

## Response of broiler chickens to substitution of vitamin-mineral premix with *Carica papaya* seed meal

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### ABSTRACT

The study investigated the physiological response of broiler chickens to substitution of commercial vitamin-mineral premix with *Carica papaya* seed meal (CPS). Two hundred and twenty four (224) mixed sexes Abor – acre day old chicks were subjected to trial for 6 weeks. Data were collected on performance, haematology, serum biochemistry, serum electrolytes and organ morphology. The birds were randomly assigned to 7 dietary treatments: T<sub>1</sub>: control with commercial vitamin-mineral-premix (VMP) at 0.3% only, T<sub>2</sub>, 0.05% CPS + 0.25 VMP, T<sub>3</sub> 0.20 VMP + 0.1 CPS, T<sub>4</sub> 0.15 VMP + 0.15 CPS, T<sub>5</sub> 0.10 VMP + 0.2 CPS, T<sub>6</sub> 0.05 VMP + 0.25 CPS and T<sub>7</sub> 0.3 CPS. Treatments composed of 4 replications with 8 birds per replicate. Results indicated that significant differences ( $p < 0.05$ ) were observed in all the treatments for WG, FCR and FI. Birds fed with 0.3% of CPS had the best FCR. At the starter phase, significant differences ( $p < 0.05$ ) were observed in the haematology of the birds, however, the values obtained for hemoglobin, white blood cell and eosinophils were not significantly different ( $p > 0.05$ ) while at the finisher phase, the inclusion of *Carica papaya* seed meal significantly influenced ( $p < 0.05$ ) the values of haematology, the values were however higher ( $p < 0.05$ ) at higher levels of inclusion except for white blood cells (WBC) and platelets counts that the control group had significantly higher ( $p < 0.05$ ) values. There was no significant difference ( $p > 0.05$ ) in serum biochemistry parameters at the starter phase except for alanine transaminase (ALT) with significantly higher ( $p < 0.05$ ) value at the control but significantly affected ( $p < 0.05$ ) all the serum biochemical parameters at the finisher phase. Birds fed CPS had significantly higher ( $p < 0.05$ ) values for glucose, cholesterol and low density lipoprotein (LDL). However, birds fed 0.20% CPS had significant highest ( $p < 0.05$ ) values for ALT, Alanine phosphatase (ALP), glucose, cholesterol, LDL and high density lipoprotein (HDL). CPS significantly influenced ( $p < 0.05$ ) serum electrolytes. Birds in 0.05 and 0.10% CPS inclusion groups had significantly higher ( $p < 0.05$ ) values for sodium, chloride and bicarbonate ions when compared to the control. There was no significant difference ( $p > 0.05$ ) for kidney, liver and spleen. The use of CPS did not impair nutrient utilization neither does it have any adverse effect on the health status of the broiler chickens, hence the use of CPS may be considered as substitute for vitamin-mineral premix in broiler

chickens nutrition.

*Keywords: Physiological response, Carica papaya seed meal, substitution, vitamin-mineral premix*

## INTRODUCTION

The actual goal of poultry producers is to maximize production and to achieve a satisfactory economic return; therefore, all nutrient requirements must be met particularly for minerals and vitamins. While the NRC (1994) recommended smallest levels of mineral-vitamin (M-V) that are necessary for optimum productivity, feed manufacturers use much higher concentrations than those specified by NRC (1994) to avoid deficiencies. According to Inal *et al* (2001) feed manufacturers use from 2-10 times more of these nutrients than those specified by the NRC. The cost of the premix supplementation may contribute up to 2-3% of the total cost of the feed, however augmenting the feed with higher levels of M-V could lead to nutrient-mineral interactions (Abudabos *et al.*, 2013).

Vitamin-mineral premix (VMP) remained an essential component of feed for broiler chickens as the gut of broilers cannot synthesize adequate vitamin and minerals (Islam *et al.*, 2004). Synthetic single vitamin and minerals for producing VMP are manufactured by few companies globally. They are, therefore, expensive and subject to irregular scarcity, which makes it imperative to seek for viable alternatives to address economic challenges faced by farmers in the rural areas of the developing world. The consistent challenge of importation and scarcity of key ingredients also allows loop of variation in quality and claims by manufacturer of vitamin-mineral premix and the means of proving the veracity of products claim are also lacking (Asaduzzman *et al.*, 2005, Ogunwole *et al.*, 2012).

The nutritional need in raising broiler chickens has been one of the major challenges faced by poultry farmers around the world, nutrition however plays a major role in the health and productivity of birds. However, the health and productivity of the birds depend on the feed that

meet their nutritional requirements. The use of commercial mineral-vitamin premixes in broiler feed is not just for only feed pallidity, growth performance but also for the health benefit of the chicken.

Antioxidants have been widely used as feed additives to provide protection against oxidative degradation of feeds. Vitamin premix is usually added but may be reduced by using vitamin-rich plant sources such as *Carica papaya*. Some other plants also provide vitamins in their leaves, hulls, and brans.

The *Carica papaya* plant has an incredible property that make it more valuable, the full plant including its fruit, leaves, seed, root, bark, juice and latex obtained from papaya plant are used as nutrients, medicine and for various other purposes. *Carica papaya* is rich sources of three powerful anti-oxidants: Vitamin C, Vitamin A and Vitamin E and also contain a digestive enzyme called papain that is effectively used for the treatment of trauma, allergies and spot injuries (Serrano and Cattaneo, 2010; Sugiharto, 2020).

Akintunde *et al.* (2021a) reported that the seeds of unripe *Carica papaya*'s mineral contents were: calcium ( $0.39\pm 0.00\%$ ), magnesium ( $0.13\pm 0.00\%$ ), potassium ( $0.11\pm 0.00\%$ ), sodium ( $0.04\pm 0.00\%$ ), phosphorus ( $5.71\pm 1.41$  mg/kg), manganese ( $26.91\pm 1.41$  mg/kg) and iron ( $105\pm 1.41$  mg/kg). The vitamins contents obtained were  $2162.50\pm 1.41$  IU/kg,  $1.27\pm 0.00$  mg/100 g,  $0.64\pm 0.00$  mg/100 g,  $3.57\pm 1.41$  mg/100 g,  $1.94\pm 1.41$  mg/100 g,  $0.86\pm 0.00$  mg/100 g and  $8.99\pm 1.41$  mg/100 g for Vitamins A, B1, B2, B3, B6, B12 and C respectively. Kolu *et al.* (2021) also reported that the ripe seeds of *Carica papaya* contained the following minerals: calcium (0.15%), magnesium (0.15%), potassium (0.15%), sodium (0.08%), manganese (31.21mg/Kg) and iron (486.97mg/Kg). Akintunde *et al.* (2021a) however, concluded

that the seeds of *Carica papaya* could be a reliable source for minerals, vitamins, fibre, fat and carbohydrate with broader activity and higher potentials for therapeutic.

