Physiological Response and Growth Performance of Broiler Chickens Fed Different Levels of Neem (*Azadirachta indica*) Leaf Powder as Phytogenic Additive

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Abstract

Neem leaf powder as a phytogenic feed additive is gaining recognition due to its potential to improve poultry production. This study was carried out to investigate the effects of neem leaf powder on broilers' blood profile and growth performance. A total of 100-day-old Arbor Acre broiler chicks were used and randomly allotted into five groups. The groups were designated as T_1, T_2, T_3, T_4 and T_5 containing 0%, 0.3%, 0.4%, 0.5%, and 0.6% of neem leaf powder respectively. Each group had four replicates with five birds per replicate in a Completely Randomized Design. Haematological results revealed no significant differences in PCV, Hb, RBC, WBC, platelets, monocytes, and eosinophils, but lymphocytes and neutrophils showed significant variation, ranging from 38.50–40.50% and 58.50–61.00%, respectively, at days 28 and 42. Neem powder significantly influenced cholesterol, triglycerides, AST, ALT, and glucose levels. Notably, T5(0.6%) recorded the highest cholesterol and triglycerides at day 28 (43.25 and 43.50) and at day 42 (47.75 and 44.70), while T3(0.4%) had elevated AST and ALT. Growth parameters results showed a significant difference in feed intake, with T1(0.0%) birds consuming more feed (8.66) than other groups, though final weight and FCR did not differ significantly. From this study it is concluded that neem leaf powder above 0.5% may elevate cholesterol and triglycerides but can enhance immune modulation, health of the animal without compromising performance when used moderately.

Keywords: Alternative feed ingredients, Blood chemistry, Feed additives, Haematology, Health status, Organ function

Réponse physiologique et performance de croissance des poulets de chair nourris avec différents niveaux de poudre de feuilles de neem (*Azadirachta indica*) comme additif phytochimique

Résumé

La poudre de feuilles de neem en tant qu'additif alimentaire phytochimique gagne en reconnaissance en raison de son potentiel à améliorer la production avicole. Cette étude a été menée pour évaluer les effets de la poudre de feuilles de neem sur le profil sanguin et les performances de croissance des poulets de chair. Au total, 100 poussins de chair Arbor Acre d'un jour ont été utilisés et répartis aléatoirement en cinq groupes désignés comme T_1, T_2, T_3, T_4 et T_5, contenant respectivement 0 %, 0,3 %, 0,4 %, 0,5 % et 0,6 % de poudre de feuilles de neem. Chaque groupe comprenait quatre répétitions de cinq oiseaux chacune, selon un dispositif complètement randomisé. Les résultats hématologiques n'ont révélé aucune différence significative pour l'hématocrite (PCV), l'hémoglobine (Hb), les globules rouges (RBC), les globules blancs (WBC), les plaquettes, les monocytes et les éosinophiles. Cependant, les lymphocytes et les neutrophiles ont montré des variations significatives, avec des plages respectives de 38,50–40,50 % et 58,50–61,00 % aux jours 28 et 42. La poudre de neem a significativement influencé les taux de cholestérol, triglycérides, AST, ALT et glucose. Notamment, le groupe T5 (0,6 %) a enregistré les valeurs les plus élevées de cholestérol et triglycérides au jour 28 (43,25 et 43,50) et au jour 42 (47,75 et 44,70), tandis que le groupe T3 (0,4 %) présentait des niveaux élevés d'AST et d'ALT. Les paramètres de croissance ont montré une différence significative dans la consommation alimentaire, les oiseaux du groupe T1 (0,0 %) consommant plus d'aliments (8,66) que les autres groupes, bien que le poids final et l'indice de conversion alimentaire (FCR) ne diffèrent pas significativement. Cette étude conclut qu'une poudre de feuilles de neem à plus de 0,5 % peut augmenter le cholestérol et les triglycérides, mais peut améliorer l'immunomodulation et la santé de l'animal sans compromettre ses performances lorsqu'elle est utilisée avec modération.

