# Haemato-biochemical indices and immune response of grower pigs fed enzyme supplemented dried cassava peel and maize cob composite meal

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**Abstract**

This study was carried out to examine the haemato-biochemical and immune response of grower pigs fed enzyme supplemented dried cassava peel and maize cob composite meal (CPMCM). A total of 36 crossbreed male grower pigs (Large white) of about 16 weeks old were randomly distributed into four groups of nine animals per treatment. Each treatment was further divided into three replicates consisting of three pigs in a completely randomized design. Pigs in treatment 1 were fed 0% CPMCM while CPMCM was used to replace maize at 40% (T2), 50% (T3) and 60% in T4. Examination of phyto-constituents in CPMCM showed that it contains alkaloids, tannins, saponins, cyanide, phenols and flavonoids at 20.05 mg/kg$^{-1}$, 9.06 mg/kg$^{-1}$, 10.04 mg/kg$^{-1}$, 15.03 mg/kg$^{-1}$, 8.92 mg/kg$^{-1}$ and 14.11 mg/kg$^{-1}$ respectively. Haematological results revealed that red blood cell, pack cell volume, haemoglobin, mean corpuscular haemoglobin, mean corpuscular volume, mean corpuscular haemoglobin concentration, white blood cell, monocytes and lymphocytes were significantly ($p < 0.05$) influenced by the treatment except for basophils count ($p > 0.05$). Total protein, total bilirubin, glucose, creatinine, alkaline phosphatase, alanine transaminase and aspartate transaminase values were significantly different among the treatment ($p < 0.05$) except for cholesterol and urea levels. It was concluded that all the blood parameters evaluated were within the established range for healthy pigs and dietary replacement of cassava peel and maize cob composite meal (CPMCM) with maize up to 60% pose no deleterious effect on the health of the animals.

**Keywords:** cassava peel, enzyme, nutrition, haematology, pigs, serum.

# Índices hemato-bioquímicos e resposta imunitária de porcos em crescimento alimentados com casca de mandioca seca suplementada com enzimas e farinha composta de espiga de milho

**Resumo**

Este estudo foi realizado para examinar a resposta hemato-bioquímica e imunológica de porcos de crescimento alimentados com farinha composta de casca de mandioca e espiga de milho seca suplementada com enzima (CMMSE). Um total de 36 suínos de crescimento machos mestiços (Grande branco) com cerca de 16 semanas de idade foram distribuídos aleatoriamente em quatro grupos de nove animais por tratamento. Cada tratamento foi dividido em três repetições compostas por três porcos em um delineamento inteiramente casualizado. Os porcos do tratamento 1 foram alimentados com 0% de CMMSE, enquanto o CMMSE foi utilizado para substituir o milho a 40% (T2), 50% (T3) e 60% em T4. O exame dos fitoconstituintes no CMMSE mostrou que ele contém alcalóides, taninos, saponinas, cianeto, fenóis e flavonóides em 20,05 mg/kg$^{-1}$, 9,06 mg/kg$^{-1}$, 10,04 mg/kg, 15,03 mg/kg$^{-1}$, 8,92 mg/kg e 14,11 mg/kg$^{-1}$ respectivamente. Os resultados hematológicos revelaram que os glóbulos vermelhos, o volume globular, a hemoglobina, a hemoglobina corpuscular média, o volume corpuscular médio, a concentração média de hemoglobina corpuscular, os glóbulos brancos, os monócitos e os linfócitos foram significativamente ($p < 0,05$) influenciados pelo tratamento, exceto a contagem de basófilos ($p > 0,05$). Os valores de proteína total, bilirrubina total, glicose, creatinina, fosfatase alcalina, alanina transaminase e aspartato transaminase foram significativamente diferentes entre os tratamentos ($p < 0{,}05$), exceto para os níveis de colesterol e uréia. Concluiu-se que todos os parâmetros sanguíneos avaliados estavam dentro da faixa estabelecida para suínos saudáveis e a substituição dietética de CMMSE por milho até 60% não apresenta efeito deletério à saúde dos animais.

**Palavras-chave:** casca de mandioca, enzima, nutrição, hematologia, suínos, soro.

## 1. Introduction

Worldwide population growth, rising incomes and urbanization are triggering an explosion in the demand for high quality protein. By 2030, the World Health Organization (WHO) projects annual meat production to reach 376 million tons globally up from 218 million tons in 1997-1999 (Dan, 2021). One of the major constraints of the development of livestock industry in developing countries including Nigeria is the high cost of conventional feedstuffs (Odunsi et al., 2013) due to stiff competition between human and animals. Maize constitutes about 60% of feed which also serves as food for many households in Nigeria (Kosemani; Bangboye, 2021). The according by Kosemani & Bamgboye (2021), maize culture is a major staple, fodder, energy plant, and model plant produced in sub-Saharan Africa, most notably in Nigeria. Competition between man and livestock for maize, soya beans among others is often responsible for high cost of these ingredients (Oladunjoye et al., 2005).