USDA (2016) reported that *Carica papaya* contains 20 mg Calcium, 21 mg Magnesium, 10mg Phosphorus, 182 mg Potassium, 8 mg Sodium, 0.08 mg Zinc, 0.045 mg Copper, 0.04 mg Manganese, 0.6 µg Selenium, 60.9 mg Vitamin C, 0.023 mg Thiamin, 0.027 mg Riboflavin, 0.357 mg Niacin, 0.191 mg Pantothenic acid, 0.038 mg Vitamin B6, 37 µg Folate, 6.1 mg Choline, 47 µg Vitamin A, 274 µ beta Carotene, 2µg Alpha Carotene, 589 µg Beta Cryptoxanthin, 95 IU Vitamin A, 1828 µg Lycopene, 89 g Lutein + Zeaxanthin. Due to the high nutrient profile of *Carica papaya*, the seed may be used or considered as substitute for mineral-vitamin premix in broiler nutrition. However, there are limited supplies of commercial vitamin-mineral premixes due to few numbers of manufacturers globally and cost of importation thus making the premix to be scarce and sometimes not available to farmers, hence the need to source for alternatives of this important ingredients. The ban on importation sometimes in Nigeria resulted in the scarcity and thus accounted for the increased cost of feeds. Also, the exorbitant import duty also accounted for the increasing cost of the CMVP which also contributed to the rising cost of feed in broiler chickens production thus making the broiler production venture less attractive to the rural farmers and small and medium scale producers. Also, the problem of adulteration of commercial VMP especially in developing countries thus, resulting in lower output when compared to the cost and benefits. The aim of this study is to evaluate the potentials of *Carica papaya* seed meal in broiler diet as a partial or whole replacement for vitamin-mineral premix.

## MATERIALS AND METHODS

### Ethical Approval

The research was carried out at the Teaching and Research Farm of the Department of Agriculture and Industrial Technology, Babcock

University, Ilishan-Remo, Ogun State, Nigeria. The use and care of poultry and animals followed the guidelines of the National Research Council (NRC) for research. Babcock University Health Research Ethics approved this work with number BUHREC325/21 effective March 31, 2021.

### Experimental Site

The experiment was conducted at the Teaching and Research Farm of the Department of Agriculture and Industrial Technology, Babcock University, Ilishan-Remo, Ogun State. Ilishan-Remo is in the rain forest of South Western Nigeria with mean rainfall of 2400mm. Ilishan is in the south-west geo-political zone of Nigeria. The mean annual temperature is about 27°C

### Source and Processing of the Test Ingredients (*Carica papaya* seed)

Ripe fruits of *Carica papaya* were purchased from the local markets of Ilishan-Remo and its environs, Ogun state, Nigeria. The seeds were removed after cutting or opening the fruit, the seeds were air dried between 7 to 14 days, milled and bagged and later used in feed formulation with other ingredients. The mineral composition the air-dried seeds of *Carica papaya* used in this study contained essential minerals, calcium (0.15 %), magnesium (0.15 %), potassium (0.15 %), sodium (0.08 %), phosphorus (0.00 mg/Kg), manganese (31.21mg/Kg) and iron (486.97 mg/Kg). The vitamins composition showed that the seed samples of ripe *Carica papaya* contained vitamin A (2266IU/Kg), vitamin B<sub>1</sub> (1.57 mg/100g), vitamin B<sub>2</sub> (0.75mg/100g), vitamin B<sub>3</sub> (3.88 mg/100g) Vitamin B<sub>6</sub> (1.88 mg/100g), vitamin B<sub>12</sub> (0.76mg/100g) and vitamin C (7.51mg/100g).

### Experimental Designs and Birds

Two hundred and twenty four-day old chicks were purchased from a reputable hatchery and raised for forty-two days. The birds were allotted into seven dietary treatments: T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> with 32 birds per treatments, four replicates, eight birds per replicate using completely randomized design, experimental

Table 1. Composition of Experimental Diet - Starter Phase

Ingredients	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Maize	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Soybean Meal	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Wheat Bran	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Palm oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Bone Meal	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Oyster Shell	1.50	1.50	1.50	1.50	1.50	1.50	1.50
VM-Premix	0.30	0.25	0.20	0.15	0.10	0.05	0.00
CPS meal	0.00	0.05	0.10	0.15	0.20	0.25	0.30
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated							
Nutrient							
% CP	21.10	21.10	21.10	21.10	21.10	21.10	21.10
ME (Kcal/Kg)	3,007.06	3,007.06	3,007.06	3,007.06	3,007.06	3,007.06	3,007.06

\*CPS – *Carica papaya* seed meal

Table 2. Composition of Experimental Diet - Finisher Phase

Ingredient	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Maize	53.00	53.00	53.00	53.00	53.00	53.00	53.00
Soybean Meal	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Groundnut Cake	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Fish Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Wheat Bran	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Palm oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Bone Meal	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Oyster Shell	1.50	1.50	1.50	1.50	1.50	1.50	1.50
VM- Premix	0.30	0.25	0.20	0.15	0.10	0.05	0.00
CPS Meal	0.00	0.05	0.10	0.15	0.20	0.25	0.30
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated							
Nutrient							
% CP	20.10	20.10	20.10	20.10	20.10	20.10	20.10
ME (Kcal/Kg)	2,971.56	2,971.56	2,971.56	2,971.56	2,971.56	2,971.56	2,971.56

\*CPS – *Carica papaya* seed meal

starter diet was served to the birds from week one to week three and finisher from week four to week six of the experiment with inclusion of commercial mineral vitamin premix and *Carica papaya* seed (CPS) meal at different level. T<sub>1</sub>: control with inclusion of commercial vitamin-mineral-premix (VMP) at 0.3% only, T<sub>2</sub>, 0.05 % CPS + 0.25 VMP, T<sub>3</sub> 0.20 VMP + 0.1CPS, T<sub>4</sub>

0.15 VMP + 0.15 CPS, T<sub>5</sub> 0.10 VMP + 0.2 CPS, T<sub>6</sub> 0.05 VMP + 0.25 CPS and T<sub>7</sub>-basal + 0.3 CPS

#### Data Collection

Body weight gains of experimental animals were recorded on weekly basis by subtracting the values of initial body weight in grams from final

body weight.

Weight Gain = Final Weight – Initial Weight.

Average weight gain/ animal =

$$\frac{\text{Final weight (g)} - \text{Initial weight (g)}}{\text{Total number of animals in the group}}$$

Feed intake was calculated by subtracting the leftover feed weight from the weight of feed initially provided to the birds.

Feed intake per bird =

$$\frac{\text{Feed supplied (g)} - \text{Left Over (g)}}{\text{Number of birds}}$$

Feed conversion ratio was obtained by dividing the quantity of total feed consumed by the weight gain FCR =

$$\frac{\text{Total feed intake (g)}}{\text{Total body weight gain (g)}}$$

Percentage mortality was also determined, mortality (%) =

$$\frac{\text{Number of dead birds} \times 100}{\text{Total number of stocked birds}}$$

At the end of the starter and finisher phases, two (2) birds from each dietary replicate were sampled to determine the haematological profile. 5ml of blood were taken from the jugular vein of randomly selected birds per replicate. The sampled blood was put into labelled blood sample bottles containing anti-coagulant (Ethyl Diamine-Tetra-Acetate powder) to determine haematological parameters.

Parameters that were analysed including packed cell volume (PCV) (%), Haemoglobin (g/l), Red Blood cells (RBC) ( $10^6 \mu\text{l}$ ), White Blood cell (WBC) ( $10^3 \mu\text{l}$ ), Lymphocytes (%), Neutrophils (%), Monocytes (%), Eosinophil (%) and Basophils (%) according to the procedure of Howlett and Jamie (2008).

The serum total protein, blood glucose, creatinine, uric acid, albumin and alkaline phosphate levels were computed according to the procedures of Smith and Scott (1965).

