HAEMATOLOGICAL AND SERUM BIOCHEMICAL PROFILES OF TWO BROILER STRAINS FED RATIONS WITH VARYING LEVELS OF PALM KERNEL OIL RESIDUE

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ABSTRACT

An experiment was carried out to evaluate the haematological and serum biochemical profiles of two broiler strains fed diets with varying levels of palm kernel oil residue (PKOR). A total of 450 unsexed birds were evaluated in a 2 x 3 factorial experiment involving two broiler strains (Cobb and Ross) and three dietary treatments of 0%, 10% and 20% levels of inclusion of PKOR. Two hundred and twenty-five (225) birds from each broiler strain were randomly assigned to each of the three dietary treatments. Each treatment group had 75 birds, replicated 3 times with 25 birds per replicate. At 56 days of age, three birds from each replicate were randomly selected and their blood sample collected for haematological and serum biochemical analyses. Results showed that apart from the packed cell volume (PCV), there were no significant differences in the haematological parameters of the two broiler strains. The Ross broiler strain had better PCV than Cobb broiler strain. With the exception of white blood cell (WBC) count, the dietary treatments did not influence any of the haematological parameters evaluated. Birds on the 0% and 10% PKOR recorded significantly higher ($p<0.05$) WBC counts than birds fed the 20% PKOR ration. All serological parameters studied were similar in both broiler strains, except alkaline phosphatase (ALP) enzyme which was significantly ($p<0.05$) higher in Cobb broiler strain. Serological parameters measured did not vary significantly ($p>0.05$) among the dietary treatments. There were no significant ($p>0.05$) interactions between broiler genotype and diet on any of the haematological and serological parameters studied. Palm kernel oil residue could be included in the diets of broilers up to 20% without adverse effects on broiler health.

Keywords: *Cobb broiler; packed cell volume; Ross broiler; serum biochemistry; white blood cell*

INTRODUCTION

Owing to the remarkable contribution of the broiler poultry industry to the global economy through the provision of food, income and employment among others, poultry meat production has developed from a side activity of numerous small scale farms into a specialized global business. This development has been achieved through improvements in the genetics of broilers and nutrition. The general goal of poultry genetics for the immediate future is to develop chickens with the ability to perform well within a wide range of nutritional planes or dietary levels (Cavero *et al*., 2011; Preisinger and Flock, 2000). The tremendous effort of poultry breeding in producing fast growing commercial broiler breeds for the global poultry industry is quite obvious (Arthur and Albers, 2003). Nutrition, however, still poses a major economic challenge to sustainable and profitable broiler enterprise, as there are continuous price hikes of poultry feeds especially in developing countries.

Recently in Ghana, palm kernel oil residue (PKOR), a variant of palm kernel cake/palm kernel meal which is a semi-solid by-product of cottage industries that extract oil manually from palm kernel (Odoi *et al*., 2007; Apori *et al*., 2013) has been found suitable for use as low-cost feed to solve the problem of acute feed shortage and high feed cost. Feed cost alone constitutes about 70 to 80% of the total cost of broiler production (Flake and Ashitey, 2008; Thirumalaisamy *et al*., 2016; Mallick *et al*., 2020). The use of PKOR has been found to reduce cost of production and increase profit margin of poultry farmers (Gyamera, 2010).

Blood analysis is a readily available and fast means of assessing the nutritional status of animals on feeding trials, because dietary components have measurable effects on blood composition and may be considered as appropriate measure of long term nutritional status (Etim *et al*., 2014a; Lim *et al*., 2021). The effects of any feed ingredient on the haematological indices of chickens are of immense assistance in deciding whether or not such a feed ingredient should be used as poultry feed stuff (Mmereole, 2008; Etim *et al*., 2014c). Haematological constituents reflect the physiological responsiveness of the animal to its internal and external environments which include feed and feeding (Esonu *et al.,* 2001; Madubuike and Ekenyem, 2006) as well as drugs (Iheukwumere *et al.,* 2007). Serum biochemical analysis is used to determine the level of heart, liver and kidney health as well as to evaluate protein quality and amino acid requirements in farm animals (Etim and Oguike, 2011). Currently, there are limited published haematological and serological indices on PKOR-based rations to examine the effect of this feed on the general health status and organ function of commercial broiler chickens. This study, therefore, aimed at assessing the haematological and serum biochemistry responses of two broiler strains fed diets with varying levels of palm kernel oil residue.

