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EFFECTS OF DIETARY SUPPLEMENTATION WITH DIFFERENT CROP-RESIDUE BIOCHARS ON HAEMATOLOGICAL AND SERUM BIOCHEMICAL INDICES OF BROILER CHICKENS

By

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Abstract

This study evaluated the effects of dietary supplementation with biochars produced from four crop residues on haematological, serum biochemical and electrolyte indices of broiler chickens. A total of 150 one-day-old broiler chicks were randomly allotted to five dietary treatments in a completely randomised design. The treatments comprised a control diet without biochar (T1), and diets supplemented with 0.4% African breadfruit husk biochar (ABHB; T2), soybean husk biochar (SBHB; T3), Bambara nut husk biochar (BNHB; T4), or melon seed husk biochar (MSHB; T5). Each treatment contained 30 birds distributed among three replicates of 10 birds each. The feeding trial lasted 56 days. At the end of the trial, blood samples were collected from two birds per replicate to determine haematological, serum biochemical, and electrolyte indices. Dietary biochar source significantly ($P < 0.05$) affected most serum electrolyte and biochemical parameters measured. Serum sodium, potassium, chloride and bicarbonate concentrations were generally higher in selected biochar treatments, whereas calcium and phosphorus concentrations varied among treatments. Biochar supplementation also significantly affected serum total protein, albumin, globulin, glucose, creatinine, urea, aspartate aminotransferase, alanine aminotransferase and alkaline phosphatase, whereas bilirubin was not significantly different among treatments. Haematological responses showed significant differences in packed cell volume, haemoglobin, white blood cell count, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, lymphocytes, heterophils, monocytes and eosinophils, while red blood cell and basophil counts were not significantly affected. Despite these differences, the observed values generally indicated no obvious adverse effect of the dietary biochars on haematological or biochemical status. The results suggest that supplementation with 0.4% crop-residue biochars, particularly biochars derived from Bambara nut and melon seed husks, can be incorporated into broiler diets without apparent impairment of physiological health. Further studies are warranted to establish the effects of biochar feedstock, pyrolysis conditions and dietary inclusion level on nutrient utilisation, gut health and long-term safety.

Keywords: biochar; crop residues; broiler chickens; haematology; serum biochemistry; electrolytes; poultry nutrition.

INTRODUCTION

The poultry industry is an important component of global food production because chicken meat provides a relatively affordable source of high-quality animal protein. However, increasing feed costs, competition for conventional feed

ingredients and environmental concerns associated with intensive agricultural production continue to constrain the sustainability and profitability of broiler production. The search for locally available feed resources and functional feed additives that can improve nutrient utilisation while reducing



dependence on conventional inputs is therefore increasingly important.

Agricultural crop residues constitute a substantial but frequently underutilised biomass resource. Residues such as husks, stalks, shells and processing by-products may contain useful minerals and organic fractions but their direct use in poultry diets is often limited by high fibre concentration, poor digestibility and the presence of anti-nutritional or potentially toxic compounds. Thermal conversion through pyrolysis provides a potential route for valorising such materials. Biochar is a carbon-rich, porous material produced through the thermochemical conversion of biomass under oxygen-limited conditions. Its physicochemical properties depend strongly on the original feedstock and pyrolysis conditions (Lehmann & Joseph, 2024).

Although biochar has traditionally received considerable attention as a soil amendment, its potential as a feed additive has increasingly been investigated. Its porous structure and surface chemistry may confer adsorption capacity for toxins and undesirable metabolites in the gastrointestinal tract, while its mineral fraction may contribute to nutrient supply. Biochar has also been investigated for possible effects on intestinal microbial populations, digestive processes, manure characteristics and environmental emissions. Recent studies in broilers have reported improvements in selected performance, mineralisation, immune and physiological responses following dietary biochar supplementation.

However, the response to biochar is not necessarily consistent. Goiri et al. (2021), for example, reported phase-dependent effects of a commercial biochar product on broiler performance and caecal fermentation, while a study using beechwood biochar reported reduced ammonia emissions but adverse effects on some production parameters at higher inclusion levels. Similarly, a study using pistachio-shell biochar found no overall improvement in broiler growth performance and reported reduced apparent ileal digestible energy at 2% inclusion during the early growth period. These findings demonstrate that the biological response to biochar may depend on feedstock, production conditions, inclusion rate and experimental environment.