Sera were used to determine the levels of minerals by specific methods. Sodium and potassium (ion-selective method), chlorine (Labtest method), magnesium (Tonks' method), total calcium (Labtest method) and phosphorus (Basques-Lustosa's method) was determined according to

the procedures of AOAC (1990).

### Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) according to the procedure of SPSS (2012). Significant differences between the treatment's means were separated using Duncan multiple range test (Duncan, 1955).

## RESULTS

The results (Table 3) from this study showed that the final live weight and weight gain of birds with *Carica papaya* seed meal either for partial or whole replacement of the commercial vitamin-mineral premix compared with the control ( $p > 0.05$ ), however, birds with 0.25% *Carica papaya* seed meal had significantly higher ( $p < 0.05$ ) values for final live weight, weight gain and total feed intake. The replacement of commercial vitamin-mineral premix with *Carica papaya* seed meal also significantly influenced ( $p < 0.05$ ) the feed conversion ratio. Birds without commercial vitamin-mineral premix but 0.3% *Carica papaya* seed meal had the best FCR but not significantly different ( $p > 0.05$ ) from the control.

Table 4 showed the hematological parameters of broiler chicken fed diets with varying levels of *C. papaya* seed meal. At the starter phase, significant differences ( $p < 0.05$ ) were observed in the packed cell volume, red blood cell, red blood cell count, lymphocytes, heterophils, monocytes, basophils and eosinophil levels of the birds, however, the values obtained for hemoglobin, white blood cell and Eosinophils were not significantly different ( $p > 0.05$ ) among treatments.

At the finisher phase as presented in Table 5, the inclusion of *Carica papaya* seed significantly influenced ( $p < 0.05$ ) the values of packed cell volume (PCV), haemoglobin (Hb), white blood Cells (WBC), red blood cells (RBC), platelets, mean corpuscular haemoglobin (MCH), Mean corpuscular volume (MCV), lymphocytes, heterophils, eosinophils and basophils but no significant difference ( $p > 0.05$ ) in MCHC. The PCV values significantly increased ( $p < 0.05$ ) from 0%

Table 3. Growth performance characteristics of broiler chicken fed varying level of *C. papaya* seeds meal-based diet at the finisher phase

Parameter	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Initial(g)	68.30± 0.00	70.00± 0.00	68.00±0.00	69.00± 0.00	71.20± 0.00	67.40± 0.00	68.00± 0.00
Final wt(g)	1785.63±74.69 <sup>ab</sup>	1709.50±51.71 <sup>a</sup>	1836.75±129.87 <sup>ab</sup>	1766.12±117.73 <sup>ab</sup>	1878.88±49.49 <sup>ab</sup>	2003.33±75.47 <sup>b</sup>	1979.00±80.33 <sup>ab</sup>
Weight Gain(g)	1724.33±74.69 <sup>ab</sup>	1639.50±51.71 <sup>a</sup>	1776.75±129.87 <sup>ab</sup>	1703.13±117.73 <sup>ab</sup>	1827.28±49.49 <sup>ab</sup>	1951.93±75.47 <sup>b</sup>	1911.00±80.33 <sup>ab</sup>
Feed intake(g)	2953.61±64.60 <sup>b</sup>	2683.65±59.68 <sup>a</sup>	3451.75±6.02 <sup>c</sup>	3036.17±62.55 <sup>b</sup>	3367.14±2.42 <sup>c</sup>	3487.16±127.67 <sup>c</sup>	2990.07±73.04 <sup>b</sup>
FCR(kg)	1.73±0.08 <sup>ab</sup>	1.65±0.06 <sup>ab</sup>	2.03±0.17 <sup>b</sup>	1.89±0.23 <sup>ab</sup>	1.85±0.05 <sup>ab</sup>	1.79±0.06 <sup>ab</sup>	1.58±0.08 <sup>a</sup>
Mortality (%)	0.03	0.06	0.20	0.03	0.00	0.14	0.03

\*a, b, c means with different superscript within a row are significantly different Group mean and standard error of samples (x±sem) shown \*(p<0.05), \*CPS – *Carica papaya* seed meal

Table 4. Hematological parameters of broiler chickens fed varying levels of *Carica papaya* seed meal-based diet

Parameter	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Packed Cell Volume (%)	12.00±4.00 <sup>a</sup>	9.50±1.50 <sup>a</sup>	29.00±4.00 <sup>c</sup>	29.00±0.00 <sup>c</sup>	24.50±1.50 <sup>bc</sup>	20.00±0.00 <sup>b</sup>	27.50±5.00 <sup>bc</sup>
Haemoglobin (g/dl)	4.00±1.30 <sup>a</sup>	4.50±1.80 <sup>a</sup>	9.65±1.35 <sup>b</sup>	9.60±0.10 <sup>b</sup>	8.20±0.50 <sup>b</sup>	6.60±0.10 <sup>ab</sup>	9.15±0.15 <sup>b</sup>
White blood cell (10 <sup>12</sup> /L)	9250.00±10.50	4950.00±2.50	8950.00±27.50	4500.00±10.00 <sup>a</sup>	7100.00±26.00 <sup>a</sup>	7400.00±31.00 <sup>a</sup>	9050.00±23.50
Red Blood Cell (10 <sup>6</sup> /μL)	2.30±0.40 <sup>a</sup>	2.05±0.15 <sup>a</sup>	4.10±0.40 <sup>c</sup>	4.10±0.00 <sup>c</sup>	3.65±0.15 <sup>bc</sup>	3.25±0.05 <sup>b</sup>	3.95±0.05 <sup>bc</sup>
Platelet	137000.00±17000.00 <sup>b</sup>	112000.00±28000.00 <sup>b</sup>	115000.00±25000.00 <sup>b</sup>	19250.00±15750.00 <sup>a</sup>	81000.00±36000.00 <sup>ab</sup>	105500.00±500.00 <sup>b</sup>	106000.00±6000.00 <sup>b</sup>
Lymphocytes (%)	4.00±4.50 <sup>b</sup>	6.00±2.50 <sup>b</sup>	1.00±4.00 <sup>a</sup>	0.00±0.0 <sup>c</sup>	0.00±4.00 <sup>ab</sup>	0.00±0.00 <sup>c</sup>	49.00±1.00 <sup>ab</sup>
Heterophils (%)	36.00±4.00 <sup>b</sup>	44.00±6.00 <sup>bc</sup>	49.00±1.00 <sup>b</sup>	20.00±0.00 <sup>a</sup>	40.00±0.00 <sup>bc</sup>	23.00±0.00 <sup>a</sup>	38.00±0.00 <sup>b</sup>
Monocyte (%)	4.50±1.00	2.50±1.00 <sup>a</sup>	4.00±1.00 <sup>a</sup>	0.00±0.00	4.00±2.50	0.00±0.00	1.00±2.00
Eosinophils (%)	1.50±0.50	1.00±0.00	1.50±0.05	1.50±0.00	1.00±0.15	1.50±0.00	1.50±0.15
Basophils (%)	3.00±0.00 <sup>c</sup>	1.50±0.50 <sup>b</sup>	1.50±0.50 <sup>b</sup>	3.00±0.00 <sup>c</sup>	0.00±0.00 <sup>a</sup>	3.00±0.00 <sup>c</sup>	3.50±0.50 <sup>c</sup>

\*a, b, c means with different superscript within a row are significantly different

Group mean and standard error of samples (x±sem) shown \*(p<0.05)

\*CPS – *Carica papaya* seed meal

to 0.2% inclusion levels but the values obtained at higher levels of inclusion were also significantly higher ( $p < 0.05$ ) than the control. The same trend was also observed for haemoglobin and RBC but values at 0.3% inclusion level was similar ( $p > 0.05$ ) to the control, meanwhile the values of WBC was significantly higher ( $p < 0.05$ ) in the control compared to other treatments, however, the values increased significantly ( $p < 0.05$ ) from lower levels of inclusion (0.05 and 0.10%) to 0.25% level of inclusion while birds that were at 0.3% CPS had significantly higher ( $p < 0.05$ ) values than that of the control. The values of platelets was also significantly higher ( $p < 0.05$ ) in the control when compared to other treatments but the least values were observed in 0.25% group. For lymphocytes, the values were significantly higher ( $p < 0.05$ ) than the control except for the 0.25% group. The highest values were significantly recorded in the 0.05% group but the lowest values at 0.2% group for heterophils and basophils. However, the values of eosinophil and monocytes were significantly higher ( $p < 0.05$ ) in the control group.