MATERIALS AND METHODS

Experiment Site

The study was conducted at the Teaching and Research Farm of the School of Agriculture, University of Cape Coast, Ghana with a period of 8 weeks. The experimental site is located in the south-western part of Ghana, with annual temperature range of 24°C and 34°C, and relative humidity of between 50% and 85%. The area has a bi-modal rainfall pattern, averaging annually between 800 mm and 1500 mm.

Table 1: Experimental diets (% composition and calculated analysis)

Ingredient	0% PKOR	10% PKOR	20% PKOR
Maize	50.0	50.0	50.0
Wheat bran	28.5	18.5	8.5
Fish meal	12.0	12.0	12.0
Commercial broiler concentrate	8.0	8.0	8.0
PKOR	0.0	10.0	20.0
Oyster shells	1.0	1.0	1.0
Vitamin premix	0.3	0.3	0.3
Salt	0.2	0.2	0.2
TOTAL	100.0	100.0	100.0
Calculated Nutrient Analysis			
% Crude Protein (CP)	19.01	19.48	19.25
% Fat (EE)	3.42	3.73	4.69
% Crude Fibre (CF)	5.13	6.03	6.53
% Ash	9.33	10.36	11.16
*ME (Kcal/kg)	2,740.13	2,740.86	2,740.75

*[1]*Calculated composition of vitamin premix per kg: Vitamin E, 25mg; Vitamin A, 6250 IU; Vitamin D3, 1250 IU; Vitamin K3, 25mg; VitaminB1, 25mg; Vitamin B2, 60mg; Vitamin B6, 40mg; Vitamin B12, 2mg; Elemental calcium, 25mg; Elemental phosphorus, 9mg; Elemental magnesium, 300mg; Iron, 400mg; Selenium 1.0mg, Iodine 20mg, Copper 60mg, Magnesium 100mg, cobalt 10mg, Zink, 150mg;Sodium Chloride, 1.5mg; Choline Chloride, 500mg; Live Lactobaccillus spore, 0.2 million cfu; Niacin, 40mg; Folic Acid, 10mg; d-Biotin,5mcg.*
[2]*PKOR – Palm kernel oil residue*

Composition of Experimental Rations (Percentage of 100 kg Weight)

Table 1 shows the feed composition of the experimental rations used. Except for wheat bran and PKOR which were varied, all other ingredients and levels were the same for all dietary treatments.

Experimental Design and Management of Birds

Four hundred and fifty (450) unsexed broilers, 225 each of Cobb and Ross strain, were randomly selected and haematological and serum biochemical parameters of the birds were analysed in a 2 x 3 factorial experiment with two broiler strains (Cobb and Ross) and three dietary treatments (consisting of 0%, 10% and 20% levels of inclusion of PKOR). The PKOR replaced wheat bran at 0% (control – Treatment 1), 10% (Treatment 2) and 20% (Treatment 3) of the total ration. Birds were assigned completely at random to each treatment. There were 75 birds on each of the three dietary treatments with three replicates consisting of 25 birds in each replicate group.

Management of the Experimental Birds

The dietary experiment involved 3-week old broiler chicks of each strain which were fed over a period of 5 weeks. After brooding, the 3-week old broiler chicks were housed in 18 deep litter pens with the floor covered with wood shavings as bedding material. The floor dimensions of each pen were 2.5 m x 2.1 m, giving a standard floor space of 0.21 m^2 per bird. All birds were fed once daily at 7.00 – 8.00 am. Both feed and water were supplied *ad libitum* under 24-hour lighting regime. Standard preventive and curative healthcare and medications were instituted along recommended lines with a high level of hygiene maintained throughout the experimental period.