Blood and serum biochemical measurements provide useful indicators of the physiological consequences of dietary interventions. Haematological variables such as packed cell volume, haemoglobin concentration, erythrocyte and leukocyte counts provide information about oxygen transport, erythropoiesis and immune status. Similarly, serum proteins, glucose, urea, creatinine, transaminases and alkaline phosphatase provide information concerning protein metabolism and hepatic and renal function. Electrolytes such as sodium, potassium, chloride, calcium and phosphorus are important for fluid balance, neuromuscular activity, acid-base regulation and skeletal metabolism.

Previous Nigerian studies have demonstrated the usefulness of haematological and serum biochemical measurements for evaluating unconventional feed resources and dietary additives in broiler chickens. For example, Onunkwo et al.

reported that dietary interventions involving alternative feed resources could alter selected haematological and biochemical parameters without necessarily producing evidence of physiological impairment. More specifically, Onunkwo et al. (2021) investigated graded dietary biochar inclusion in broilers and reported effects on haematological indices, providing local evidence for the evaluation of biochar as a poultry feed additive. A recent Nigerian study involving coconut-shell charcoal likewise found effects on selected serum biochemical and haematological parameters, although the authors cautioned against the use of the tested charcoal levels because of associated microbial responses.

Importantly, most available studies have evaluated either a single biochar source or commercially produced biochar. There is comparatively limited information on whether biochars produced from different locally available crop residues produce distinct physiological responses when included at the same dietary concentration. The present study therefore evaluated the effects of African breadfruit husk, soybean husk, Bambara nut husk and melon seed husk biochars, each included at 0.4% of the diet, on haematological, serum biochemical and electrolyte indices of broiler chickens.

The hypothesis was that dietary supplementation with crop-residue biochars would not adversely affect the physiological status of broiler chickens and that responses would differ according to biochar source.

Materials and Methods

Experimental site

The experiment was conducted at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Umudike is located at a latitude of 05°29'N and longitude 07°33'E, approximately 122 m above sea level, within the humid rainforest agro-ecological zone of southeastern Nigeria.

The area is characterised by a warm-humid tropical climate with mean daily temperatures ranging from 27–36 °C (maximum) and 20–26 °C (minimum). Relative humidity ranges from 57–91%, and average annual rainfall is approximately 2,177 mm. These climatic conditions are typical of the hot-humid tropics and present significant thermal challenges to poultry production, thereby providing an appropriate environment for evaluating thermotolerant genotypes.

Collection and preparation of crop residues

African breadfruit husk, soybean husk, Bambara nut husk and melon seed husk were obtained from an agricultural produce-processing outlet at Ndoro market, Ikwuano Local Government Area, Abia State, Nigeria. The materials were manually cleaned to remove soil, stones and other extraneous materials and subsequently sun-dried before pyrolysis.

Production of biochars

The dried crop residues were converted into biochar by slow pyrolysis using a metal drum under oxygen-limited conditions. The residues were loaded into the drum and

subjected to external heating. Following carbonisation, the material was quenched and allowed to cool completely. The resulting biochars were removed, ground into a fine powder and stored in airtight containers until incorporation into the experimental diets.

Experimental animals and design

A total of 150 one-day-old broiler chicks obtained from a commercial hatchery were used. The chicks were randomly assigned to five dietary treatments in a completely randomised design. Each treatment comprised 30 birds distributed among three replicates of 10 birds each.

The treatments were:

- i. **T1:** Basal diet without biochar (control)
- ii. **T2:** Basal diet + 0.4% African breadfruit husk biochar (ABHB)
- iii. **T3:** Basal diet + 0.4% soybean husk biochar (SBHB)
- iv. **T4:** Basal diet + 0.4% Bambara nut husk biochar (BNHB)
- v. **T5:** Basal diet + 0.4% melon seed husk biochar (MSHB)

Birds were reared on deep litter and provided with feed and water ad libitum. Standard broiler management practices were followed throughout the 56-day experimental period.

Experimental diets

The experimental diets were formulated to meet the nutrient requirements of broiler chickens. The starter diets contained approximately 2,883.75 kcal/kg metabolizable energy and 23.03% crude protein, while the finisher diets contained approximately 3,023.98 kcal/kg metabolizable energy and 20.48% crude protein.

Because all diets were formulated with the same basal ingredients and the biochars were incorporated at 0.4%, the principal experimental factor was biochar source.