Table 6 showed the serum biochemical analysis of broiler chickens to varying levels of *C. papaya* seeds meal as alternatives to commercial vitamin-mineral premix in broiler nutrition. There was no significant difference ( $p > 0.05$ ) in AST, TP, albumin, glucose, cholesterol, triglycerides, LDL and HDL.

As presented in Table 7, the inclusion of *Carica papaya* seed meal significantly affected ( $p < 0.05$ ) all the serum biochemical parameters analyzed at the finisher phase. As presented in Table 6, the inclusion of *Carica papaya* seed at the finishers' phase significantly affected ( $p < 0.05$ ) all the serum biochemical parameters analyzed. The values of ALT compared well ( $p > 0.05$ ) with the control except for the 0.15% inclusion level that was significantly high ( $p < 0.05$ ) than the control and all other treatment groups. For AST and ALP, the birds in 0.05% group had significantly least ( $p < 0.05$ ) values while the significantly highest values ( $p < 0.05$ ) were obtained from birds in 0.1%-0.3% groups.

However, the control was significantly different from all the treatment groups. For total protein, albumin and globulin, the control was not significantly different ( $p > 0.05$ ) from the values obtained at higher levels of inclusion (0.25 and 0.30%) however, least values were obtained in the 0.10% inclusion groups. The values were also significantly different ( $p < 0.05$ ) for urea and uric acid but the least values were obtained from the 0.2% group. For glucose and cholesterol, the values were significantly lower ( $p < 0.05$ ) in the control. The highest values for glucose and cholesterol were recorded in the 0.2% group. The 0.3% group had the highest value for triglyceride while the least values were obtained in 0.15% group however there was no significant difference ( $p > 0.05$ ) between the control and 0.05% groups. The control group had significantly least value for LDL while the 0.3% group had the least values for HDL. However, in both cases the birds in 0.2% group had the highest values of LDL and HDL.

Serum electrolytes concentration were significantly influenced ( $p < 0.05$ ) with the inclusion of *Carica papaya* seed meal as presented in Tables 8 and 9. For Sodium, the values for the control was significantly different ( $p < 0.05$ ) from all other treatment groups values. The least values were obtained from the 0.25% group. For potassium, the least values were observed from the birds receiving the least inclusion levels of *Carica papaya* seeds (0.05 and 0.10% inclusion) while the highest values of chlorine were observed from the birds in these treatment groups.  $\text{HCO}_3^{2-}$ , the control had significantly least ( $p < 0.05$ ) values while the highest values were recorded from birds receiving the highest levels of inclusion (0.2%, 0.25% and 0.30% inclusion). The control and 0.05% groups had significantly lowest ( $p < 0.05$ ) values for chromium.

For organ weights as shown in Table 10, there was no significant difference ( $p > 0.05$ ) for kidney, liver and spleen, but significant difference ( $p < 0.05$ ) was observed for heart, proventriculus and gizzard. Birds fed higher levels of *Carica papaya* seed (0.25% and 0.30%) had significantly highest ( $p < 0.05$ ) values for heart, birds



fed 0.25% inclusion had significantly highest ( $p < 0.05$ ) value for proventriculus while the birds in 0.01% inclusion group had significantly highest ( $p < 0.05$ ) values for the gizzards.

## DISCUSSION

From the present study, the substitution of commercial mineral-vitamin premix with the seeds of *Carica papaya* significantly influenced the performance characteristics of broiler chickens. However, the results obtained from this study was in contrast with the findings of Adegbenro *et al.* (2017) who studied the performance characteristics of broiler chickens fed composite leaf meal as alternative premix, they observed that the final body weight (FBW), total weight gain (TWG), total feed intake (TFI) and feed conversion ratio (FCR) of the birds fed the control diet were not significantly different ( $p > 0.05$ ) from those fed the composite leaf meal diets (the composite leaf meal was made of leaves from cassava, moringa, fluted pumpkin, basil and bitter leaves).

It should however be noted that the best FCR was recorded in the birds fed the 0.3% CPS while the lowest feed intake, weight gain and final live weight was recorded among birds fed with 0.05% inclusion level while other treatment groups receiving higher levels of CPS were not significantly different from the control. This however suggests the potential of higher levels of inclusion from 0.1% to 0.3% as a good source for partial or whole replacement of commercial vitamin-mineral premix. The results obtained from this study was however in agreement with the findings of Moury *et al.* (2018) who concluded that the diets containing no vitamin-mineral premix with 100% *Spirulina* improved the performance of broiler chickens.

Also in a similar study done by Banjoko *et al.* (2020) who studied the evaluation of varying levels of *Carica papaya* leaf meal on growth, carcass, hematological parameters and its use as anticoccidial for broiler chicken, it was observed that the inclusion of *Carica papaya* leaf meal significantly influenced the final live weight.

The results from the present study was also in agreement with the observations of Muazu and Aliyu-Paiko (2020) who carried out a study on the evaluation of the potentials of *Carica papaya* seed as phytobiotic to improve feed efficiency, growth performance and serum biochemical parameters in broiler chickens, it was observed that weight gain increased with increasing levels of *Carica papaya* seed.

The finding was also in agreement with the report of Ogunwole and Mosuro (2020) who observed significant difference in feed conversion efficiency when commercial vitamin-mineral premix was substituted in the diets of broiler chickens. The findings of this study was also in agreement with the report of Ashour *et al.* (2020) that natural supplement of dried okra fruit powder (*Abelmoschus Esculentust*) in broiler diet can improve the growth performance of the bird and birds fed higher levels of *Carica papaya* seed meal either as partial or whole replacement for commercial vitamin-mineral premix had the best final live weight, weight gain and feed conversion ratio.

The results also corroborate with the conclusion of Dassidi *et al.* (2020) that the inclusion of *Carica papaya* seed improve the performance parameters of chickens but in contrast with the findings of Haripour *et al.* (2011) who evaluated the effect of dietary inclusion of pawpaw leaf meal on the performance of finishing broilers chickens, no significant differences were observed in the feed conversion ratio of birds fed diets containing varying level of *C. papaya* seed meal. This result however suggests the efficiency of CPS either as a partial or whole replacement for commercial vitamin-mineral premix.