Collection and Analysis of Blood Samples

At the end of the eighth week, birds were subjected to 12 hours fasting prior to slaughtering and blood collection. Three birds from each replicate (making a total of 54 birds) were randomly selected from the three treatments. Fifty-four blood samples (2 ml each) were collected from the birds by venipuncture of the wing vein using a sterile syringe and needle and put in ethylene diamine tetra-acetic acid (EDTA) treated bottles. The samples were quickly stored in an ice box, using icepacks and transferred to the laboratory for haematological and serum biochemical analysis, within three hours' post sampling. An Automatic Fully Digital Hematology Analyzer (Auto Hematology Analyzer, 3 Parts, HEMA-D6031, Bioevopeak Ltd, China) was used for determination of Haemoglobin, Hb (g/dl), Packed Cell Volume, PCV (%), red blood cell, RBC ($X10^6/\mu l$) and white blood cell, WBC ($X10^3/\mu l$). The Universal Clinical Auto Analyzer (Biochemistry Analyzer, BA-A-120, Boevopeak Ltd, China) was used for serological determination. The haematological parameters; Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Corpuscular Haemoglobin Concentration (MCHC) were estimated with the respective formulae presented below:

$$\mathrm{MCV(fl)} = \frac{\mathrm{PCV\ (\%)}}{\mathrm{RBC\ (x\ 10^6 / \mu l)}} \times 10$$

$$\mathrm{MCH(pg)} = \frac{\mathrm{Hb(g/dl)}}{\mathrm{RBC\ (x\ 10^6 / \mu l)}} \times 10$$

$$\mathrm{MCHC(\%)} = \frac{\mathrm{Hb(g/dl)}}{\mathrm{PCV\ (\%)}} \times 100$$

Statistical Analysis

Data collected were subjected to two-way analysis of variance (ANOVA) with broiler strain and dietary treatment as fixed factors and haematological and serum biochemical profiles of the birds as variables using the generalized linear model procedure of the Genstat Discovery Edition (VSNI, 2011). Where differences in means were observed, the means were separated using the Least Significant Difference (LSD) Test at 5% level of significance. The statistical model used was as presented below:

$$Y_{ijk} = \mu + S_i + D_j + (SD)_{ij} + e_{ijk}$$

Where:
Y_{ijk} = observation of variable on the *k*th individual of the *i*th broiler strain and *j*th dietary treatment,
μ = the general mean,
S_i = the fixed effect of the *i*th strain of broiler,
D_j = the fixed effect of the *j*th dietary treatment,
$(SD)_{ij}$ = the fixed effect interaction of the *i*th broiler strain and the *j*th dietary treatment,
e_{ijk} = the random error associated with each observation ~ $N(0, \sigma^2_e)$ where σ^2_e is residual variance.

RESULTS AND DISCUSSION

All haematological parameters were similar for both broiler strains, except PCV which was significantly (p<0.05) higher for Ross broiler strain (Table 2). This observation suggests that Cobb and Ross broiler strains possessed similar genetic constitution for all the haematological parameters evaluated except PCV (percentage of red blood cells in the blood). This agrees with earlier reports by Abdi-Hachesoo *et al.* (2011) and Rasheed and Olusegun (2017) in broiler chickens and Chineke *et al.* (2006) and Etim *et al.* (2014b) in rabbits. The higher mean value of PCV recorded for Ross broilers suggests that oxygen and nutrient transport in Ross were better than in Cobb. The largely non-significant effect of broiler strain on many of the haematological parameters of birds corroborates the results of Olawumi *et al.* (2019) in broiler chickens at finisher phase but different from findings of Peters *et al*. (2011) who reported variations in haematological parameters among Nigerian native normal-feathered, frizzled feather and naked neck chicken genotypes. Islam *et al*. (2004) have also previously reported genetic differences or variations in haematological parameters among Nigerian native chickens

Nevertheless, most of the haematological values of the current study were within the normal reference ranges for chicken haematology (Table 2) documented by Jain (1993). The MCHC (39.75 – 39.18%) observed in this study was, however, above the normal range (26.0 – 35.0%). The high MCHC in the broiler strains could be attributed to the genetic makeup of the birds which suggests increased concentration of haemoglobin in the red blood cells of the broiler strains. Haematological studies have been found useful for disease prognosis and for assessing