Table 1. Experimental treatment structure

Treatment	Dietary treatment	Biochar inclusion
T1	Basal diet/control	0%
T2	African breadfruit husk biochar	0.4%
T3	Soybean husk biochar	0.4%
T4	Bambara nut husk biochar	0.4%
T5	Melon seed husk biochar	0.4%

Table 2. Broiler Starter Experimental Diets

Ingredient (%)	T1 Control	T2 ABH Biochar	T3 SBH Biochar	T4 BNH Biochar	T5 MSH Biochar
Maize	50.00	50.00	50.00	50.00	50.00
Soybean meal	28.00	28.00	28.00	28.00	28.00
Wheat bran	8.00	8.00	7.00	7.00	7.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Bone meal	3.00	2.60	2.60	2.60	2.60
Palm oil	2.50	2.50	2.50	2.50	2.50
Limestone	1.60	1.60	1.60	1.60	1.60
Blood meal	1.50	1.50	1.50	1.50	1.50
Brewer's dried grain	1.50	1.50	1.50	1.50	1.50
Biochar	—	0.40 ABH	0.40 SBH	0.40 BNH	0.40 MSH
Salt	0.30	0.30	0.30	0.30	0.30
Vitamin-mineral premix	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100

Table 3. Broiler Finisher Experimental Diets

Ingredient (%)	T1 Control	T2 ABH Biochar	T3 SBH Biochar	T4 BNH Biochar	T5 MSH Biochar
Maize	55.00	55.00	55.00	55.00	55.00
Soybean meal	23.00	23.00	23.00	23.00	23.00
Wheat bran	8.00	8.00	8.00	8.00	8.00
Fish meal	2.50	2.50	2.50	2.50	2.50
Bone meal	3.00	2.60	2.60	2.60	2.60
Palm oil	3.00	3.00	3.00	3.00	3.00
Limestone	1.50	1.50	1.50	1.50	1.50
Blood meal	1.60	2.00	2.00	2.00	2.00
Brewer's dried grain	1.50	1.50	1.50	1.50	1.50
Biochar	—	0.40 ABH	0.40 SBH	0.40 BNH	0.40 MSH
Salt	0.30	0.30	0.30	0.30	0.30
Vitamin-mineral premix	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15
Total	100	100	100	100	100

Blood collection

At the end of the 56-day feeding period, two birds were randomly selected from each replicate, giving six birds per treatment. Blood samples were collected through the wing vein using sterile syringes and needles.

Appropriately handled blood samples were used for haematological analyses, while serum was obtained for biochemical and electrolyte determinations.

Haematological analyses

The haematological parameters evaluated were packed cell volume (PCV), haemoglobin concentration (Hb), red blood cell count (RBC), white blood cell count (WBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), lymphocytes, heterophils, monocytes, eosinophils and basophils.

Serum biochemical and electrolyte analyses

Serum biochemical variables included total protein, albumin, globulin, glucose, creatinine, urea, bilirubin, aspartate aminotransferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP).

Electrolytes and minerals evaluated included sodium, chloride, potassium, bicarbonate, calcium and phosphorus.

Statistical analysis

Data were analysed using analysis of variance appropriate for a completely randomised design. Treatment means were compared using the least significant difference test at the 5% probability level.

The statistical model was:

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

Results

Serum electrolyte concentrations

Dietary supplementation with different crop-residue biochars significantly ($P < 0.05$) affected all serum electrolyte variables measured (Table 2).

Serum sodium ranged from 140.11 mEq/L in T2 to 142.85 mEq/L in T5. The highest sodium concentration occurred in birds receiving MSHB, whereas the control and ABHB treatments had comparable values.

Potassium concentration increased from 3.92 mEq/L in T2 to 4.27 mEq/L in T5. Birds receiving SBHB, BNHB and MSHB had higher potassium concentrations than the control and ABHB groups.

Serum chloride was lowest in T2 (104.40 mEq/L) and highest in T4 (109.87 mEq/L). Bicarbonate concentration was highest in T4 (21.54 mEq/L), whereas the other treatments ranged from 20.06 to 20.81 mEq/L.

In contrast, calcium and phosphorus concentrations tended to be lower in several biochar treatments than in the control. Calcium decreased from 10.04 mg/dL in T1 to 9.51 mg/dL in

T5, while phosphorus declined from 4.96 mg/dL in T1 to 4.10 mg/dL in T2.