Haematological tests of experimental animals are very significant when evaluating the toxic effects of a supplemented compound or plant extract. They are also tools that can be used to determine the physiological and pathological statuses of the organisms (Oloruntola *et al.*, 2016). The haematological blood indicators in this study were found to be within normal ranges (Thrall *et al.*, 2012). The normal haematological values in this study indicated the ade-

Table 5. Hematological parameters of broiler fed varying levels of *Carica papaya* seed meal-based diet at the finisher phase

Parameter	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Packed Cell Volume (%)	8.00±0.00 <sup>a</sup>	9.50±0.50 <sup>ab</sup>	15.00±0.00 <sup>c</sup>	23.50±0.50 <sup>d</sup>	34.00±1.00 <sup>f</sup>	26.50±0.50 <sup>e</sup>	11.00±1.00 <sup>b</sup>
Haemoglobin (g/dl)	2.75±0.050 <sup>a</sup>	3.40±0.10 <sup>a</sup>	5.00±0.00 <sup>b</sup>	7.60±0.10 <sup>c</sup>	11.50±0.50 <sup>c</sup>	8.60±0.10 <sup>d</sup>	3.40±0.10 <sup>a</sup>
White blood cell (10 <sup>12</sup> /L)	15625.00±25.00 <sup>f</sup>	5650.00±50.00 <sup>a</sup>	5650.00±150.00 <sup>a</sup>	7450.00±50.00 <sup>e</sup>	6650.00±50.00 <sup>b</sup>	13450.00±50.00 <sup>e</sup>	10500.00±500.00 <sup>d</sup>
Red Blood Cell (10 <sup>9</sup> /μL)	1.00±0.00 <sup>a</sup>	1.30±0.10 <sup>ab</sup>	1.85±0.05 <sup>bc</sup>	2.85±0.15 <sup>d</sup>	3.95±0.05 <sup>e</sup>	2.50±0.50 <sup>e</sup>	1.35±0.15 <sup>ab</sup>
Platelet	200,000.00±0.00 <sup>e</sup>	159,000.00±1000.00 <sup>e</sup>	105,500.00±500.00 <sup>d</sup>	80,750.00±250.00 <sup>b</sup>	174,500.00±500.00 <sup>f</sup>	13,450.00±50.00 <sup>a</sup>	84,500.00±500.00 <sup>e</sup>
MCHC (%)	34.36±0.63	35.94±2.94	33.33±0.00	32.36±1.11	33.81±0.48	32.47±0.99	31.08±1.92
MCH (μg/g)	2.75±0.10 <sup>ab</sup>	2.63±0.13 <sup>ab</sup>	2.71±0.07 <sup>ab</sup>	2.68±0.18 <sup>ab</sup>	2.91±0.09 <sup>ab</sup>	3.58±0.68 <sup>b</sup>	2.54±0.21 <sup>a</sup>
MCV (fl)	8.00±0.00 <sup>ab</sup>	7.38±0.95 <sup>a</sup>	8.11±0.22 <sup>ab</sup>	8.26±0.26 <sup>ab</sup>	8.61±0.14 <sup>ab</sup>	11.08±2.42 <sup>b</sup>	8.17±0.17 <sup>ab</sup>
Lymphocytes (%)	38.00±0.00 <sup>a</sup>	44.50±0.50 <sup>b</sup>	54.50±0.50 <sup>c</sup>	50.00±0.00 <sup>c</sup>	55.50±0.50 <sup>c</sup>	39.00±1.00 <sup>a</sup>	52.50±0.50 <sup>d</sup>
Heterophils (%)	47.50±0.50 <sup>c</sup>	55.50±0.50 <sup>d</sup>	35.00±1.00 <sup>a</sup>	40.00±0.00 <sup>b</sup>	32.50±0.50 <sup>a</sup>	49.50±0.50 <sup>c</sup>	42.50±2.50 <sup>b</sup>
Monocyte (%)	10.00±0.00 <sup>b</sup>	9.50±0.50 <sup>b</sup>	10.00±0.00 <sup>b</sup>	6.50±0.50 <sup>a</sup>	9.50±0.50 <sup>b</sup>	8.50±0.50 <sup>b</sup>	5.50±0.50 <sup>a</sup>
Eosinophils (%)	3.00±0.00 <sup>d</sup>	0.00±0.00 <sup>a</sup>	0.00±0.00 <sup>a</sup>	1.00±0.00 <sup>b</sup>	0.50±0.50 <sup>ab</sup>	0.50±0.50 <sup>ab</sup>	2.00±0.00 <sup>c</sup>
Basophils (%)	2.00±0.00 <sup>b</sup>	3.50±0.50 <sup>c</sup>	2.00±0.00 <sup>b</sup>	2.50±0.50 <sup>bc</sup>	0.00±0.00 <sup>a</sup>	2.50±0.50 <sup>bc</sup>	0.50±0.00 <sup>a</sup>

\*a, b, c means with different superscript within a row are significantly different

Group mean and standard error of samples (x±sem(n)) shown \*(p<0.05), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC)  
\*CPS – *Carica papaya* seed meal

Table 6. Serum biochemical parameters of broiler chickens fed varying levels of *Carica papaya* seed meal-based diet at the starter phase

Parameter	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
ALT(U/l)	72.00±0.00 <sup>c</sup>	52.50±9.50 <sup>b,c</sup>	57.50±0.50 <sup>c</sup>	22.00±1.00 <sup>a</sup>	51.00±1.00 <sup>b,c</sup>	38.50±9.50 <sup>ab</sup>	24.50±0.50 <sup>a</sup>
AST(U/l)	18.50±4.50	23.00±4.00	26.00±1.00	14.50±4.50	20.50±0.50	13.00±0.00	15.50±0.50
TP	7.30±0.10	6.70±1.30	5.10±0.10	4.75±0.25	6.50±0.50	5.25±1.25	6.00±0.00
Albumin	4.35±0.05	4.00±0.80	3.05±0.05	2.85±0.15	4.10±0.10	3.15±0.75	3.55±0.05
Urea	16.30±0.30 <sup>ab</sup>	14.85±0.15 <sup>a</sup>	15.40±0.10 <sup>ab</sup>	19.65±1.35 <sup>ab</sup>	18.50±0.50 <sup>ab</sup>	20.50±3.50 <sup>b</sup>	6.50±0.05 <sup>c</sup>
Glucose	105.00±2.00	101.00±4.00	103.50±1.50	120.00±10.00	100.50±0.50	123.00±19.00	122.50±0.50
Cholesterol	136.50±57.90	104.50±5.25	74.30±12.00	100.5±0.5 <sup>a</sup>	131.00±11.00	93.50±0.50	93.50±0.50
Triglyceride	108.00±63.50	150.00±50.00	52.50±2.50	111.00±1.00	85.00±15.00	85.00±15.00	165.00±1.00
LDL	75.00±3.50	41.60±1.63	35.80±0.20	73.50±11.50	41.00±1.00	70.50±4.50	24.60±0.40
HDL	40.00±10.00	33.50±8.50	28.50±0.50	46.50±1.00	39.00±1.00	43.50±3.50	36.00±1.00

\*a, b, c means with different superscript within a row are significantly different

Group mean and standard error of samples (x=sem) shown \*(p<0.05),

Aspartate transaminase (AST), alanine transaminase (ALT), total protein (TP), low density lipoprotein (LDL), high density lipoprotein (HDL)

\*CPS – *Carica papaya* seed meal

quacy of nutrients and better immune status of the broiler chickens fed with *Carica papaya* seed meal as partial or whole replacement for commercial vitamin-mineral premix.