Table 2: Effect of broiler strain on haematological parameters

Parameter	Cobb	Ross	SEM	*p-value*	Normal reference ranges
Haemoglobin (g/dl)	10.42	11.09	0.35	0.07	7.0 – 13.0
PCV (%)	26.24^a	28.42^b	0.67	0.01	22.0 – 35.0
RBC (X10^6/µl)	2.18	2.38	0.11	0.10	2.5 – 3.5
WBC (X10^3/µl)	2.30	2.28	0.11	0.90	1.2 – 3.0
MCV (fl)	120.50	118.90	4.18	0.71	90.0 – 140.0
MCH (pg)	47.75	46.91	1.27	0.53	33.0 – 47.0
MCHC (%)	39.75	39.18	1.00	0.50	26.0 – 35.0

[1]*Means within a row with different superscripts are significantly different at p<0.05.*
[2]*PCV – Packed Cell Volume; RBC – Red Blood Cell; WBC – White Blood Cell; MCV – Mean Corpuscular Volume; MCH – Mean Corpuscular Haemoglobin; MCHC – Mean Corpuscular Haemoglobin Concentration.*
[3]*SEM – standard error of means*

Table 3: Effects of dietary treatment on haematological indices in broiler chickens

Parameter	0% PKOR	10% PKOR	20% PKOR	SEM	*p-value*	Normal Reference ranges[4]
Haemoglobin (g/dl)	10.57	10.92	10.78	0.42	0.71	7.0 – 13.0
PCV (%)	26.48	27.99	27.53	0.82	0.21	22.0 – 35.0
RBC ($X10^6/\mu l$)	2.22	2.28	2.35	0.14	0.64	2.5 – 3.5
WBC ($X10^3/\mu l$)	2.42^a	2.38^a	2.07^b	0.14	0.04	1.2 – 3.0
MCV (fl)	119.70	121.20	118.30	5.12	0.85	90.0 – 140.0
MCH (pg)	47.63	48.05	46.31	1.55	0.52	33.0 – 47.0
MCHC (%)	39.99	39.03	39.18	15.86	0.71	26.0 – 35.0

[1]*Means within a row with different superscripts are significantly different (p<0.05).*
[2]*PCV – Packed Cell Volume; RBC – Red Blood Cell; WBC – White Blood Cell; MCV – Mean Corpuscular Volume; MCH – Mean Corpuscular Haemoglobin; MCHC – Mean Corpuscular Haemoglobin Concentration.*
[3]*SEM – standard error of means.*

general health status (Babeker and Elmansoury, 2013; Bezerra *et al.*, 2017). The results of the current study revealed that Cobb and Ross broiler strains shared similar superior immunogenetic composition which conferred healthy status on the two genotypes as their haematological values did not deviate from the normal ranges.

The influence of different dietary treatments on some haematological parameters of birds evaluated in this study is presented in Table 3.

The blood analysis did not reveal significant effect of PKOR inclusion on most of the haematological parameters (Table 3) studied except for WBC count. Bello *et al*. (2011) obtained similar results with broilers fed varying levels (0%, 10%, 20%, 30% and 40%) of palm kernel meal (PKM); which were also in consonance with work by Egenuka *et al*. (2013) who fed broilers with varying levels (0%, 20% and 40%) of palm kernel cake (PKC). The birds on 0% and 10% PKOR recorded significantly higher ($p<0.05$) WBC count than birds on 20% PKOR ration. On the contrary, Zekeri *et al.* (2022) did not observe any significant effect of varying levels of palm kernel cake inclusion on WBC counts of broiler chickens at 42 days of age. The significantly ($p<0.05$) higher levels of WBC in the birds fed 0% and 10% PKOR diets were not alarming and did not necessarily suggest cases of infections in birds as all the WBC values fell within the normal ranges for birds (Jain, 1993). A readily available and fast means of assessing clinical and nutritional health status of animals on feeding trials may be the use of blood analysis since ingestion of dietary components has measurable effects on blood composition which may be considered or used as appropriate measure of long term nutritional status (Olabanji *et al*., 2007) of animals. According to Togun and Oseni (2005), haematological studies are useful in disease prognosis, monitoring therapeutic and feed stress, and immune response. Togun *et al*. (2007) indicated that when haematological values fall within the normal range reported for the animal, it is an indication that diets do not show any adverse effect on haematological parameters; but when the values fall below the normal range (Bawala *et al*., 2007), it could be due to the harmful effects of high levels of some dietary contents. However, most of the haematological parameters assessed in this study were within the normal ranges (Table 3) reported for chickens by Jain (1993). The results in the present study indicates that the inclusion of PKOR up to 20% is not toxic to the health of broilers.