Mots-clés : Ingrédients alimentaires alternatifs, Biochimie sanguine, Additifs alimentaires, Hématologie, État de santé, Fonction des organes

Introduction

The poultry industry has become the world's leading supplier of efficient, high-quality animal proteins (Rabobank, 2025). Broiler chicken is one of the most economically important protein sources. (Korver, 2023). The rapid global growth of poultry production drives increasing demand However, the problem of attaining optimal health and productivity in broiler chickens persists, especially in environments like Nigeria where environmental conditions like disease prevalence and the high cost of conventional feed ingredients are formidable. (Anosike, 2021; Cocou *et al*., 2021). In recent years, the inclusion of phytogenic feed additives in poultry nutrition has garnered attention, mainly because of their capacity to boost immunological responses, optimise growth performance, and mitigate dependency on artificial growth promoters and antibiotics (Windisch *et al*., 2008; Rehman *et al*., 2022). Gonzalez and Vargas (2022) reported that feed additives have gained popularity in poultry production because of their many advantages, without leaving any residues in poultry products such as Neem leaf. Neem (*Azadirachta indica*), popularly known as Indian neem (margosa) or Dogoyaro is of the family *Maliaceae* and is one of such non-conventional and available ingredient sources in the tropics with great potential in the 21st century. Ganguli (2002); Kabeh and Jalingo (2007); Koona and Budida (2011); and Ogbuewu *et al*. (2011); all described the neem leaf as a tropical tree plant which is widely distributed in Africa, and available all year round. Neem (*Azadirachta indica*), a tropical evergreen tree has been attracting worldwide importance in agriculture and traditional medication with its incredible array of absolutely natural pharmacological benefits, which only some other plants might come near (Marina and Scott 2022). For example, Neem leaves are known to have several bioactive chemicals like nimbin, nimbidin, saponin, tannins, flavonoids, and steroids that have antibacterial, anti-inflammatory, and antioxidant properties like limonoids, flavonoids, and terpenoids. (Verma *et al*., 2017; Tasha *et al*., 2025). Because of these properties, research has been emphasized to reveal the possibilities of utilisation of neem leaf meal as a feed supplement which is widely considered in poultry nutrition as a promising phytogenic additive due to its potential to boost growth performance, immune responses, and gut health status of broiler chickens (Esonu *et al*., 2006; Amaechi *et al*., 2020). Owning to its dynamic nature, blood is a major indicator or reflector of the physiological, pathological and nutritional statuses of the animal body. This is because the blood is susceptible to internal and external changes/stimuli provoked by nutrition, pests, diseases, metabolism, seasonal and any other stimuli or stressors to which the animal may respond (Salami and Odunsi 2017). Evaluation of the blood profile of farm animals is, therefore, pertinent in monitoring the metabolic status of farm animals, feed quality, disease diagnosis, prophylaxis and treatment as well as evaluation of adaptation traits to various ecological/environmental factors. For fast-growing animals like broiler chickens, nutritional studies should therefore not be limited to the assessment of the biological performance traits, carcass and organ evaluation but also to the evaluation of the animal's blood profile. Therefore, this study envisioned assessing the physiological response and the growth performance of the broiler chickens when fed with diets supplemented with varied levels of neem leaf powder as a phytogenic feed additive.

Materials and methods

The research was carried out at the Poultry Unit of the Teaching and Research Farm, University of Ibadan, Oyo State, Nigeria. This study area is situated between latitude 07^0 23' 28.19" N and longitude 03^0 54' 59.99" E with elevation ranging from 205m – 227m above.

Procurement and processing of the experimental material

Fresh leaves from a neem tree were harvested, shed and air dried for two weeks till they became dried and the colour changed to light brown. Direct contact with sunlight was avoided to prevent the loss of active components of the neem leaves. The dried leaves were then ground to powder to enhance the easy mixture with the feed of the birds according to Salisu *et al.* (2022).

Experimental animals and management

A total of one hundred Arbor Acres day-old chicks were used for the experiment. The birds were brooded for 2 weeks to adjust to feed and confinement before the actual start of the experiment. The experiment was carried out for four weeks and the birds were reared for a total of six weeks. Feed and water were given *ad libitum*, the birds were fed without the test ingredient for the first two weeks. Proper sanitation, routine vaccination and medications were maintained to prevent any disease outbreak.