Several studies have been carried out on many energies supplying agricultural products as substitute for maize in swine feed. Among such products that have been tried are sweet potatoes, cocoyam, yam, rice by- products, peels of tubers, molasses, sorghum and wheat (Oladunjoye et al., 2017). One of such agro-industrial by-products is cassava peels and maize cob which are cheaper unconventional alternative feed resources for livestock animals (Anuore et al., 2024).

Cassava peel has to be processed to reduce the toxicity caused by some of its content and this content includes hydrocyanic acid (HCN) which is harmful to animals. Cassava is processed by various methods to increase acceptability and palatability by animals. Several processing methods have been applied over the years. Cassava peel can be processed using any of the following methods: grating and sun-drying, boiling, parboiling and sun-drying (Salami; Odunsi, 2003). According to Oladimeji et al. (2022), dry cassava peel after processing contains a significant protein content (3.66 g/100 g), crude fiber (9.40 g/100 g), ether extract (1.37 g/100 g), neutral detergent fiber (27. 78 g/100 g), hemicellulose (17.73 g/100 g) and cellulose. Cassava peel is a potential nutritional source for use in feed, as observed in the study by Oladimeji et al. (2022).

Studies have also revealed that cassava peel and maize cob mixture can be used to replace maize up to 30% in the diet of weaner pigs without causing any negative effect on their performance (Anuore et al., 2024). Ojediran et al. (2019), also reported a non-significant difference in blood parameters of growing pigs fed cassava peel at 50% replacement. There is a direct relationship between nutrition and blood parameters (Shittu et al., 2021). However, there is scanty information on the use of cassava peel/maize cob meal mixture in grower pigs. A timely, evaluation will give a clue on the optimum replacement level and also help to use cassava peel/maize cob meal mixture to bridge the gap between livestock production and sustainability.

Therefore, this research was designed to examine the haemato-biochemical indices and immune response of grower pigs fed enzyme supplemented dried cassava peel maize cob composite meal.

## 2. Materials and Methods

### *2.1 Experimental site*

This study was conducted at the University of Abuja Teaching and Research Farm, Main Campus, along Airport Road, Gwagwalada, Abuja, Nigeria; the Department of Animal Science, Faculty of Agriculture. Gwagwalada, situated between latitudes 8o571 and 8o551N and longitudes 7o051 and 7o061E, serves as the headquarters of the Gwagwalada Area Council (NPC, 2006).

### *2.2 Obtaining and getting ready test materials*

Fresh maize cobs and cassava peels were gathered from several Gwagwalada cassava/maize processing facilities. For a duration of 16 days, the samples were exposed to sunlight in order to lower their anti-nutritional factor levels and prevent microbial responses that could cause spoiling and nutrient leaching. After being individually ground into meals in a hammer mill and treated with a multi-enzyme before it was mixed with other ingredients.

Samples of each meal was taken into the laboratory for additional examination.

### *2.3 Experimental animals, design and management*

Thirty-six male large white grower pigs, aged 16 weeks, were purchased from a well-known farm in Abuja. The animals were kept in quarantine for a period of two weeks, fed a basal diet designed to satisfy the needs of grower pigs in accordance with the NRC's (2002) recommendation, and given preventive treatment, which included injections of long-acting Oxytetracycline at a rate of 2 mL/20 $kg^{-1}$ body weight and subcutaneous Ivermectin® at a rate of 0.5 mL/25 $kg^{-1}$ of body weight to control ecto and endo parasites. Pigs were divided into four treatment groups according to body weight, and each treatment was fully randomized and repeated three times with three animals in each replicate. Feeding was place twice a day at 8:00 and 16:00, and everyday access to fresh, clean water was provided. Daily feed intake was calculated by subtracting the left over from the feed supplied while the weight was taken weekly. All other management procedures were rigorously followed during the three-month duration of the investigation.

### *2.4 Experimental diets*

Four experimental diets were formulated to meet the nutrient requirements for swine according to NRC (2002). Cassava peel and maize cob meal (CPMCM) at ratio 1:1 was incorporated into the experimental diet to replace maize as follows: treatment 1 (T1) control diet (0% CPMCM), T2 (40% CPMCM), T3 (50% CPMCM), T4 (60% CPMCM) as presented in (Table 1).

Table 1. Gross composition of the experimental diets (% DM).