Table 4: Effect of genotype x diet interaction on haematological profile of broiler chickens

Parameter	Broiler strain						SEM	*p-value*	Normal reference ranges of Jain (1993)
	Cobb			Ross					
	Rations								
	0% PKOR	10% PKOR	20% PKOR	0% PKOR	10% PKOR	20% PKOR			
Haemoglobin (g/dl)	9.84	11.02	10.39	11.29	10.81	11.18	0.70	0.18	7.0 –13.0
PCV (%)	26.54	28.22	26.60	28.86	27.75	28.45	1.15	0.11	22.0 – 35.0
RBC ($X10^6/\mu l$)	2.08	2.30	2.17	2.36	2.25	2.53	0.19	0.31	2.5 – 3.5
WBC ($X10^3/\mu l$)	2.42	2.34	2.13	2.42	2.42	2.01	0.19	0.75	1.2 – 3.0
MCV (fl)	116.40	122.70	122.60	123.00	119.80	114.00	7.24	0.35	90.0 – 140.0
MCH (pg)	47.41	47.94	47.89	47.85	48.16	44.73	2.20	0.45	33.0 – 47.0
MCHC (%)	41.09	39.08	39.07	38.89	38.99	39.29	1.73	0.58	26.0 – 35.0

[1]*Means within a row with different superscripts are significantly different at p<0.05.*
[2]*PCV – Packed Cell Volume; RBC – Red Blood Cell; WBC – White Blood Cell; MCV – Mean Corpuscular Volume; MCH – Mean Corpuscular Haemoglobin; MCHC – Mean Corpuscular Haemoglobin Concentration.*
[3]*SEM: standard error of means.*

Effect of genotype x diet interaction on haematological profile of broiler chickens is presented in Table 4.

There was no significant (p>0.05) strain x diet interaction effect on haematological parameters of broilers (Table 4). The results of this study implied that there was absence of joint effect of strain and diet on birds' haematological traits; that is, the two factors acted independently of each other as explained by Olawumi *et al.* (2012). The absence of strain x diet interaction in the present study indicates that the nutritional environment of the three diets (0%, 10% and 20% PKOR) similarly favoured gene expression and regulation of traits. Hence, the two genotypes did not differ in ranking. The implication is that poultry farmers can raise any of the two broiler strains on any of the three diets without detrimental effect on organ function and general health of the birds; provided nutritional composition of diets fed are adequate for requirements of birds in that group.

From Table 5, Cobb broilers recorded significantly (p<0.05) higher alkaline phosphate (ALP) than Ross broilers. However, values of all the other serological parameters were similar for the two genetic groups. This observation also suggests that Cobb and Ross broiler genotypes possessed similar genetic composition for all the serological parameters evaluated except ALP enzymes which indicates that there is increased liver function in Cobb broiler strain than Ross. Feeding elevated levels of PKOR is reported to be associated with oxidative stress in organs such as liver and intestines as palm kernel oil has lower antioxidant compounds (Izuddin *et al.,* 2022). The lower levels of ALP in the Ross strain suggests Ross broilers could tolerate the PKOR diets better than Cobb strain. The results of the present work are in consonance with that of Ladokun *et al.* (2008) who reported no significant (p>0.05) differences in total protein, albumin, urea, glucose and cholesterol levels of naked-neck and normal feathered genotypes of Nigerian indigenous chickens in a sub humid