Experimental design

The Completely Randomized Design (CRD) was adopted for this experiment. The 100 two-week-old chicks were randomly allotted to five treatments (T1, T2, T3, T4, and T5) having four replicates each. A total of five birds were randomly assigned per replicate.

Experimental diet

A basal diet was formulated both during the starter and the finisher phase. The starter and finisher diets with 23%CP, 3200Kcal/Kg ME and 19%CP, 3100Kcal/Kg respectively were compounded to meet the nutritional requirements of the birds. The quantity of neem leaf powder used was measured and mixed thoroughly to ensure proper mixing through over-the-top method. Treatment 1 (T1) was the control diet, it had no inclusion of neem leaf powder per 100% composite feed, treatment 2 (T2) had 0.3% inclusion of neem leaf powder per 100% composite feed, treatment 3 (T3) had 0.4% inclusion of neem leaf powder per 100% composite feed, treatment 4 (T4) had 0.5% inclusion of neem leaf powder per 100% composite feed, treatment 5 (T5) had 0.6% inclusion of neem leaf powder per 100% composite feed.

Table 1: Composition of the experimental broiler starter diet (%)

Ingredients	**T1 (0%)**	**T2 (0.3%)**	**T3 (0.4%)**	**T4 (0.5%)**	**T5 (0.6%)**
Maize	42.00	42.00	42.00	42.00	42.00
Soya bean meal	39.60	39.30	39.20	39.10	39.00
Wheat offals	14.50	14.50	14.50	14.50	14.50
Fish meal	2.00	2.00	2.00	2.00	2.00
Palm oil	0.50	0.50	0.50	0.50	0.50
Bone meal	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25
Limestone	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Table salt	0.20	0.20	0.20	0.20	0.20
Neem leaf meal	0.00	0.30	0.40	0.50	0.60
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient composition					
Energy (Kcal/Kg)	2894.50	2895.10	2895.30	2895.50	2895.70
Crude protein (%)	24.18	24.09	24.00	24.04	24.01
Crude fibre (%)	5.28	5.31	5.58	5.33	5.34
Available Calcium (%)	0.48	0.49	0.30	0.49	0.50
Available Phosphorus(%)	0.49	0.52	0.41	0.49	0.49

Vitamin & Mineral Premix (Starter) composition
Vitamin A 30,000,000 i.u, vitamin D3 6,000,000 i.u, vitamin E 30,000 i.u, vitamin K 2,000 mg, vitamin B 25,000 mg, vitamin C 20 g, niacin 40,000 mg, pantothenic acid 12,000 mg, vitamin B6 1,500.00 mg, vitamin B12 10,000 mg, folic acid 1,000 mg, biotin 400 mg, choline chloride 300,000 mg, cobalt 200 mg, copper 1,200 mg, iodine 20,000 mg, Iron 40,000 mg, manganese 100,000 mg, selenium 150 mg, zinc 30,000 mg, antioxidant 1, 250 mg.

Table 2: Composition of the experimental broiler finisher diet (%)

Ingredients	**T1 (0%)**	**T2 (0.3%)**	**T3 (0.4%)**	**T4 (0.5%)**	**T5 (0.6%)**
Maize	50.00	50.00	42.00	42.00	42.00
Soya bean meal	31.60	31.30	31.20	31.10	31.00
Wheat offal	14.50	14.50	14.50	14.50	14.50
Fish meal	2.00	2.00	2.00	2.00	2.00
Palm oil	0.50	0.50	0.50	0.50	0.50
Bone meal	0.50	0.50	0.50	0.50	0.50
Premix	0.25	0.25	0.25	0.25	0.25
Limestone	0.25	0.50	0.50	0.50	0.50
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Table salt	0.20	0.20	0.20	0.20	0.20
Neem leaf meal	0.00	0.30	0.40	0.50	0.60
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient composition					
Energy (Kcal/Kg)	2950.50	2943.00	2953.30	2954.00	2954.70
Crude protein (%)	21.22	21.13	21.04	20.99	20.95
Crude fibre (%)	4.96	4.99	4.94	4.93	4.92
Calcium(%)	0.21	0.21	0.21	0.21	0.21
Available Phosphorus (%)	0.40	0.43	0.39	0.39	0.39

Vitamin & Mineral Premix (Finisher) composition
Vitamin A 8,000,000 i.u, vitamin D31,600,000 i.u, vitamin E 15,000 i.u, vitamin K 2,000 mg. vitamin B2 3,000 mg, vitamin C 20 g, niacin 20,000 mg, pantothenic acid 6,000 mg, vitamin B6 1,500.00 mg, vitamin B/2 10,000 mg, folic acid 500 mg, biotin 400 mg, choline chloride 150,000 mg, cobalt 100 mg, copper 600 mg, iodine 10,000 mg, Iron20,000 mg, manganese 90,000 mg, selenium 100 mg, zinc 20,000 mg, antioxidant 1,300 mg.