| **Ingredients** | **T1 (0%)** | **T2 (4%)** | **T3 (50%)** | **T4 (60%)** |
|---|---|---|---|---|
| Maize | 60.00 | 36.00 | 30.00 | 24.00 |
| Wheat offal | 8.00 | 8.00 | 8.00 | 8.00 |
| Soya beans | 17.30 | 17.30 | 17.30 | 17.30 |
| Groundnut cake | 6.50 | 6.50 | 6.50 | 6.50 |
| CPM-CM | 0.00 | 24.00 | 30.00 | 36.00 |
| Bone meal | 3.03 | 3.03 | 3.03 | 3.03 |
| Limestone | 1.50 | 1.50 | 1.50 | 1.50 |
| Methionine | 0.20 | 0.20 | 0.20 | 0.20 |
| Lysine | 0.25 | 0.25 | 0.25 | 0.25 |
| *Premix | 0.25 | 0.25 | 0.25 | 0.25 |
| Salt | 3.00 | 3.00 | 3.00 | 3.00 |
| **Total** | 100.0 | 100.0 | 100.0 | 100.0 |
| Determined analysis | | | | |
| Crude protein (%) | 15.10 | 14.34 | 14.22 | 14.20 |
| Crude fibre (%) | 6.00 | 8.12 | 8.87 | 9.01 |
| Ether extract (%) | 2.40 | 2.37 | 2.35 | 2.30 |
| Calcium (%) | 1.83 | 1.83 | 1.83 | 1.83 |
| Phosphorus (%) | 0.67 | 0.67 | 0.67 | 0.67 |
| Energy (Kcal/$kg^{-1}$) | 2801.8 | 2798.5 | 2779.6 | 2765.9 |

Note: *Vitamin A, 8,000 I.U., Vitamin E, 5 mg, Vitamin D3, 3000 I.U., Vitamin K, 3 mg, Vitamin B2, 5.5 mg, Niacin, 25 mg, Vitamin B12, 16 mg, Choline chloride, 120 mg, Mn, 5.2 mg, Zn, 25 mg, Cu, 2.6 mg, Folic acid, 2 mg, Fe, 5 mg, Pantothenic acid, 10 mg, Biotin, 30.5 mg, and antioxidant, 56 mg are provided as a premix per kilogramme meal. Source: Authors, 2024.

*2.5 Data collected*

2.5.1 Blood collection and analysis

Two pigs per replicate making a total of six pigs per treatment were chosen on the 12th day of the experiment for hemo-biochemical measurement. During the blood collection process, a stress-free environment was maintained for a selected group of animals to avoid deoxygenating the oxygenated blood. The pigs under study had their jugular veins bled in order to extract 4 millilitres of blood per animal. Of this volume, 2 millilitres were placed in a bijou bottle and subjected to ethylene diamine tetra acetate treatment for haematological testing, while the remaining 2 millilitres were utilised for serum analysis. The Sysmex XN-3100 automated analyzer equipment was utilised to perform haematological analysis on red blood cells, haemoglobin, packed cell volume, white blood cells, and their respective differentials.

Two millilitres of blood were drawn and placed into bottles free of ethylene, diamine, tetraacetic acid, and then subjected to tests for serum biochemical indices, including total protein, creatinine, uric acid, bilirubin, lipoproteins, cholesterol, glucose, calcium, phosphorus, potassium, sodium, bicarbonate, and enzymes. The Analytica 705 clinical diagnostics system was used for the analysis. The technical specifications included optical flow (30 µL quartz), reaction volume (350-1000 µL), photometricrange (-0.1 to 3.0 absorbance), and filter (7 interference filters: 340, 405, 505, 546, 578, 620, and 670 nm).

2.5.2 Immunological status estimation

The blood specimens utilized for haematological examination were used to perform immune-globulin (A, G, and M) activities. The MAGICL 6000 chemilum immunoassay analyzer, made in China, was used for the analysis. Samples were organised in the sample chamber and the temperature was adjusted to 32 ºC. The monitor (output unit) showed the findings of each parameter. Technical information included in the commercial kit includes the following information: technique (fluorescence enzyme immunoassay); detection (LED illuminant, non-flow cell); reaction time (antigen antibody reaction: 10 minutes); highest sample load limit (25 samples); sample container (primary tube, 13 × 75/100 mm, 16 × 75/100 mm diameter); temperature (15-30 ºC); and humidity (40-80%).

*2.6 Phytochemical analysis in test ingredients*

Concentrations of phytochemicals in maize cob and cassava peel were determined using standard procedures outlined by Sofowora (2009).

*2.7 Statistical analysis*

Data collected from the study was subjected to analysis of variance (ANOVA) using the computer software package SPSS 22.0; differences among treatment means were compared with Duncan's multiple range test (Duncan, 1995).

## 3. Results and Discussion

The phytochemical composition of cassava peel meal showed that it contains alkaloids 9 mg/kg$^{-1}$, tannins 4 mg/kg$^{-1}$, saponins 2 mg/g$^{-1}$, cyanide 16 mg/g$^{-1}$, flavonoids 7 mg/g$^{-1}$ and phenols 3 mg/kg$^{-1}$. Maize cob meal has a higher proportion of alkaloids 10 mg/g$^{-1}$, followed by saponins 6 mg/g$^{-1}$, flavonoids 5 mg/g$^{-1}$, tannins 3 mg/g$^{-1}$ and phenol 2 mg/g$^{-1}$. Cassava peel/maize cob meal mixture CPMCM treated with enzymes revealed showed that alkaloids 20 mg/g$^{-1}$, tannins 9 mg/g$^{-1}$, saponins 10 mg/g$^{-1}$, cyanide 15 mg/g$^{-1}$, flavonoids 14 mg/g$^{-1}$ and phenols 8 mg/g$^{-1}$ (Table 2).