Table 5: Serum biochemical profile of the two broiler strains

Parameter	Cobb	Ross	SEM	*p-value*	Normal Reference Ranges
Glucose (mg/dl)	196.00	161.00	22.80	0.15	197 – 299
Cholesterol (mg/dl)	116.60	108.60	5.71	0.19	129 – 297
Triglyceride (mg/dl)	94.60	97.70	12.87	0.81	-
Total protein (mg/dl)	3.86	3.94	0.21	0.71	3.0 – 4.9
Albumin (mg/dl)	2.02	2.20	0.18	0.34	-
ALP (μ/l)	95.00^{a}	78.00^{b}	6.90	0.01	10 – 106
Sodium (mmol/l)	142.00	151.30	10.03	0.37	139 – 155
Potassium (mmol/l)	7.30	12.60	3.70	0.17	1.7 – 4.2
Calcium (mmol/l)	10.57	9.70	0.49	0.10	8.1 – 12.0
Chloride (mmol/l)	119.00	163.00	49.40	0.39	108 – 124

[1]*Means within a row with different superscripts are significantly different at p<0.05.*
[2]*ALP – Alkaline phosphate*

tropical environment. Similar result has also been reported by El-Safty *et al*. (2006). Generally, the serum biochemical parameters obtained were within the reference ranges for chickens (Table 5) provided by Clinical Diagnostic Division (1990). Serum biochemical profile helps to assess the functions of major organs such as heart, liver and kidney in the body of animals. Cholesterol and triglyceride values are usually positively correlated and are used to assess the function of the heart and cardiovascular disease status. The liver is one of the most important organs in the body and in this study alkaline phosphatase was the only parameter assessed for liver function test. Measures of calcium, sodium, potassium and chloride are used to check whether or not the kidneys are functioning properly. The normal serum biochemical values observed in the current research showed that Cobb and Ross shared similar superior immunogenetic composition which ensured normal and healthy functioning of major organs in the two chicken genotypes.

The influence of dietary treatments on the serum biochemical profile of birds evaluated in this study is presented in Table 6. The serum biochemical parameters evaluated did not vary significantly (p>0.05) among the different dietary treatments. The non-significant increase in the value of glucose and protein with increasing PKOR inclusion indicate that increasing PKOR resulted in increasing energy (in the form of glucose) and protein levels in the blood serum. Egenuka *et al*. (2013) reported that glucose level was slightly higher in 40% PKC group than in the 0% and 20% PKC group and linked it to the slightly higher energy level of the feed consumed by the birds in 40% PKC group. According to Shakila *et al*. (2012), the total serum protein (4.68-4.89 mg/dl) in broilers fed with PKM at different levels of inclusion (0, 2.5, 5.0, 7.5 and 10.0 %) was not significantly (p>0.05) affected, with or without enzymes supplementation, and it might be ascribed to adequate protein levels in the diets that were able to support normal reserve of the proteins in the body; and this is supported by Adesehinwa (2007). These findings were in agreement with the observations of the current work. The findings of Egenuka *et al*. (2013) again indicated that their values for cholesterol were not significantly different for varying levels of PKC fed, which is similar to the results of the present study. The non-significant differences observed for the levels of calcium, sodium, potassium and chloride among the control and the PKOR-based rations in this study is

Table 6: Effects of dietary treatment on serological profile of the broiler chickens

Parameter	0% PKOR	10% PKOR	20% PKOR	SEM	*p-value*	Normal reference ranges
Glucose (mg/dl)	172.00	176.00	188.00	27.90	0.84	197 – 299
Cholesterol (mg/dl)	116.80	113.60	107.40	6.99	0.42	129 – 297
Triglyceride (mg/dl)	112.30	75.90	100.20	15.76	0.10	–
Total protein (mg/dl)	3.76	3.79	4.14	0.26	0.28	3.0 – 4.9
Albumin (mg/dl)	2.12	2.09	2.12	0.22	0.99	–
ALP (µ/l)	81.00	93.00	80.00	26.75	0.84	10 – 106
Sodium (mmol/l)	141.90	139.10	159.00	12.28	0.25	139 – 155
Potassium (mmol/l)	5.80	12.20	11.80	4.53	0.32	1.7 – 4.2
Calcium (mmol/l)	9.78	10.12	10.51	0.60	0.49	8.1 – 12.0
Chloride (mmol/l)	114.00	190.00	119.00	60.50	0.41	108 – 124

[1]*Means within a row with different superscripts are significantly different (p<0.05).*
[2]*ALP – Alkaline phosphate*