Data Collection

Feed Intake

At the beginning of each week, a known quantity of feed was measured for the birds. The feed was offered twice daily (morning and evening), and the birds had ad *libitum* access during these periods. Feed refusals were collected and weighed daily. The total leftover feed for the week was calculated by summing the daily leftovers to determine weekly feed intake.

Body Weight Gain

The weight of the birds was recorded at the end of every week to determine the weekly body weight gain. Weight gain i.e Final weight – Initial weight.

Feed Conversion Ratio

This refers to the ratio of feed intake to weight gained by the bird. Feed Conversion Ratio (FCR) was computed as the total feed intake divided by the weight gain. i.e. FCR = Feed intake / Weight gain.

Blood Collection

Blood collection was done in the 4th and 6th week of the experiment for the broiler starter and finisher phases respectively. A bird per replicate was randomly selected to make a total of four birds per treatment. 5 mL of blood, haematology and serum biochemistry was collected) was collected very early in the morning from the jugular vein found around the right side of the

chicken's neck. The 2 mL of blood was collected into sample bottles containing Ethylene Diamine Tetra Acetate (EDTA) and processed to analyze the haematological parameters while the 3 mL blood was collected in a plain bottle without anti-coagulants and was allowed to clot at room temperature, it was later centrifuged at 3000rpm for 5 minutes to obtain serum for biochemical studies according to method of Kohn and Allen (1995).

Haematological Parameters

The following hematological parameters were assessed: Pack Cell Volume (PCV), Heamoglobin (Hb), Red Blood Cell (RBC), White Blood Cell (WBC), Lymphocytes, Neutrophils, Monocyte and Eosinophils as outlined by (Adeyemi *et al*., 2000; Feldman *et al*., 2000) and all these parameters were analysed in this study.

Serum Biochemical Parameters

Blood was analysed for albumin, globulin, glucose, triglycerides, cholesterol, and serum enzymes like Alanine Amino Transferase (ALT), and Aspartate Amino Transaminase (AST) as outlined by Ochei and Kolhatker (2000). Biuret method of serum total protein determination was employed as described by Kohn and Allen (1995). Albumin was determined using Bromcresol Green (BCG) method as described by Peter *et al*. (1982). The globulin concentration was obtained by subtracting albumin values from the total protein while the albumin/globulin ratio was obtained by dividing the albumin value by the calculated globulin value. Alanine amino transferase and Aspartate amino transferase activity were determined using spectrophotometric method with their respective kits.

Statistical analysis

All data collected were analyzed using one-way analysis of variance (Statistical Analysis System, version 9.2, 2017) and the differences in mean values were separated using the Tukey's Honestly Significant Difference. Values were considered statistically significant at $P<0.05$.

The design for the model used is as follows:

$Y_{ij} = \mu + T_i + e_{ij}$

Where;

Y_{ij} = individual observation

μ = Overall mean

T_i = Effect of treatment diets

e_{ij} = Experimental error.

Results

Table 3: Haematological Indices of Broiler Birds Fed Different Inclusion Levels of Neem Leaf Powder at Starter Phase

	Treatments					
Parameters	**T1 (0%)**	**T2 (0.3%)**	**T3 (0.4%)**	**T4 (0.5%)**	**T5 (0.6%)**	**SEM**
PCV (%)	25.00	29.00	29.00	27.50	27.25	0.52
Hb (g/dl)	8.25	9.60	9.60	9.10	9.03	0.17
RBCx10^{12}/L	4.85	4.41	5.01	3.73	5.26	0.23
WBCx10^{12}/L	4.80	4.50	5.85	3.90	3.75	0.35
Platelet x10^{12}/L	7.00	8.50	8.50	8.50	8.00	0.23
Lymphocyte (%)	40.25^{ab}	38.50^{b}	40.50^{a}	39.25^{ab}	39.50^{ab}	0.24
Neutrophil (%)	58.75^{ab}	61.00^{a}	58.50^{b}	60.25^{ab}	60.00^{ab}	0.31
Eosinophil (%)	0.00	0.00	0.00	0.00	0.00	0.00
Monocyte (%)	1.00	0.50	1.00	0.75	0.50	0.18

^{a,b,c} means with different superscripts on the same row are significantly different ($p<0.05$).