The cyanide content 15.03 mg/g$^{-1}$ recorded in this study is within the tolerable range 50.00 mg/kg$^{-1}$ for monogastric animal reported by Okoli et al. (2012). Alkaloids, flavonoids, tannins, saponins and phenols have different therapeutic properties such as, analgesics, antimicrobial, anti-inflammatory, antioxidant, hepato-protective, immune-stimualatory activities amongst others (Daniel et al., 2023).

Table 2. Phytochemical composition of maize cob and cassava peel meal.

| **Specifications (mg/kg$^{-1}$)** | **Cassava peel meal** | **Maize cob meal** | ****CPMCM** |
|---|---|---|---|
| Alkaloids | 9.00 | 10.88 | 20.05 |
| Tannins | 4.51 | 3.91 | 9.06 |
| Saponins | 2.72 | 6.87 | 10.04 |
| Cyanide | 15.03 | - | 15.03 |
| Flavonoids | 7.66 | 5.00 | 14.11 |
| Phenols | 3.91 | 2.92 | 8.92 |

Note: **CPMCM: Cassava peel/maize cob meal mixture treated with enzymes. Source: Authors, 2024.

Haematological parameters of grower pigs fed cassava peel – maize cob meal mixture as replacement for maize (Table 3). The dietary treatment influenced ($p < 0.05$) the pack cell volume (PCV), haemoglobin (Hb), platelets, red blood cell (RBC), mean corpuscular volume (MCV), mean corpuscular heamoglobin (MCH), mean corpuscular haemoglobin concentrations (MCHC), white blood cell (WBC), neutrophils, monocytes and leucocytes values except for basophil count ($p > 0.05$). Pack cell volume, Hb, platelet, MCV, MCH, MCHC, WBC, neutrophils, monocytes and leucocyte count were higher ($p < 0.05$) in T3 and T4 relative to the other groups. Hematological analysis is routinely used in veterinary medicine to evaluate the health status of animals and poultry (Mafuvadze; Erlwanger, 2007).

Heamatological values could serve as base line information for comparison in condition of nutrient deficiency, physiology and health status of farm animals (Daramola et al., 2005). The results obtained in this study shows that the dietary treatment had significant ($p < 0.05$) effect on all the observed hematological parameters of growing pigs. Togun et al. (2007) state that when an animal's haematological values are within the normal range that has been defined for it, there was no negative effect of the diet during the trial period. In terms of trend, the PCV was greater in T4, closely followed by T3, T2, and T1 (control). The results are consistent with those of Adesehinwa et al. (2011), who observed that in growing pigs fed diets based on cassava peel meal (CPM) and CPM + Farmazyme-3000, the enzyme marginally increased PCV but not above that of a diet based on maize.

Increased cells destruction and subsequent enhanced erythropoiesis in the liver, spleen, and kidneys cause macrocytic (regenerative) anaemia, which is indicated by reductions in concentrations of erythrocyte parameters (e.g., packed cell volume (PCV), red blood cell counts (RBC), and haemoglobin (Hb) concentration) and elevations in MCV (Jain, 1986). The study's haemoglobin readings fell between the ideal ranges for developing pigs (Mercks Veterinary Manual, 2010). According to Merck's Veterinary Manual (2010), this further implies that the anti-nutritional components in cassava peel had been reduced to a manageable, non-fatal level, which explains why all the haematological measures were within normal limits.

This corroborates the findings of Maxwell et al. (2000a) who asserted that ingestion of dietary components had measurable effect on blood composition and may be considered as appropriate measure of long term nutritional status (Olabanji et al., 2007). Thus, everything that has an impact on blood, like diet, will undoubtedly have a negative or moderate effect on the body's overall health, growth, maintenance, and reproduction (Oke et al., 2007). According to Etim et al. (2014), there was a correlation between the nutritional state of animals and haematological features, specifically PCV and Hb. Even in cases when an animal did not exhibit overt clinical symptoms of illness, PCV and other haematological measures might be helpful prognostic tools and may indicate an unfavorable condition (Eze et al., 2010).

The fact that the concentration values of haematological features in this study did not fall below normal suggested that the minor amounts of anti-nutritional elements did not have a detrimental effect on these haematological parameters. The RBC concentration recorded in this study was similar to that of Enyenihi et al. (2008). The trend in the RBC, PCV and Hb in this study could be ascribed to the direct relationship among RBC, PCV and Hb (Jain, 1986).

According to Kaneko (1989) and Musa et al. (2021), the normal WBC and their differentials indicated sufficient defense against infectious pathogens. This is most likely because the diets contain enough protein. Daniel & Alagbe (2023) and Adewale et al. (2021), observed that nutritional shortage, particularly that of protein, reduced most haematological and serum parameters. Based on the comparable results obtained, it is sufficient to declare that the nutrient profiles of the diets were adequate to support the performance of the pigs.