Table 4. Effect of dietary crop-residue biochars on serum electrolyte concentrations of finisher broiler chickens

Parameter	T1	T2	T3	T4	T5	SEM
Sodium (mEq/L)	140.26 ^b	140.11 ^b	141.62 ^{ab}	141.01 ^{ab}	142.85 ^a	0.35
Chloride (mEq/L)	105.95 ^b	104.40 ^b	108.73 ^a	109.87 ^a	105.33 ^b	0.63
Potassium (mEq/L)	3.93 ^b	3.92 ^b	4.21 ^a	4.15 ^a	4.27 ^a	0.04
Bicarbonate (mEq/L)	20.06 ^b	20.13 ^b	20.81 ^b	21.54 ^a	20.46 ^b	0.17
Calcium (mg/dL)	10.04 ^a	9.79 ^b	9.87 ^{ab}	9.70 ^b	9.51 ^c	0.05
Phosphorus (mg/dL)	4.96 ^a	4.10 ^c	4.46 ^{bc}	4.66 ^{ab}	4.41 ^{bc}	0.08

Means within a row bearing different superscripts differ significantly at $P < 0.05$.

Serum biochemical indices

Dietary treatment significantly affected total protein, albumin, globulin, glucose, creatinine, urea, AST, ALT and ALP ($P < 0.05$), whereas bilirubin did not differ significantly among treatments.

Total protein was highest in T4 (4.85 g/dL), followed by T5 (4.58 g/dL) and T3 (4.55 g/dL), while T2 had the lowest value (4.07 g/dL). Albumin was highest in T4 (2.39 g/dL) and lowest in T2 (2.00 g/dL). Globulin followed a similar pattern, with T4 recording the highest concentration (2.46 g/dL).

Serum glucose ranged from 186.33 mg/dL in T1 to 202.00 mg/dL in T4. Creatinine was highest in the control (0.96 mg/dL) and lowest in T2 (0.88 mg/dL). Urea concentration was also highest in T1 (10.90 mg/dL), whereas T2 recorded the lowest value (9.24 mg/dL).

AST, ALT and ALP were numerically highest in the control or control-associated groups. AST declined from 90.84 U/L in T1 to 86.15 U/L in T5, while ALT declined from 42.39 U/L in T1 to 37.84 U/L in T5. ALP ranged from 96.09 U/L in T5 to 98.27 U/L in T1.

Table 5. Effect of dietary crop-residue biochars on serum biochemical indices of finisher broiler chickens

Parameter	T1	T2	T3	T4	T5	SEM
Total protein (g/dL)	4.31 ^{bc}	4.07 ^c	4.55 ^{ab}	4.85 ^a	4.58 ^{ab}	0.07
Albumin (g/dL)	2.18 ^{ab}	2.00 ^b	2.22 ^a	2.39 ^a	2.31 ^a	0.04
Globulin (g/dL)	2.12 ^{cd}	2.07 ^d	2.33 ^{ab}	2.46 ^a	2.27 ^{bc}	0.04
Glucose (mg/dL)	186.33 ^b	197.00 ^{ab}	197.00 ^{ab}	202.00 ^a	193.00 ^{ab}	1.88
Creatinine (mg/dL)	0.96 ^a	0.88 ^b	0.95 ^{ab}	0.90 ^{ab}	0.92 ^{ab}	0.01
Urea (mg/dL)	10.90 ^a	9.24 ^d	10.06 ^{bc}	9.46 ^{cd}	10.50 ^{ab}	0.18
Bilirubin (mg/dL)	0.50	0.47	0.49	0.48	0.51	0.00
AST (U/L)	90.84 ^a	88.89 ^{ab}	87.98 ^{ab}	87.73 ^{ab}	86.15 ^b	0.53
ALT (U/L)	42.39 ^a	39.31 ^c	39.19 ^c	40.70 ^b	37.84 ^d	0.44
ALP (U/L)	98.27 ^a	96.39 ^{ab}	96.59 ^{ab}	98.00 ^a	96.09 ^b	0.31

Haematological indices

The effects of dietary biochars on haematological indices are presented in Table 4.

Packed cell volume ranged from 29.33% in T4 to 31.33% in T5. Haemoglobin concentration was highest in T5 (12.06 g/dL) and lowest in T4 (11.63 g/dL). Red blood cell count did not differ significantly among treatments.

White blood cell count differed significantly among treatments, with the highest value occurring in T5 ($24.06 \times 10^3/\mu\text{L}$) and the lowest in T4 ($22.45 \times 10^3/\mu\text{L}$).

Mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration were

significantly affected by dietary treatment. Lymphocyte percentage was highest in T5 (62.67%), whereas heterophil percentage was highest in T4 (34.00%) and lowest in T5 (29.67%). Monocyte and eosinophil percentages also differed significantly among treatments. Basophil percentage was not significantly affected.

Table 6. Effect of dietary crop-residue biochars on haematological indices of finisher broiler chickens

Parameter	T1	T2	T3	T4	T5	SEM
PCV (%)	31.00 ^a	30.67 ^{ab}	30.00 ^{bc}	29.33 ^c	31.33 ^a	0.22
Hb (g/dL)	11.83 ^b	11.86 ^b	11.70 ^{bc}	11.63 ^c	12.06 ^a	0.04
RBC ($\times 10^6/\mu\text{L}$)	2.53	3.60	3.51	3.50	3.62	0.20
WBC ($\times 10^3/\mu\text{L}$)	22.68 ^c	23.73 ^b	23.65 ^b	22.45 ^d	24.06 ^a	0.16
MCV (fL)	87.73 ^a	85.18 ^b	85.31 ^b	83.73 ^c	86.39 ^b	0.38
MCH (pg)	33.49 ^a	32.96 ^b	33.27 ^b	33.21 ^b	33.27 ^b	0.09
MCHC (g/dL)	38.17 ^b	38.70 ^b	39.00 ^{ab}	39.66 ^a	38.51 ^b	0.16
Lymphocytes (%)	60.33 ^b	60.00 ^b	60.67 ^b	60.33 ^b	62.67 ^a	0.29
Heterophils (%)	32.67 ^{ab}	31.67 ^b	31.33 ^b	34.00 ^a	29.67 ^c	0.42
Monocytes (%)	4.67 ^a	5.00 ^a	4.00 ^{ab}	3.33 ^b	5.00 ^a	0.21
Eosinophils (%)	2.33 ^{ab}	2.67 ^{ab}	3.00 ^a	1.67 ^b	2.67 ^{ab}	0.16
Basophils (%)	0.33	1.00	0.67	0.67	0.00	0.16

Discussion

Serum electrolytes

The observed differences in serum electrolytes demonstrate that biochar source influenced mineral and electrolyte homeostasis in the experimental birds. However, the magnitude of the differences was relatively small for several parameters, suggesting that the physiological effects were modest rather than indicative of severe electrolyte disturbance.

Potassium concentration was higher in the SBHB, BNHB and MSHB groups than in the control and ABHB groups. Potassium is essential for intracellular osmotic regulation, membrane potential and neuromuscular function. The increase observed in some biochar treatments may partly reflect differences in the mineral composition of the respective feedstocks and the mineral concentration retained during pyrolysis.

The increase in sodium in MSHB-fed birds and the higher chloride and bicarbonate values in selected treatments may also reflect differences in mineral availability or acid-base regulation. Nevertheless, interpretation should be conservative because the mineral composition of the four biochars was not determined in the present study. Without direct mineral analysis, it is not possible to attribute the observed differences specifically to mineral contributions from the biochars.

Calcium and phosphorus showed a different pattern, with the control generally recording the highest values. This is important because biochar should not automatically be interpreted as a source of increased mineral availability. Biochar may adsorb or alter the availability of nutrients depending on its physicochemical characteristics. Consequently, future studies should determine both dietary mineral concentrations and apparent mineral digestibility or retention.

The findings are broadly consistent with recent work showing that dietary biochar can influence mineral-related physiological responses in broilers. Mahmoud et al. (2026), for example, reported increases in serum calcium and phosphorus following dietary biochar supplementation, illustrating that biochar effects on mineral metabolism may depend strongly on the particular biochar used.

Serum biochemical indices

Serum biochemical measurements provide an important means of evaluating the physiological response of broiler chickens to novel dietary materials. In the present study, biochar supplementation significantly affected serum proteins, glucose, urea, creatinine and hepatic enzymes.

The higher total protein, albumin and globulin concentrations observed particularly in T4 suggest that BNHB may have influenced protein metabolism or nutrient utilisation. Serum

albumin is synthesised primarily in the liver and contributes substantially to maintenance of colloid osmotic pressure and transport functions, whereas globulins include proteins involved in immune responses. Nevertheless, increased serum protein concentrations should not automatically be interpreted as improved nutritional status without complementary measurements of feed intake, nutrient digestibility and protein retention.