- PCV (%) – Packed Cell Volume
- Hb (g/dl) – Hemoglobin

- RBC ($x10^{12}$/L) – Red Blood Cell count
- WBC ($x10^{12}$/L) – White Blood Cell count
- SEM – Standard Error of Mean

Table 4 shows PCV (%) parameters of broiler starter birds aged 4 weeks fed different inclusion level of neem leaf powder. PCV and hemoglobin levels show no significance difference, this trend is also observed in other parameters like RBC, WBC, Platelets, Eosinophil and Monocytes but not in Lymphocytes and Neutrophils. PCV, Hemoglobin, and Platelets in T2, T3, T4 and T5 are relatively higher as compared to T1. T3 however, has the highest level of WBC as compared to other treatments while T5 and T3 has the highest and second highest count of RBC respectively.

Table 4: Haematological Indices of Broiler Birds Fed Different Inclusion Levels of Neem Leaf Powder at Finisher Phase

Parameters	Treatments T1 (0%)	T2 (0.3%)	T3 (0.4%)	T4 (0.5%)	T5 (0.6%)	SEM
PCV (%)	25.00	29.00	29.00	27.50	27.25	0.52
Hb (gm%)	8.25	9.60	9.60	9.10	9.03	0.17
RBC$x10^{12}$/L	4.85	4.41	5.01	3.73	5.26	0.23
WBC$x10^{12}$/L	4.80	4.50	5.85	3.90	3.75	0.35
Platelets $x10^{12}$/L	7.00	8.50	8.50	8.50	8.00	0.23
Lymphocytes (%)	40.25^{ab}	38.50^{b}	40.50^{a}	39.25^{ab}	39.50^{ab}	0.24
Neutrophils (%)	58.75^{ab}	61.00^{a}	58.50^{b}	60.25^{ab}	60.00^{ab}	0.30
Eosinophils (%)	0.00	0.00	0.00	0.00	0.00	0.00
Monocytes (%)	1.00	0.50	1.00	0.75	0.50	0.18

^{a,b,c} means with different superscripts on the same row are significantly different ($p<0.05$).

PCV (%) – Packed Cell Volume
Hb (g/dL) – Hemoglobin
RBC ($x10^{12}$/L) – Red Blood Cell count
WBC ($x10^{12}$/L) – White Blood Cell count
SEM – Standard Error of Mean

Table 4 shows the haematological indices of broiler birds at finisher birds aged 6 weeks fed different inclusion level of neem leaf powder. PCV and Hemoglobin values show no significance difference, this trend is also observed in other parameters like RBC, WBC, Platelets, Eosinophil and Monocytes but not in Lymphocytes and Neutrophils. PCV, Hemoglobin, and Platelets in T2, T3, T4 and T5 are relatively higher as compared to T1. T3 however, has the highest level of WBC as compared to other treatments while T5 and T3 has the highest and second highest count of RBC respectively.

Table 5: Serum Biochemical Indices of Broiler Birds Fed Different Inclusion Levels of Neem Leaf Powder at Starter Phase