Table 3. Haematological parameters of grower pigs Fed CPMCM.

| Specifications | T1 | T2 | T3 | T4 | SEM | Reference range |
|---|---|---|---|---|---|---|
| Pack cell volume (%) | 29.70$^{b}$ | 34.11$^{a}$ | 35.10$^{a}$ | 35.87$^{a}$ | 0.02 | 29.00 – 40.00 |
| Haemoglobin (g/L) | 99.56$^{c}$ | 107.2$^{b}$ | 112.8$^{a}$ | 115.9$^{a}$ | 1.16 | 50.00 – 167.1 |
| Platelet ($\times 10^9$/L) | 126.90$^{b}$ | 139.55$^{a}$ | 140.16$^{a}$ | 141.80$^{a}$ | 1.95 | 33.4 – 181.0 |
| Mean platelet volume (fl) | 6.00$^{b}$ | 8.40$^{a}$ | 8.55$^{a}$ | 8.90$^{a}$ | 0.02 | 1.22 – 11.40 |
| Red blood cell ($\times 10^{12}$/L) | 7.05$^{b}$ | 9.66$^{a}$ | 9.80$^{a}$ | 9.94$^{a}$ | 0.02 | 6.40 – 12.30 |
| Mean corpuscular volume (fl) | 52.91$^{c}$ | 59.00$^{b}$ | 65.77$^{a}$ | 68.50$^{a}$ | 1.00 | 23.0 – 48.0 |
| MCH (pg) | 29.83$^{c}$ | 30.40$^{b}$ | 34.00$^{a}$ | 35.72$^{a}$ | 0.02 | 17.0 – 23.0 |
| MCHC (g/L) | 49.02$^{b}$ | 56.91$^{a}$ | 57.00$^{a}$ | 58.15$^{a}$ | 0.04 | 22.0 – 76.9 |
| White blood cell ($\times 10^9$/L) | 12.02$^{b}$ | 15.00$^{a}$ | 15.10$^{a}$ | 15.72$^{a}$ | 0.01 | 8.70 – 37.9 |
| Neutrophils ($\times 10^9$/L) | 8.78$^{b}$ | 10.00$^{a}$ | 10.15$^{a}$ | 10.85$^{a}$ | 0.02 | 0.09 – 9.71 |
| Basophils ($\times 10^9$/L) | 0.15 | 0.10 | 0.15 | 0.13 | 0.01 | 0.0 – 0.71 |
| Monocytes ($\times 10^9$/L) | 0.96$^{b}$ | 1.05$^{b}$ | 1.75$^{a}$ | 1.89$^{a}$ | 0.01 | 0 – 4.90 |
| Lymphocytes ($\times 10^9$/L) | 9.95$^{b}$ | 12.00$^{a}$ | 12.70$^{a}$ | 13.56$^{a}$ | 0.01 | 3.60 – 18.50 |

Note: $^{a\ b,c}$ Means on the same row with different superscripts are significantly different ($p < 0.05$); T1: 0% CPMCM; T2: 40% CPMCM; T3: 50% CPMCM; T4: 60% CPMCM; SEM: standard error of mean; Reference range : Mercks veterinary manual (2010). Source: Authors, 2024.

Serum biochemical parameters of grower pigs fed dried cassava peel maize cob mixture as replacement for maize is presented in Table 4. Total protein, albumin, globulin, cholesterol, urea, creatinine, total bilirubin, direct bilirubin, glucose, alanine transaminase, aspartate transferase, alanine phosphatase values varied from 6-7 g/dL, 4-4 g/dL, 2-2 g/dL, 3-3 mmol/L, 2-2 mmol/L, 59-67 mmol/L, 3-6 µmol/L, 1-3 µmol/L, 73-74 IU/L, 64-65 IU/L and 113-114 (IU/L) respectively. Dietary treatment influenced all parameters except alanine transaminase, aspartate transferase, alanine phosphatase and cholesterol values ($p > 0.05$).

The serum total protein and albumin of the growing pigs used in this study were affected ($p < 0.05$) by the treatments. This indicated that the protein level in CPMCM was able to support the protein reserves of the pigs across the groups. The presence of variations in the serum metabolites could also be attributed to the protein and feed intakes across the groups. According to Gouache et al. (1991) and Alagbe (2017), a protein deficit has a particular impact on albumin content. The levels found in this investigation fell within the Adesehinwa (2007) normal range. The food therapy had no discernible effect on serum urea, an animal marker of muscle waste (Mitruka; Rawnsley, 1977). Rather, despite the diets' high fibre content, they appeared to have been used well, leading to substantial tissue deposition.

The results for creatinine, bilirubin, and cholesterol were all within the recommended ranges for pigs (Alagbe, 2024), indicating that there was no risk of renal failure or excessive fat content in the carcass of the animal. Elevated serum glucose level can be triggered during the period of stress or poor management (Shittu et al., 2023). ALT, AST and ALP values were within the normal range for healthy pigs (Merck Veterinary Manual, 2010), indicating the absence of liver or health issues (Olafadehan et al., 2023; Alagbe, 2024).