The current study findings indicated significant increases in RBC counts, and in Hb and PCV values. These outcomes are comparable with the results of Reis *et al.* (2018), who indicated that inclusion of phytobiotics such as cinnamic aldehyde, thymol, and carvacrol in broiler chickens significantly increased erythrocyte counts and haemoglobin in comparison with the control. Similar findings in another study were reported by Krauze *et al.* (2020), who studied the dietary effects of probiotic *Bacillus subtilis* (0.25 g/L), *Enterococcus faecium* (0.25 g/L), and phytobiotics containing cinnamon oil (0.25 mL/L) in broiler chickens and found improvements in the immune system and parameters such as RBCs and Hb. In another experiment, Gilani *et al.* (2018) examined the efficacy of organic acids and phytobiotics (possessing flavonoids) in poultry feed as alternatives to AGPs, observing significant increases in RBC and WBC counts, as well as an increase in PCV in broiler chickens. Similar observations were observed when broiler chickens were fed Garden cress (*Lepidium sativum*) seed powder (Shawle *et al.*, 2016), cayenne pepper (*Capsicum frutescens*) and turmeric (*Curcuma longa*) powders (Adegoke *et al.*, 2018), and pawpaw leaf and seed meal (Oloruntola, 2019).

Isaac *et al.* (2013) stated that haematological components, which consists of red blood cells, white blood cells or leucocytes, Mean Corpuscular Haemoglobin and Mean Corpuscular Haemoglobin Concentration are valuable in monitoring feed toxicity, especially, with feed constituents that affect the blood as well as the health status of farm animals. Aro and Akinmoegun (2012) and Aro *et al.* (2013) reported that haematological parameters like hematocrit value, haemoglobin concentration, white blood cell count, red blood cell count among others are used in routine screening for the health and physiological status of livestock and even humans.

Etim *et al.* (2014) and Akintunde *et al.* (2019) reported that haematological traits especially Packed Cell Volume (PCV) and Haemoglobin (Hb) were correlated with the nutritional status of the animal. Isaac *et al.* (2013) stated that PCV is involved in transport of oxygen and absorbed nutrient. Other blood parameters like blood viscosity are often neglected in routine clinical and physiological investigations. Blood viscosities are however, also affected by nutrition, especially, when processed agro-industrial wastes are taken into consideration. Livestock blood, for instance, may be subjected to hyperviscosity syndrome consequent on the feed they consume which may ultimately affect other blood values like hematocrit and erythrocyte sedimentation rate (Rosencranz and Bogen, 2006; Aro *et al.*, 2013). Blood viscosity can also help to unravel clinical case of blood abnormalities like polycythemia and reduced plasma volume (Jain, 1993; Aro and Akinmoegun, 2012).

Haematological constituents reflect the physiological responsiveness of the animal to its internal and external environments which include feed and feeding (Esonu *et al.*, 2001).

Adamu *et al.* (2006) observed that nutrition had significant effect on haematological values like PCV, Hb and RBC. Togun *et al.* (2007) reported that increase in PCV coupled with the marginal increase in RBC is indicative of more efficient erythropoiesis in experimental rabbits.

Eheba *et al.* (2008) noted that a decrease in WBC count, however, reflected a fall in the production of defensive mechanism to combat infection. Togun *et al.* (2007) reported that a significantly lower lymphocyte count was an indication of a reduction in the ability of the experimental rabbits to produce and release antibodies when infections occur (Campbell and Lasley, 1975). White Blood Cells Count (WBC) of 5 – 13 ( $\times 10^9/l$ ) is considered to be within normal range according to Burke (1994). Reilly (1993) opined that normal range of values for WBC indicated that the animals were healthy because decrease in number of WBC below the normal range is an indication of allergic conditions, anaphylactic shock and certain parasitism.

Table 7. Serum biochemical parameters of broiler fed varying levels of *Carica papaya* seed meal-based diet at the finisher phase

Parameter	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
ALT(U/l)	17.00±0.00 <sup>ab</sup>	12.00±0.00 <sup>a</sup>	20.50±0.50 <sup>ab</sup>	17.50±0.50 <sup>ab</sup>	34.50±0.50 <sup>c</sup>	15.50±9.50 <sup>a</sup>	29.50±0.50 <sup>bc</sup>
AST(U/l)	51.50±0.50 <sup>e</sup>	30.50±0.50 <sup>a</sup>	59.50±0.50 <sup>f</sup>	40.50±0.50 <sup>c</sup>	35.50±0.50 <sup>b</sup>	40.50±0.50 <sup>c</sup>	47.50±0.50 <sup>d</sup>
ALP (U/l)	84.50±0.50 <sup>c</sup>	71.00±1.00 <sup>a</sup>	79.50±0.50 <sup>b</sup>	73.00±1.00 <sup>a</sup>	141.00±1.00 <sup>f</sup>	100.00±0.00 <sup>d</sup>	121.00±1.00 <sup>e</sup>
TP (g/dl)	7.95±0.05 <sup>c</sup>	7.50±0.50 <sup>bc</sup>	5.90±0.10 <sup>a</sup>	6.00±0.00 <sup>a</sup>	6.60±0.10 <sup>ab</sup>	8.50±0.50 <sup>c</sup>	7.75±0.25 <sup>c</sup>
Albumin (g/dl)	4.750±0.05 <sup>c</sup>	4.100±0.1 <sup>b</sup>	3.450±0.50 <sup>a</sup>	3.550±0.05 <sup>a</sup>	3.950±0.05 <sup>b</sup>	4.900±0.10 <sup>c</sup>	4.750±0.25 <sup>c</sup>
Urea (mg/dl)	43.50±0.50 <sup>c</sup>	40.50±0.50 <sup>bc</sup>	28.50±1.50 <sup>a</sup>	39.00±1.00 <sup>b</sup>	26.00±1.00 <sup>a</sup>	40.50±0.50 <sup>bc</sup>	40.50±0.50 <sup>bc</sup>
Uric acid (mg/dl)	8.45±0.05 <sup>f</sup>	7.10±0.10 <sup>d</sup>	8.15±0.05 <sup>e</sup>	8.40±0.10 <sup>ef</sup>	3.60±0.10 <sup>a</sup>	3.95±0.05 <sup>b</sup>	4.55±0.05 <sup>c</sup>
Glucose (mg/dl)	98.50±0.50 <sup>a</sup>	111.50±0.50 <sup>b</sup>	105.50±5.50 <sup>ab</sup>	121.00±1.00 <sup>c</sup>	157.50±2.50 <sup>e</sup>	136.00±1.00 <sup>d</sup>	140.00±0.00 <sup>d</sup>
Cholesterol (mg/dl)	192.50±2.50 <sup>a</sup>	251.00±1.00 <sup>d</sup>	210.50±0.50 <sup>b</sup>	202.50±2.50 <sup>b</sup>	273.50±1.50 <sup>e</sup>	242.50±2.50 <sup>d</sup>	225.00±5.00 <sup>c</sup>
Triglyceride(mg/dl)	104.50±0.50 <sup>c</sup>	100.50±0.50 <sup>c</sup>	91.00±1.00 <sup>b</sup>	86.50±1.50 <sup>a</sup>	142.50±2.50 <sup>d</sup>	172.50±0.50 <sup>e</sup>	181.00±1.00 <sup>f</sup>
LDL (mg/dl)	118.50±1.50 <sup>a</sup>	171.00±1.00 <sup>d</sup>	136.00±1.00 <sup>b</sup>	135.50±0.50 <sup>b</sup>	174.50±0.50 <sup>d</sup>	152.50±2.50 <sup>c</sup>	149.00±1.00 <sup>c</sup>
HDL (mg/dl)	51.50±0.50 <sup>bc</sup>	61.50±1.50 <sup>e</sup>	54.50±0.50 <sup>cd</sup>	48.50±0.50 <sup>b</sup>	72.50±2.50 <sup>f</sup>	56.50±1.50 <sup>d</sup>	36.50±0.50 <sup>a</sup>