Parameters	Treatments T1 (0%)	T2 (0.3%)	T3 (0.4%)	T4 (0.5%)	T5 (0.6%)	SEM
TP(g/100mL)	3.26	3.55	2.55	3.04	2.60	0.13
Albumin(g/dL)	1.30	1.27	1.16	1.27	1.21	0.03
Globulin(g/dL)	1.96	2.28	1.39	1.77	1.39	0.12
Cholesterol(mg/dL)	26.50^{ab}	24.50^{b}	21.75^{b}	28.25^{ab}	43.25^{a}	2.32
Triglyceride(mg/dL)	29.50^{b}	27.50^{b}	24.75^{b}	31.50^{ab}	43.50^{a}	1.94
AST(U/L)	59.75^{ab}	54.00^{bc}	46.25^{c}	36.25^{d}	69.00^{a}	2.72
ALT(U/L)	50.25^{ab}	43.75^{bc}	36.00^{c}	26.25^{d}	57.50^{a}	2.61
Glucose(mg/dL)	69.75^{b}	65.00^{c}	52.75^{d}	47.25^{e}	75.50^{a}	2.43

^{a,b,c} means with different superscripts on the same row are significantly different ($p<0.05$).

TP – Total Protein
AST – Aspartate Amino Transferase
ALT – Alanine Amino Transferase
SEM – Standard Error of Mean

Serum biochemical indices of broiler starters aged four weeks and fed different inclusion level of neem leaf powder is presented in Table 5. Total protein, Albumin and Globulin show no significance difference while other parameters show significance difference. However, T1 and T5 showed a higher significant difference compared to other treatments for ALT, AST and Glucose, while T5 has higher significant difference for Cholesterol and Triglyceride.

Table 6: Serum Biochemical Indices of Broiler Birds Fed Different Inclusion Levels of Neem Leaf Powder at Finisher Phase

Parameters	Treatments T1 (0%)	T2 (0.3%)	T3 (0.4%)	T4 (0.5%)	T5 (0.6%)	SEM
TP (g/100mL)	3.35	4.20	3.41	3.72	4.45	1.05
Albumin (g/dL)	1.45	1.97	1.33	1.57	2.26	0.66
Globulin(g/dL)	1.91	2.23	2.08	2.16	2.27	0.86
Cholesterol(mg/dL)	35.75^{ab}	45.25^{ab}	32.75^{b}	42.25^{ab}	47.75^{a}	7.97
Triglyceride(mg/dL)	22.25^{b}	24.50^{b}	21.25^{b}	23.00^{b}	44.70^{a}	10.38
AST(U/L)	57.75^{ab}	62.50^{ab}	66.75^{a}	52.50^{ab}	53.00^{ab}	7.96
ALT(U/L)	40.75	46.25	51.50	42.00	44.75	6.26
Glucose (mg/dL)	62.25^{b}	53.00^{c}	43.50^{d}	63.25^{b}	72.25^{a}	10.28

^{a,b,c} means with different superscripts on the same row are significantly different ($p<0.05$).

TP – Total Protein
AST – Aspartate Amino Transferase
ALT – Alanine Amino Transferase

SEM – Standard Error of Mean

Serum biochemical indices of broiler finishers aged six weeks and fed different inclusion level of neem leaf powder is presented in Table 6. Total protein, Albumin, Globulin and ALT show no significance difference while other parameters show significance difference. However, T5 showed a higher significant difference in Cholesterol and Triglycerides as compared to other treatments, while T3 has higher significant difference for AST and ALT.

Table 7: Growth Performance of Broilers Chickens Fed Different Inclusion Level of Neem Leaf Powder

Parameters	Treatments T1 (0%)	T2 (0.3%)	T3 (0.4%)	T4 (0.5%)	T5 (0.6%)	SEM
Initial weight (Kg)	1.10	0.89	1.00	0.96	1.11	0.16
Final weight (Kg)	7.15	6.84	6.83	6.49	6.74	0.52
Weight gain(Kg)	6.05	5.95	5.83	5.53	5.63	0.43
Feed intake (Kg)	8.66^{a}	7.77^{ab}	7.95^{ab}	7.55^{b}	8.29^{ab}	0.22
FCR	1.44	1.30	1.37	1.38	1.48	0.11

^{a,b,c} means with different superscripts on the same row are significantly different ($p<0.05$).

FCR – Feed Conversion Ratio

SEM – Standard Error of Mean

Table 7 describes the growth performance of broilers fed different inclusion level of neem leaf powder. Feed intake of birds was significantly different with birds in T1 and T5 consuming more feed (8.66 kg) compared to birds in T2, (7.77) T3 (7.95) and T4 (7.55). The initial weight, final weight, weight gain and feed conversion ratio were not significantly different across all treatments.