Table 4. Serum biochemical parameters of grower pigs fed cassava peel meal-maize cob mixture (CPMCM).

| **Parameters** | **T1** | **T2** | **T3** | **T4** | **SEM** | **REFERENCE RANGE** |
|---|---|---|---|---|---|---|
| Total protein (G/DL) | 6.12$^{b}$ | 7.18$^{a}$ | 7.22$^{a}$ | 7.25$^{a}$ | 0.02 | 4.40-9.21 |
| Albumin (G/DL) | 4.01$^{b}$ | 4.70$^{a}$ | 4.81$^{a}$ | 4.70$^{a}$ | 0.10 | 1.90-4.00 |
| Globulin (G/DL) | 2.11$^{b}$ | 2.48$^{a}$ | 2.41$^{a}$ | 2.55$^{a}$ | 0.45 | 2.00-4.20 |
| Cholesterol (Mmol/L) | 3.02 | 3.11 | 3.09 | 3.00 | 0.36 | 2.00-4.50 |
| Urea (Mmol/L) | 2.85 | 2.30 | 2.00 | 2.70 | 0.10 | 2.90-9.93 |
| Creatinine (µmol/L) | 59.81$^{c}$ | 60.80$^{b}$ | 67.00$^{a}$ | 67.18$^{a}$ | 2.09 | 67.0-188.0 |
| Total bilirubin (µmol/L) | 3.70$^{c}$ | 5.31$^{b}$ | 6.11$^{a}$ | 6.28$^{a}$ | 0.72 | 2.00-9.50 |
| Direct bilirubin (µmol/L) | 1.93$^{b}$ | 3.03$^{a}$ | 3.00$^{a}$ | 3.06$^{a}$ | 0.12 | 0-4.00 |
| Glucose (Mmol/L) | 3.11$^{b}$ | 5.66$^{a}$ | 5.87$^{a}$ | 5.92$^{a}$ | 0.25 | 3.50-10.40 |
| ALT (IU/L) | 74.08 | 73.67 | 74.06 | 74.07 | 2.33 | 15.0-98.0 |
| AST (U/L) | 65.67 | 65.00 | 64.84 | 65.53 | 1.97 | 22.0-100.7 |
| ALP (U/L) | 113.1 | 113.5 | 113.8 | 114.0 | 3.55 | 10.2-200.6 |

Note: $^{a, b, c}$ Means on the same row with different superscripts are significantly different ($p$ < 0.05); T1: 0% CPMCM; T2: 40% CPMCM; T3: 50% CPMCM; T4: 60% CPMCM; SEM: standard error of mean; ALT- alanine transaminase, AST- aspartate transferase, ALP- alanine phosphatase; Reference range: Merck's veterinary manual (2010). Source: Authors, 2024.

The results revealed that there was significant difference ($p$ < 0.05) in all parameters among all dietary treatments. Pigs fed T3 (50% CPMCM) and T4 (60% CPMCM) recorded the highest ($p$ < 0.05) value of IgA, IgG and IgM followed by T2 (40% CPMCM) and T1 (0% CPMCM) (Table 5). This suggests that the presence of phytochemicals in CPMCM especially flavonoids may pose improve immune functions in pigs. According to Hashem et al. (2013); Alagbe (2024), flavonoids has been found to have antioxidant, anti-inflammatory and immunomodulation activities. Activities of these phytochemicals in CPMCM will further maintain a healthy gut in pigs. The result recorded in this study, is in agreement with the findings of Tripathi et al. (2008) who used FarmazymeR supplementation on processed cassava meal to feed growing pigs.

Table 5. Immune status of grower pigs fed CPMCM.

| Specifications | T1 | T2 | T3 | T4 | SEM |
|---|---|---|---|---|---|
| IgA (µg/mL) | 1.58$^{b}$ | 2.26$^{ab}$ | 2.31$^{ab}$ | 2.97$^{a}$ | 0.92 |
| IgG (µg/mL) | 2.70$^{c}$ | 2.78$^{c}$ | 3.00$^{b}$ | 5.93$^{a}$ | 0.28 |
| IgM (µg/mL) | 1.93$^{b}$ | 1.98$^{b}$ | 2.50$^{a}$ | 2.60$^{a}$ | 0.85 |

Note: $^{a, b, c}$ Means on the same row with different superscripts are significantly different ($p$ < 0.05); T1: 0% CPMCM; T2: 40% CPMCM; T3: 50% CPMCM; T4: 60% CPMCM; SEM: standard error of mean; IgA:immunoglobulin A; IgG: Immunoglobulin G; IgM: Immunoglobulin M. Source: Authors, 2024.

**4. Conclusions**

Livestock production and sustainability lies in the ability to produce healthy and least cost ration using available raw materials to meet up with animals nutritional requirements. It was concluded that cassava peel and Maize cob can be explored in the production of feed for swine because it contains several essential nutrients which can positively influence the performance of pigs. Replacing maize with CPMCM had no deleterious effect on the health status of animals.

**5. Acknowledgments**

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### 6. Authors Contributions

*Daniel Nnadozie Anorue*: wrote the manuscript, did the statistical analysis and gathered all results together.

### 7. Conflicts of Interest

No conflicts of interest.