\*a, b, c means with different superscript within a row are significantly different

Group mean and standard error of samples (x±sem) shown \*(p<0.05),

Aspartate transaminase (AST), alanine transaminase (ALT), ALP (Alamine phosphatase), total protein (TP), low density lipoprotein (LDL), high density lipoprotein (HDL)

\*CPS – *Carica papaya* seed meal

Table 8. Mineral concentrations of broiler chickens fed *Carica papaya* seed meal as replacement for vitamin/mineral premix at the starter phase

Parameters	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Na <sup>+</sup> (mg/100ml)	135.00±0.00	135.00±3.00	135.00±0.50	134.00±6.00	132.50±2.50	132.50±2.50	140.50±0.50
K <sup>+</sup> (mg/100ml)	3.85±0.05 <sup>b</sup>	4.05±0.15 <sup>b</sup>	4.05±0.05 <sup>b</sup>	3.65±0.65 <sup>a,b</sup>	4.10±0.10 <sup>b</sup>	4.00±0.2 <sup>b</sup>	2.90±0.10 <sup>a</sup>
Cl <sup>-</sup> (mg/100ml)	102.00±1.00	99.00±1.00 <sup>b</sup>	105.50±0.00 <sup>c</sup>	103.50±0.50 <sup>bc</sup>	91.00 ±1.00 <sup>a</sup>	103.00±3.00	99.50±0.50 <sup>b</sup>
HCO <sub>3</sub> <sup>2-</sup> (mg/100ml)	22.50±2.50 <sup>a</sup>	24.00±30 <sup>ab</sup>	23.50±0.50 <sup>ab</sup>	29.50±1.50 <sup>bc</sup>	26.00±2.00 <sup>abc</sup>	31.50±0.50 <sup>c</sup>	30.50±0.50 <sup>c</sup>
Cr <sup>-</sup> (mg/100ml)	0.50±0.00 <sup>ab</sup>	0.35±0.50 <sup>a</sup>	1.50±0.40 <sup>a</sup>	1.50±0.40 <sup>c</sup>	1.00±0.00 <sup>bc</sup>	1.05±2.50 <sup>bc</sup>	1.15 ±0.05 <sup>c</sup>

\*a, b, c means with different superscript within a row are significantly different

Group mean and standard error of samples (x±sem) shown \*(p<0.05), Na<sup>+</sup> (sodium ion), K<sup>+</sup> (potassium ion), Cl<sup>-</sup> (chloride ion), HCO<sub>3</sub><sup>2-</sup> (bicarbonate ions) and Cr<sup>-</sup> (Chromide ion)

\*CPS – *Carica papaya* seed meal

Schalm *et al.* (1975) reported a normal PCV range of 31 – 50%. Harkness and Wagner (1989) reported a RBC range of 4.8 – 6.3 ( $\times 10^6/\text{mm}^3$ ). Etim *et al.* (2014) opined that increased RBC values are associated with high quality dietary protein and with disease free animals. PGCVS (1990) reported a normal range of values for Hb of 8 – 17g/dl. Normal range of values for Hb indicated that the vital physiological relationship of haemoglobin with oxygen in the transport of gases (oxygen and carbon dioxide) to and from the tissues of the body has been maintained and was normal (Njidda *et al.*, 2006). According to Isaac *et al.* (2013) Packed Cell Volume is involved in the transport of oxygen and absorbed nutrients. Njidda *et al.* (2006) posited that MCV, MCH and MCHC are used in diagnosing anemic conditions. Ahmed *et al.* (1994) observed that MCHC values decrease with increase in the level of protein. The dietary replacement of commercial-vitamin premix with *Carica papaya* seed meal improved the RBCs, WBCs, PCV, and Hb, suggesting better utilization of the dietary nutrients. The improvements could be as a result of high values of iron, vitamins A and B of *Carica papaya* seeds.

The result of serum biochemistry in this trial was in contrast with the report of Jimoh *et al.*, (2012) who observed a linear decrease in the serum level of total cholesterol, low-density lipoprotein (LDL) and triacylglycerol but progressive increase in high-density lipoprotein (HDL) was obtained from the birds fed with garlic-supplemented diets when their sera were analyzed. This indicated that the partial and whole replacement of commercial vitamin-mineral premix with *Carica papaya* seeds has modulatory effect on cholesterol and lipid metabolism and can elicit hypo-cholesterolaemic effects. The levels of cholesterol in sera of the birds in all the treatments were lower than the level considered risky to human health especially for birds with 0.00, 0.10, 0.15 and 0.30% of *Carica papaya* seeds. According to Helen (1989), hypercholesterolaemic ( $>240\text{mg/dl}$ ) is considered a risk factor in coronary heart disease especially when LDL cholesterol in serum is relatively

higher compared to HDL cholesterol. In this case, the chance of heart disease is greater. This could be as a result as higher values of 27.50% and 29.50% for crude fat reported by Kolu *et al.* (2021) and Akintunde *et al.* (2021) respectively for the seeds of *Carica papaya*. Liver accounts for approximately 50% of total cholesterol synthesis (Murray *et al.*, 1988). The hypocholesterolemic effects of *Moringa oleifera* and of its various extracts on chickens have been reported to occur, mainly through the inhibition of the key liver enzymes involved in cholesterol and lipid synthesis (Akintunde *et al.*, 2021b) but this is contrary to the results obtained in this present study. This may be due to the fact that the crude fat level in the seeds of *Carica papaya* is relatively high. CPS used in this study contained considerable concentrations of vitamin and bioactive compounds composition that reduced inflammatory markers and anti-platelet aggregation and prevents hypercholesterolemia—factors that can be triggered by obesity.

The high blood  $\text{K}^+$  concentration observed in the present study may be related to decreased lactic acid and a subsequent decrease in the observed  $\text{Na}^+$  level for birds fed higher levels of CPS (0.20 – 0.30%) (Trefz *et al.*, 2015). The reduced and elevated blood  $\text{Na}^+$  and  $\text{K}^+$  levels respectively observed among the chickens on diets containing 0.20 – 0.30% CPS were below and above the reference values (135–145 mEq/L for  $\text{Na}^+$  and 3.5–5.0 mEq/L for  $\text{K}^+$  respectively) (Jain 1993)) for chickens apart from being significantly different from those on the control diets. High blood  $\text{K}^+$  concentration could be an indirect effect of increased feed intake (Ao *et al.*, 2019; Borges, 2004). The ion  $\text{K}^+$  is critical for the normal functioning and maintenance of cells. With low  $\text{K}^+$  levels, skeletal muscles and nerves may become weaker and require stronger stimuli to attain the response threshold, resulting in generalized muscle and limb weakness (Balos *et al.*, 2016). This is indicative that a high dose of CPS as a partial or whole replacement for broiler chickens above 0.20% could result in both hyponatremia and hyperkalemia (Olarotimi, 2020). Peterson and Levi (2013), however, opined that

Table 9: Mineral Concentrations of Chickens fed *Carica papaya* Seed Meal as Replacement for Vitamin/Mineral Premix at the finisher phase