Discussion

Haematological Indices of Broilers Chickens Fed Different Inclusion Level of Neem Leaf Powder

This study focused on the examination of the heamatology of broiler chicken fed different inclusion level of neem leaf powder. Packed Cell Volume (PCV), Red Blood Cell (RBC), White Blood Cell (WBC), Haemoglobin (Hb), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC), Mean Corpuscular Volume (MCV), Lymphocyte, Monocyte, Eosinophil, Neutrophil, and Basophil are among the haematological parameters that are most frequently used for assessment of the overall health of animals (Chineke, 2006; Adeyemi *et al*., 2000). According to Barde *et al*., (2022) the typical range of haematological parameters in chicken are: 27- 42% for Packed Cell Volume, $2.2 – 4.0 \times 10^{6}$µL for Red Blood Cell, $1.0 – 9.5 \times 10^{3}$µL for White Blood Cell, 20-50 for Lymphocytes, 0-4 for Eosinophils and 0-2 for Monocyte, 50-65 for Neutrophil, 7.0-11.0 for Hemoglobin. PCV and heamoglobin are crucial parameters used to determine the red blood cells in circulation and they are key to detection of anemia in broilers (Peters *et al*., 2011). According to Isaac *et al*., (2013), the transport of oxygen and absorbed nutrients is facilitated by PCV. A higher PCV indicates improved transportation, which raises primary and secondary polycythemia. PCV above the normal range is a sign of harmful substances that may negatively impact formation of blood (Togun *et al*., 2007). The findings from this study are in line with standard range (27-42%) as referenced by Barde *et al*., (2022), aside T1 where the PCV was 25%. However, it is obvious from the current study that the inclusion of *Azadirachta indica* in the diet of broilers supports blood cells proliferation as animals in T2 to T5 showed higher PCV values as compared to the control experiment (T1). The iron-containing oxygen-transport metalloprotein found in nearly all vertebrates is the Hemoglobin (Hb). Anemia or poor production of RBC is as a result of

reduced production of hemoglobin. In this study, the Hemoglobin concentration ranged 8.25 – 9.6 (g/dl). These values fall within the reference range of 7.0 – 11.0 (g/dl) for broiler chickens as reported by Barde *et al*. (2022). The heamoglobin concentration values however falls slightly below studies reported by Ayo-Enwerem *et al*. (2017) who in their study reported hemoglobin values ranging 8.5-11.00 (g/dL) and 9.83-10.70 (g/dL) respectively. This result indicates that all birds across the treatments in the current study exhibit a high capacity to resist respiratory stress. This is attributed to the presence of normal hemoglobin levels, which is the oxygen-carrying pigment found in red blood cells, essential for effective oxygen transport and respiratory function (Muhammad and Oloyede, 2009) White blood cells (Leukocytes) are very vital in fighting the effects of pathogens in the body of animals. Our entire environment is habitable with numerous pathogens organisms which pose constant challenge to the animal's body, hence the white blood cells stands as chief cells of defense in the mammalian body. This study revealed that there was no significant difference in the total White blood cells as well as platelets among treatments which fell within the normal range as reported by Barde *et al*., (2022). Although the lymphocyes and neutrophil counts fell into the normal range as repored by Barde *et al*. (2022), however, significant differences were observed in lymphocyte and neutrophils with T3 having the highest count and T2 having the highest count respectively. Animals with low WBC are exposed easily to disease causing pathogens while those with high WBC are able to combat the disease-causing pathogens and stand a chance of being healthy because of their high immune system. Hence, lymphocyte counts in T3 could be an indication of improved immunity in the animal. This correspond with the study by Jawad *et al*., (2013) where Neem leaf improved animals' health or immunity. There were no traces of Eosinophil recorded among all treatments. However, monocytes which are the largest of the white blood cells differentials have the tendency of migrating to the site of infection or inflammation in the body to eliminate infections or dead tissues. Although as reported by Barde *et al*.(2022), the Monocyte count in this study which ranges from 0.5-1.0% falls within the normal range of 0-2.0%. However, the presence of monocyte across the treatment could be a sign of infection among animals in the treatments. Thus, further study is needed to investigate the reason for the presence of monocyte in the animals fed 0.3-0.6% neem leaf powder.