The lower creatinine concentrations in several biochar treatments relative to the control do not suggest an obvious deterioration of renal function. Similarly, urea concentrations were lower in T2 and T4 than in the control. These changes could reflect differences in nitrogen utilisation or protein metabolism, although definitive interpretation would require concurrent measurements of nitrogen intake and excretion.

An important finding was the reduction in AST and ALT concentrations in the biochar-supplemented groups relative to the control. AST and ALT are commonly used as indicators of cellular and hepatic integrity, although AST is not liver-specific and may also originate from skeletal muscle and other tissues. The lower values therefore provide some evidence that the tested biochars did not induce obvious hepatic stress under the experimental conditions.

This interpretation is supported by recent research. Mahmoud et al. (2026) reported that dietary biochar reduced AST, creatinine and total bilirubin while increasing total protein and globulin in broiler chickens. Similarly, Enyenih et al. (2023) found that coconut-shell charcoal altered selected serum biochemical and haematological parameters but did not produce evidence of general physiological toxicity at the measured blood indices.

The present findings also demonstrate why biochar source should be considered when interpreting physiological responses. The biochars in this study were generated from four different crop residues, each potentially differing in ash content, mineral composition, surface area, volatile matter and adsorption capacity. Consequently, the observed differences cannot necessarily be extrapolated to biochar products made from other feedstocks.

Haematological responses

Haematological parameters are useful indicators of erythropoietic activity, oxygen-carrying capacity and immune status. In the present study, PCV and haemoglobin were significantly influenced by biochar source, while RBC count was not significantly affected.

The highest haemoglobin concentration occurred in MSHB-fed birds, while the lowest occurred in BNHB-fed birds. The absence of a significant difference in RBC count, despite differences in PCV and haemoglobin, suggests that the dietary treatments may have influenced erythrocyte characteristics rather than simply altering erythrocyte numbers.

The MCV, MCH and MCHC values were significantly affected by dietary treatment. These indices describe erythrocyte size and haemoglobin content and can provide additional information regarding erythrocyte status. However,

claims concerning enhanced erythropoiesis should be avoided because the study did not measure bone-marrow activity, erythrocyte lifespan or relevant micronutrients such as iron, folate and vitamin B12.

White blood cell count was significantly higher in T5 than in the control, while T4 had the lowest WBC value. The higher lymphocyte percentage and lower heterophil percentage in MSHB-fed birds may indicate an altered leukocyte profile. Nevertheless, increased WBC concentration alone should not be interpreted as definitive evidence of enhanced immunity. Functional immune assays, antibody titres or cytokine measurements would be required to establish an immunostimulatory effect.

The present results are consistent with earlier Nigerian research demonstrating that dietary interventions can modify broiler haematological indices without necessarily causing pathological effects. Onunkwo et al. (2021), in a study specifically involving dietary biochar, reported that biochar inclusion affected selected haematological responses in broilers. Other studies by Onunkwo and colleagues have similarly used haematological and serum biochemical variables to evaluate alternative poultry feed resources.

Recent international evidence also supports the general conclusion that biochar does not necessarily impair haematological status. Mahmoud et al. (2026) reported that most haematological parameters remained stable following dietary biochar supplementation, with increases observed in selected indices.

Conclusion

Dietary supplementation with 0.4% biochars produced from African breadfruit husk, soybean husk, Bambara nut husk and melon seed husk significantly modified several haematological, serum biochemical and electrolyte indices of finisher broiler chickens.

The biochar treatments did not produce an overall pattern suggestive of adverse physiological effects. In particular, the generally lower serum AST, ALT, creatinine and urea values observed in several supplemented groups, together with the maintenance of haematological indices, suggest that the tested biochars were tolerated by the birds under the conditions of the study.

Among the biochars evaluated, Bambara nut husk biochar produced comparatively favourable responses in serum protein variables, whereas melon seed husk biochar produced the highest haemoglobin and WBC concentrations and favourable responses in several serum biochemical indices. However, these responses should not be interpreted as evidence that either biochar is universally superior because the study evaluated only one inclusion level and did not characterise the physicochemical properties of the biochars.

Overall, the findings indicate that crop-residue biochars can be investigated as potential functional feed additives for broiler chickens and provide a promising approach for agricultural-residue valorisation.

Recommendations

Further research should:

1. Evaluate multiple inclusion levels of each biochar to establish dose-response relationships.
2. Characterise each biochar for pH, ash, moisture, organic carbon, volatile matter, surface area, mineral composition and potential contaminants.
3. Determine the effects of biochar on nutrient digestibility, nitrogen retention and mineral retention.

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