Table 7: Effect of genotype x diet interaction on serum biochemical profile of broiler chickens

Parameter	Breeds						SED	*p-value* refer-ence	Normal Reference Ranges
	Cobb			Ross					
	Rations								
	0% PKOR	10% PKOR	20% PKOR	0% PKOR	10% PKOR	20% PKOR			
Glucose (mg/dl)	176.00	216.00	195.00	167.00	135.00	181.00	39.50	0.38	197 – 299
Cholesterol (mg/dl)	124.20	113.90	111.60	109.4	113.20	103.20	9.89	0.61	129 – 297
Triglyceride (mg/dl)	99.60	68.30	115.90	125.00	83.60	84.60	22.29	0.20	-
Total protein (mg/dl)	3.61	3.83	4.12	3.90	3.75	4.17	0.39	0.78	3.0 – 4.9
Albumin (mg/dl)	2.11	1.91	2.04	2.12	2.27	2.21	0.32	0.75	-
ALP (µ/l)	85.00	88.00	94.00	77.00	81.00	89.00	8.70	0.23	10 – 106
Sodium (mmol/l)	140.10	134.20	151.70	143.70	144.00	166.30	17.36	0.90	139 – 155
Potassium (mmol/l)	6.00	8.30	7.50	5.60	16.20	16.10	6.40	0.55	1.7 – 4.2
Calcium (mmol/l)	10.50	10.46	10.75	9.05	9.78	10.28	0.84	0.70	8.1 – 12.0
Chloride (mmol/l)	114.00	126.00	117.00	114.00	253.00	122.00	85.50	0.51	108 – 124

[1]*Means within a row with different superscripts are significantly different (p<0.05).*
[2]*ALP – Alkaline phosphate*

an indication that the inclusion of PKOR in the diets did not affect the integrity of the kidney and its function, as reported in a study by Ibrahim *et al*. (2012). However, elevated levels of potassium outside the normal range suggests that PKOR inclusion in diets could potentially after kidney health of birds. In this study, ALP enzyme as a measure of liver function did not vary significantly (p>0.05) among the different rations. Similarly, serum ALP was not significantly (p>0.05) affected by PKM inclusion up to 10% in diets, indicating that PKM and its variants can safely be incorporated in broiler diets without any adverse effects on liver function (Shakila *et al*., 2012). The results from this study indicate that the inclusion of PKOR in broiler finisher rations would not affect the integrity of liver and its function in broiler chickens.

Effect of genotype x diet interaction on serological profile of broiler chickens is presented in Table 7.

There was no significant (p>0.05) genotype x diet interaction effect on serological parameters in broilers (Table 7). This is similar to report by Tudorache *et al*. (2022) which did not observe any significant genotype x diet interaction in plasma biochemical parameters in different crossbred broiler genotypes. The results of this work implied that there was absence of joint effect of genotype and diet on birds' serological traits. The absence of genotype x diet interaction in the present study indicates that the nutritional environment of the three diets (0%, 10% and 20% PKOR) similarly favoured gene expression and regulation of traits. Hence, the two genotypes did not differ in ranking. The implication is that poultry farmers can raise any of the two genotypes on any of the three diets without detrimental effect on organ function and general health of the birds; if nutritional composition of diets fed are adequate for requirements of birds in that category.

CONCLUSION

The absence of significant differences in the serum biochemical profiles of both Ross and Cobb broiler strains, except for ALP, is an indication of the similarity in the genetic constitution of both strains. Moreover, most of the parameters studied were within normal reference ranges for chicken. The serum biochemical indices did not vary significantly among the various dietary treatments. This may be an indication that the inclusion of PKOR up to 20% in the diets of broilers would be safe for the birds. In addition, the two broiler strains did not differ in the haematological parameters studied; apart from PCV for which the Ross broiler strains was superior to the Cobb broiler strain. The level of inclusion of the PKOR in broiler diet did not affect the health status of the birds except for WBC count. No significant effect of genotype by diet interaction was observed for any of the haematological and serological parameters studied. It is therefore recommended that up to 20% level of inclusion of PKOR in broiler diets is safe for the two broiler strains.

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