percentage was significantly (P<0.05) higher than T0 and T1 heart percentages. Again, T2 was statistically (P>0.05) higher in gizzard percentage than T0 and T1 gizzard percentages but T0 and T1 were statistically similar in gizzard percentages. The intestines and liver were not influenced by the diets. The results of this study collaborate with the findings of Ndelekwute *et al*. (2016), Amu *et al.* (2018) and Arabi & Adam (2021) who reported no significant effect of dietary treatment on carcass characteristics and internal organ relative weights. However, the dressing percentage values (78-82) were lower than the values (95-96) of Amu *et al.* (2018) but higher than the results of Ndelekwute *et al*. (2016)(65-66) and Arabi & Adam (2021)(73-77). It was observed that carcass yield percentages in this report increased with increasing blood meal in the diet in contrast to the results of Arabi & Adam (2021) who reported a decreasing trend in dressing percentage with increasing blood meal. The non-significant dietary effect of the BM-based diets on the liver showed that the blood meal were hygienically processed and might have contained no pathogens.

CONCLUSION

Based on the results of this current study, bovine blood meal can partially replace fish meal up to 50% in the diets of broiler chickens without deleterious effects on growth performance, blood parameters, carcass quality and general well-being of the birds. Poultry farmers can take advantage of this untapped protein resource to economically produce poultry products for the citizenry while curbing environmental pollution. However, amino acid profile of the bovine blood meal and nutrient digestibility were not evaluated in this study. There is the need for the determination ofamino acid composition of the blood meal andthe utilization of the various feed nutrients in future research.

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