### 8. Ethics Approval

Yes applicable. The study follows the standards of the Nigerian Ethics Committee with the data: ANS/19/003. The study follows: Animal Research: Reporting of *in vivo* experiments (ARRIVE).

### 9. References

Adesehinwa, A. O. K. (2016). Energy and protein requirements of pigs and the utilization of fibrous feedstuffs in Nigeria. *African Journal of Biotechnology*, 7(25), 4798-4806.

Adesehinwa, A. O. K., Obi, O. O., Makanjuola, B. A., Oluwole, O. O., & Adesina, M. A. (2011). Growing pigs fed cassava peel based diet supplemented with or without Farmazyme® 3000 proenx: Effect on growth, carcass and blood parameters. *African Journal of Biotechnology*, 10, 2791-2796. https://doi.org/10.5897/AJB10.967

Adewale, A. O., Alagbe, J. O., & Adeoye, A. O. (2021). Dietary supplementation of *Rauvolfia vomitoria* root extract as a phytogenic feed additive in growing rabbit diets: Haematology and serum biochemical indices. *International Journal of Current Researches in Sciences, Social Sciences and Languages*, 1(3), 15-26. https://www.ijcrsssl.com/papers/v1/i3/IJCRSSSLV1I30003.pdf

Alagbe, J. O (2023). Investigating the effects of dietary supplementation of *Eucalyptus camaldulensis* essential oil on haemato-biochemical indices, immune response and oxidative stress of weaned rabbits. *Matrix Science Pharma*, 7(3), 103-108. https://doi.org/10.4103/mtsp.mtsp_17_23

Alagbe, J. O (2023). Investigating the effects of dietary supplementation of *Eucalyptus camaldulensis* essential oil on the growth performance, nutrient digestibility and caecal fermentation of weaned rabbits. *Research in: Agricultural and Veterinary Sciences*, 7(3): 139-148. http://jomardpublishing.com/UploadFiles/Files/journals/RV/V7N3/Alagbe.pdf

Alagbe, J. O., & Anuore, D. N. (2023). Effect of doum palm mesocarp meal (*Hyphaene thebaica*) as partial replacement for maize on growth performance and heamatological indices of weaned pigs. *Journal of Biotechnology and Bioinformatics Research*, 5(3), 1-6. http://doi.org/10.47363/JBBR/2023(5)161

Alagbe, J. O., Anuore, D. N., Daniel, S. M., & Ramalan, S. M. (2023). Growth performance and physiological response of weaned pigs fed diet supplemented with novel a phytogenics. *Brazilian Journal of Science*, 3(1), 43-57. https://doi.org/10.14295/bjs.v3i1.444

Alagbe, J. O. (2017). Growth performance and blood parameters of weaner pigs fed diets supplemented with turmeric powder. *Scholarly Journal of Agricultural Science*, 7(2), 57-61.

Alagbe, J. O. (2017). Nutrient evaluation of sweet orange (*Citrus sinensis*) fruit peel as a replacement for maize in the diets of weaner grass cutters. *Scholarly Journal of Agricultural Science*, 6(8), 277-282.

Alagbe, J. O. (2023). Impact of dietary supplementation of *Carica papaya* essential oil on the blood chemistry of broiler chickens. Food *Science & Applied Microbiology Reports*, 2(2), 58-67. https://doi.org/10.61363/meqmwj94

Alagbe, J. O (2023). Investigating the effects of dietary supplementation of *Eucalyptus camaldulensis* essential oil on the growth performance, nutrient digestibility and caecal fermentation of weaned rabbits. *Research in: Agricultural and Veterinary Sciences*, 7(3), 139-148.

Anorue, D. N., Ubong F., & John, A. O. (2023). Investigating the effects of pawpaw (*Carica papaya*) essential oil dietary supplementation on the growth performance and carcass characteristics of broilers. *Research in: Agricultural and Veterinary Sciences*, 7(3), 164-174.

Daramola, J. O., Adeloye, A. A., Fatoba, T. A., & Soladoye, A. O. (2005). Haematological and serum biochemical parameters of West African Dwarf goats. *Livestock Research for Rural Development*, 17(8). Available at: http://www.irrd.org17/8/clara/17095.htm

Etim, N. N., Enyenihi, G. E., Akpabio, U., & Offiong, E. E. A. (2014a). Effects of nutrition on haematology of rabbits: A Review. *European Scientific Journal*, 10(3), 413-424. https://core.ac.uk/download/pdf/236412845.pdf

Jain, N. C. (1986). Schalm's Veterinary Haematology. 4th Edition, Lea and Febiger, Philadelphia.

Kosemani, B. S., & Bamgboye, A. I. (2021). Modelling energy use pattern for maize (*Zea mays* L.) production in Nigeria. *Cleaner Engineering and Technology*, 2, 100051. https://doi.org/10.1016/j.clet.2021.100051

Mathivanan, R., Selvaraj, P., & Nanjappan, K. (2006). Feeding of fermented soybean meal on broiler performance. *International Journal of Poultry Science*, 5(9), 868-872.