Serum Biochemical indices of broilers fed different inclusion level of neem leaf powder

The serum biochemical tables as shown in tables 4.3 and 4.4 indicated that Total protein, Albumin and Globulin show no significance difference ($P<0.05$) while other parameters (Triglycerides, cholesterol, AST, ALT and glucose) show significant difference. However, T1 and T5 showed a higher significant difference compared to other treatments for ALT, AST, ALP and Glucose, while T5 has higher significant difference for Cholesterol and Triglyceride. Parameters of serum biochemistry are strong indicators of the general wellbeing, health, nutrition, and management exposed to the animals (Asaniyan and Akinduro, 2020). The availability of protein and micro nutrients in the blood is crucial for the production of albumin and globulin that is present in the animal. The highest value recorded for the Total protein at the end of the finisher phase was in T2 (3.55) and T5 (4.45) at the end of the experiment. Serum proteins are produced in the liver to preserve blood volume by the colloidal osmotic effect, buffer blood pH, carry medications and hormones, promote cell coagulation, catalyze enzymatic reactions, control hormones, and protect the body from external substances (Mmereole, 2008). The high globulin and albumin levels in T2 and T5 in the starter and finisher phase respectively contribute to the total protein's high value. The AST value is observed to fall within the normal range,(40-80 IU/L) this is in line with findings by Obikaonu *et al*. (2011). However, ALT values significantly rise above the normal range (0-45 IU/L) for liver enzymes which could indicate presence of toxins in the liver parenchyma of the birds. Further studies are therefore needed to investigate this situation. An increase in the level of serum AST and ALT can be as a result of exposure to toxins which may lead to inflammation, diseases or an alteration in permeability of hepatocellular membrane (Khanyile *et al*. 2016). Serum cholesterol (triglycerides) are synthesised in the

intestinal mucosa and in the liver from the digestion of dietary components and the absorption of fatty acids. The result shows that the Neem leaf meal significantly ($P<0.05$) influenced the triglyceride and cholesterol level as it is observed that there is a change in the values of triglyceride across treatments and T5 having the highest values for Cholesterol and Triglyceride. Glucose also follows the trend of being significantly different within the treatments and T5 having the highest value of glucose. However, it is observed that the values of glucose in the treatments (43.5-72.25mg/dL) falls below the normal range of glucose in broilers 72-180mg/dL as reported by Daniel *et al*., (2016). This is a condition known as hypoglycemia which could indicate stress, inadequate nutrition or diseases in the animals.

Growth performance of broilers fed different inclusion level of neem leaf powder

The performance table showed significant difference in feed intake with T1 consuming more feed as compared to other treatments. However, there was no significant difference in the weight gain and feed conversion ratio amongst treatments. The significant drop in the feed intake among the treatments could indicate that at higher inclusion level of neem leaf powder, palatability of the feed may be affected due to the bitter taste of the neem leaf as reported by Deka *et al*., (2019). However, this had no significant difference on their weight gain and FCR which could imply that neem leaf may not directly improve animal's growth but could be vital in enhancing animal's performance with little feed intake. This was shown evidently in the weight gain where there was no significant difference among treatments despite the significant difference in feed intake. This study is in line with findings by Esonu *et al*., (2005) and Bonsu *et al*., (2012).

Conclusion

The study found that neem leaf powder, when used as a phytogenic additive in broiler chicken diets, did not significantly alter core haematological parameters, indicating its safety without any negative effects. The intermediate inclusion (0.3-0.5%) improved immunological functions, increasing lymphocyte counts. However, the maximum inclusion level (0.6%) led to increased cholesterol and triglycerides, suggesting potential lipogenesis. Despite increased feed intake, *Azadirachta indica* did not affect weight gain or feed conversion ratio, suggesting its immune-modulatory role without affecting performance or overall well-being.

Recommendation

The study suggests that neem leaf powder should be used at moderate levels (up to 0.5%) in broiler chicken diets to improve immune function and performance. However, levels above 0.5% should be treated cautiously as it may increase lipid metabolism and affect carcass quality. Further research should explore the long-term impact of neem leaf powder on broiler chickens' health, including the presence of hemoparasites and parasites, and the carcass characteristics of broiler chickens fed different doses.

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