Parameter	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Na <sup>+</sup> (mg/100ml)	135.50±0.50 <sup>c</sup>	144.50±0.50 <sup>d</sup>	149.00±1.00 <sup>d</sup>	132.50±2.50 <sup>c</sup>	122.50±2.50 <sup>b</sup>	111.00±1.00 <sup>a</sup>	125.50±0.50 <sup>b</sup>
K <sup>+</sup> (mg/100ml)	5.00±0.00 <sup>b</sup>	3.50±0.50 <sup>a</sup>	3.10±0.10 <sup>a</sup>	4.95±0.05 <sup>b</sup>	6.50±0.50 <sup>c</sup>	5.95±0.05 <sup>bc</sup>	5.75±0.25 <sup>bc</sup>
Cl <sup>-</sup> (mg/100ml)	95.50±0.50 <sup>cd</sup>	101.00±1.00 <sup>e</sup>	100.50±0.50 <sup>e</sup>	92.50±2.50 <sup>bc</sup>	91.00±1.00 <sup>b</sup>	84.50±0.50 <sup>a</sup>	97.00±1.00 <sup>de</sup>
HCO <sub>3</sub> <sup>2-</sup> (mg/100ml)	22.50±0.50 <sup>a</sup>	25.50±0.50 <sup>bc</sup>	27.50±0.50 <sup>c</sup>	24.00±1.00 <sup>ab</sup>	34.50±0.50 <sup>d</sup>	34.00±1.00 <sup>d</sup>	34.50±0.50 <sup>d</sup>
Cr <sup>-</sup> (mg/100ml)	0.40±0.00 <sup>ab</sup>	0.30±0.00 <sup>a</sup>	1.15±0.05 <sup>c</sup>	0.80±0.10 <sup>c</sup>	1.00±0.00 <sup>de</sup>	0.85±0.05 <sup>cd</sup>	0.55±0.05 <sup>b</sup>

\*a, b, c means with different superscript within a row are significantly different

Group mean and standard error of samples (x±sem) shown \*(p<0.05), Na<sup>+</sup> (sodium ion), K<sup>+</sup> (potassium ion), Cl<sup>-</sup> (chloride ion), HCO<sub>3</sub><sup>2-</sup> (bicarbonate ions) and Cr<sup>-</sup> (Chromide ion)

\*CPS – *Carica papaya* seed meal

Table 10. Visceral organs characteristics of broiler chickens fed *carica papaya* seed meal as replacement for vitamin/mineral premix at the finisher phase

Parameter (g)	0.00% CPS	0.05% CPS	0.10 CPS	0.15% CPS	0.20% CPS	0.25% CPS	0.30% CPS
Kidney	2.0±0.0	2.0±0.0	2.0±0.0	2.0±0.0	2.0±0.0	2.0±0.0	2.0±0.0
Liver	55.5±4.5	46.5±1.5	55.5±2.5	62.5±5.5	61.0±11.0	52.0±5.0	61.0±4.0
Heart	13.0±0.0 <sup>ab</sup>	12.0±2.0 <sup>ab</sup>	11.5±1.5 <sup>ab</sup>	10.0±2.0 <sup>a</sup>	17.5±1.5 <sup>bc</sup>	22.0±2.0 <sup>c</sup>	18.5±3.5 <sup>bc</sup>
Spleen	5.5±1.5	3.5±0.5	4.5±0.5	6.5±1.5	7.0±4.0	5.0±0.0	3.5±0.5
Proventriculus	10.5±1.5 <sup>a</sup>	10.0±0.0 <sup>a</sup>	11.0±2.0 <sup>a</sup>	9.5±1.5 <sup>a</sup>	9.5±0.5 <sup>a</sup>	20.0±0.0 <sup>b</sup>	10.5±0.5 <sup>a</sup>
Gizzard	62.0±4.0 <sup>ab</sup>	55.0±7.0 <sup>a</sup>	82.0±13.0 <sup>b</sup>	62.0±4.0 <sup>ab</sup>	60.0±9.0 <sup>ab</sup>	53.5±1.5 <sup>a</sup>	55.5±0.5 <sup>a</sup>

\*a, b, c means with different superscript within a row are significantly different

hyperkalemia is an indication of renal failure since renal excretion is the common route of potassium elimination. Hypertensive rats were also reported to have an increased serum  $\text{Na}^+$  concentration (Ilegbedion et al. 2013). Hence, feeding broiler chickens CPS above a tolerable level of 0.20% as partial or replacement for commercial vitamin-mineral premix could predispose broiler chickens to renal dysfunction as well as coronary problem.

The  $\text{HCO}_3^-$  system is the most important buffer system in the body for maintaining healthy blood pH, as regulated by the lungs and kidneys (Jones, 2010). Low levels of  $\text{HCO}_3^-$ , as observed in the current study, were indicative of primary metabolic acidosis.

The increased chloride ion concentration attracts hydrogen ions into plasma making the blood acidic (Testerman et al., 1995). On the other hand, birds on diets containing 0.15 – 0.25% CPS recorded hypochloremia. This is lower than normal blood chloride levels of 98 – 105mEq/l reported by Olarotimi (2020). It was also suggestive of defective renal tubular absorption.

The visceral organ characteristics of chickens fed *carica papaya* seed meal as replacement for vitamin/mineral premix at the finisher phase shows numerical difference in organ weights of kidney, liver and heart of broilers chickens, this may probably be due to their differences in live weight, since the surface area and the live weight determine the amount of feathers and visceral organs required hence the need to compare the weights of the visceral organs relative to their live weights (Akintunde et al., 2021b). According to Butcher et al. (1983), external and internal offal percentages tend to increase as slaughter weight of the animal increase. Esonu et al. (2008) reported that organ weights are an index of nutrients retained by the birds.

The birds that received *Carica papaya* seeds compared well with the control for gizzard and proventriculus weights. The results also showed that the inclusion of *Carica papaya* seed meal at higher levels indicated that seed meal influenced the heart weight gain. This can be explained by

an attempt to supply oxygen and an increase in blood circulation (Khanyile, 2013). Moreover, this might be due to an increase in other internal organs such as gizzard and intestines. The increase in gizzard and intestinal weight can also increase the metabolic activities such as digestion, which led to increased demand for oxygen and blood circulation, and thus contributes to increase in heart weights. The results agree with Agbede and Aletor, (2003), who reported an increase in relative heart weight with increasing levels of *Glyricidia sepium* leaf meal. Also Ayssiwede et al. (2011) reported the increase in heart weight of broilers fed on incremental level of *Leucaena leucocephala* leaf meal. Ekenyem and Medubuike, (2006) on the other hand, reported a decrease in heart weight with graded level of *Lpomoea asarifolia* leaf meal. The catabolism of nitrogenous compounds should increase the concentration of wastes in blood, thereby increasing the work load of the kidneys, causing them to increase in size, due to consumption of protein rich leaf meal-based diets (Khanyile, 2013).

## CONCLUSION

The substitution of *Carica papaya* seed meal did not impair nutrient utilization, haematological, serum biochemical parameters and serum electrolytes concentration; neither does it have any adverse effect on the health status of the broiler chickens at both the starter and finisher phases, hence the use of *Carica papaya* seeds meal may be considered as substitute for vitamin-mineral premix in broiler chickens nutrition.

## Conflict of Interest

The authors have no conflicts of interest related to the present study.

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