Maxwell, M. H., Robertson, G. W., Spence, S., & McCorquodale, C. C. (1990). Composition of haematological values in restricted and ad libitum fed domesticated fowls. RBC characteristics. *British Poultry Science*, 60, 1474-1484.

Merck Veterinary Manual. (2010). Merck Veterinary. *In*: Manual 10th edition. Merck and Co. Inc. Rahway N. J.

Mitruka, H. M., & Rawnsley, S. K. (1977). Chemical, biochemical and haematological reference in normal experimental animals. Mason, N.Y., 287-380 p.

Musa, B., Alagbe, J. O., Betty, A. M., & Omokore, E. A. (2020). Growth performance, caeca microbial population and immune response of broiler chicks fed aqueous extract of *Balanites aegyptiaca* and *Alchornea cordifolia* stem bark mixture. UIJRT - *United International Journal for Research & Technology*, 1(11), 13-21. https://uijrt.com/articles/v1/i11/UIJRTV1I110002.pdf

NPC. (2006). National Population Commission, National Population Census Headquarters, Abuja, Nigeria.

NRC. (2012). Nutrient Requirements of Poultry. *In*: 9th Revised Edn. National Academy of Service Washington DC.

Odunsi, A. A., Ojifade, A. A., & Babatunde, G. M. (1999). Response of broiler chicks to virginmycin and dietary protein concentration in the humid tropics. Archivos de Zootecnia, 48(183), 317-325. https://dialnet.unirioja.es/servlet/articulo?codigo=4141

Oke, U. K., Herbert, U., Ebuzoeme, C. O. and Nwachukwu, E. N. (2007). Effect of genotype on the haematology of Nigerian local chickens in a humid tropical environment. Proceedings of 32nd Annual Conference of Nigerian Society for Animal Production (NSAP), Calabar, Nigeria 18th-21st March, 18-21 p.

Okoli, F. C., Okparaocha, C. O., Chinweze, C. E., & Udedibie, A. B. I. (2012). Physicochemical and hydrogen cyanide content of three processed cassava products used in feeding poultry in Nigeria. *Asian Journal of Animal and Veterinary Advances*, 7(4), 334-340.

Olabanji, R. O., Farinu, G. O., Akinlade, J. A., & Ojebiyi, O. O. (2007). Growth performance and haematological characteristics of weaner rabbits fed cyanide in processed cassava peel meals on haematological and biochemical indices of growing rabbits. Proc. of the 35th Annual Conference of the Nigerian Society for Animal Products, 212 p.

Oladimeji, S. O., Adeyemi, A. A., Mosuro, A. O., Adebayo, B. F., Etop, S. C., Adebiyi, F. G., & Ogunwole, O. A. (2022). Nutritional composition of cassava (*Manihot esculenta* Crantz) peel products. *Livestock Research for Rural Development*, 34(10), 1-7. https://www.lrrd.org/lrrd34/10/3490olad.html

Oladunjoye, I. O., Ojedapo, L. O., & Ojebiyi, O. O. (2005). Essential of non ruminant animal production. *In*: Publisher positive press Ibadan, Nigeria.

Oladunjoye, I. O., Ojebiyi, O. O., & Odunsi, A. A (2008). Performance, characteristics and egg quality of laying chicken fed lyre treated cassava peel meal. *In*: Proceedings of the Annual Conference of ASAN. 12th -19th September. ABU, Zaria, 355-357 p.

Oladunjoye, I. O., Ojebiyi, O., & Amao, O.A (2010). Effect of feeding processed cassava (*Manihot esculenta* Crantz) peel meal based diet on the performance characteristics, egg quality and blood profile of laying chicken. *Agricultural Tropica et Subtropica*, 43(2), 119-126.

Olafedehan, O. A., Olafadehan, O. O., Adewumi, M. K.,Omotugba, S. K., & Daniel N. E. (2008). Proceedings of the 33rd Annual Conference, Nigeria Society of Animal Production, 132-135 p.

Oleforuh-Okoleh, V. U., Adeolu, A. I., & Egbuhelu C. O. (2010). Growth performance and economic benefits of cockerels fed diet containing graded levels of cassava peel meal. *In*: Proceedings of the 35th Annual Conference of the Nigeria Society for Animal Production. March 14-17th, University of Ibadan Nigeria, 324-326 p.

Shittu, M. T., Alagbe, J. O., Ojebiyi, O. O., Ojediran, T. K., & Rafiu, T. A. (2022). Growth performance and haematological and serum biochemical parameters of broiler chickens given varied concentrations of *Polyalthia longifolia* leaf extract in place of conventional antibiotics. *Animal Science and Genetics*, 18(2).

Togun, V. A., Oseni, B. S. A., Ogundipe, J. A., Arewa, T. R., Hameed, A. A., Ajonijebu, D. C., Oyeniran, A., Nwosisi, I. and Mustapha, F. (2007). Effects of chronic lead administration on the haematological parameters of rabbit - a preliminary study. *In*: Proceedings of the 41st Conferences of the Agricultural Society of Nigeria, Zari, 22-26 October, 341 p.

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