Effect of coconut shell extract on the growth performance and some haemato-biochemical parameters of broiler chicken

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Abstract

This experiment was carried out at Sumitra Research Institute, Gujarat, India to evaluate the effect of coconut shell extract on the growth performance and some haemato-biochemical parameters of broiler chicken. 240 – 1 day old Hubbard broiler chicks of mixed sex were randomly distributed to six treatments with six replicates containing ten birds each in a completely randomized design. Birds in treatment 1(T1) was fed standard diet with no coconut shell extract; T2: standard diet with 1.0 mL coconut shell extract per liter of water; T3: standard diet with 2.0 mL coconut shell extract per liter of water and T4: standard diet with 3.0 mL coconut shell extract per liter of water. Standard diet was formulated according to the nutritional needs of broilers. The study lasted for fifty-six day and birds were offered fresh clean water and feed ad libitum. Phenols (410.3 mg/g^{-1}), tannins (98.21 mg/g^{-1}), alkaloids (100.6 mg/g^{-1}), flavonoids (309.5 mg/g^{-1}), saponins (71.4 mg/g^{-1}) and steroids (28.7 mg/g^{-1}) were identified coconut shell extract. Overall weight gains of birds fed T3 (2506.3 g) and T4 (2527.6 g) had a numerical and a remarkable significant improvement if feed conversion ratio from 1.92 to 1.59 compared to T2 (2210.0 g) and T1 (1996.1 g). Mortality was only recorded among birds in T1 (2.00 %) ($p < 0.05$). Pack cell volume, red blood cell, white blood cell, haemoglobin, mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentrations were influenced ($p < 0.05$) by the treatments. However, values were within the normal range for healthy birds. Total protein, albumin and globulin values were higher in T2, T3 and T4 except for alanine phosphatase, aspartate transaminase and alanine transaminase values which were not significantly ($p > 0.05$) different among the treatment. Total cholesterol was higher ($p < 0.05$) in T1 relative to the other treatments. It was concluded that coconut shell extract can be fed to broilers up to 3.0 mL without causing any negative effect on the health status of animals.

Keywords: coconut shell, phytochemicals, growth, haematology, serum, broilers.

Efeito do extrato da casca de coco no desempenho de crescimento e em alguns parâmetros hematobioquímicos de frangos de corte

Resumo

Este experimento foi realizado no Sumitra Research Institute, Gujarat, Índia, para avaliar o efeito do extrato de casca de coco no desempenho de crescimento e em alguns parâmetros hematobioquímicos de frangos de corte. 240 pintos de corte Hubbard de sexo misto, com 1 dia de idade, foram distribuídos aleatoriamente em seis tratamentos com seis repetições contendo dez aves cada, em delineamento inteiramente casualizado. As aves do tratamento 1(T1) foram alimentadas com dieta padrão sem extrato de casca de coco; T2: dieta padrão com 1,0 mL de extrato de casca de coco por litro de água; T3: dieta padrão com 2,0 mL de extrato de casca de coco por litro de água e T4: dieta padrão com 3,0 mL de extrato de casca de coco por litro de água. A dieta padrão foi formulada de acordo com as necessidades nutricionais dos frangos de corte. O estudo durou cinquenta e seis dias e as aves receberam água limpa e fresca e ração ad libitum. Fenóis (410,3 mg/g^{-1}), taninos (98,21 mg/g^{-1}), alcalóides (100,6 mg/g^{-1}), flavonóides (309,5 mg/g^{-1}), saponinas (71,4 mg/g^{-1}) e esteróides (28,7 mg/g^{-1}) foram identificados extrato de casca de coco. O ganho de peso geral das aves alimentadas com T3 (2.506,3 g) e T4 (2.527,6 g) teve uma melhoria numérica e notável significativa na taxa de conversão alimentar de 1,92 para 1,59 em comparação com T2 (2.210,0 g) e T1 (1.996,1 g). A mortalidade foi registrada apenas entre as aves do T1

(2,00%) ($p < 0,05$). O volume globular, hemácias, leucócitos, hemoglobina, volume corpuscular médio, hemoglobina corpuscular média e concentrações médias de hemoglobina corpuscular foram influenciados ($p < 0,05$) pelos tratamentos. No entanto, os valores estavam dentro da normalidade para aves saudáveis. Os valores de proteína total, albumina e globulina foram maiores em T2, T3 e T4, exceto para os valores de alanina fosfatase, aspartato transaminase e alanina transaminase que não foram significativamente ($p > 0,05$) diferentes entre os tratamentos. O colesterol total foi maior ($p < 0,05$) no T1 em relação aos demais tratamentos. Concluiu-se que o extrato de casca de coco pode ser fornecido a frangos de corte em até 3,0 mL sem causar qualquer efeito negativo no estado de saúde dos animais.

Palavras-chave: casca de coco, fitoquímicos, crescimento, hematologia, soro, frangos de corte.

1. Introduction

Concerns regarding the presence of drug residues in edible animal products and the environment, as well as the potential transfer of antibiotic resistance to humans has directed research towards alternative solution such as the use of medicinal plants and other natural products as feed additives for animals (Peter, 2021). Medicinal plants contain chemical compounds (phytochemicals) which are found in different parts of plants (stem, leaves, root, flowers and bud) and they have multiple therapeutic properties (Musa et al., 2021).

These compounds are generally regarded as safe, non-toxic and its quantity and quality can be altered by age of plant, specie, geographical location, storage and processing techniques amongst others (Singh et al., 2021). The World Health Organization (WHO) in 2001, recorded more than 50,000 species of plant distributed globally and are used traditionally for the treatment of several ailments in animals and human.

There is a recent report that coconut shell is loaded with several bioactive compounds with medicinal properties (antioxidant, anti-hyperglycemic and anti-hyperlipidemic) (Dhanya et al., 2018). Coconut (*Cocos nucifera*) is a monocotyledonous plant belonging to the family Arecaceae and order Arecales (Huie, 2002; DebMandal; Mandal, 2011). The plant is originally from Southeast Asia (Malaysia, Indonesia, and the Philippines) and the islands between the Indian and Pacific Oceans and recently found in most countries of the World (Lima et al., 2015).

Coconut can grow up to 30 meters tall and it can yield up to 75 fruits per year depending on its variety (Lima et al., 2015). Coconut shell has a wide range of nutritional benefits including, minerals, vitamins, fibres, carbohydrates and some phyto-constituents such as tannins, alkaloids, flavonoids, saponins, phenols, steroids amongst others which performs several biological activities viz: anti-inflammatory, analgesics, antioxidants, anti-helminthic, antineoplastic, antifungal, anti-hypertensive, antiviral, anti-parasitic, anti-osteoporosis, and antibacterial (Silva et al., 2013; Akinpelu et al., 2015).

Extracts from coconut shell have also been reported to inhibit the activities of *Staphylococcus aureus*, *Salmonella* sp., *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella pneumonia*, *Acinetobacter baumannii*, *Citrobacter freundii*, *Enterococcus* sp., *Streptococcus pyrogens*, *Bacillus subtilis*, *Micrococcus luteus* and *Aspergillus* spp. (Al-Adhroey et al., 2011; Singla et al., 2011). Previous studies have revealed that plant extracts are capable of enhancing the average weight gain and feed intake of birds (Emami et al., 2012; Khan et al., 2012), improving nutrient utilization through rapid enzymatic secretion (Hernandez et al., 2004; Joeng and Kim, 2015), preventing dysbiosis in the intestinal flora (Alagbe, 2023a, 2023b), inhibiting the proliferation of pathogenic organisms (Khattak et al., 2014; Daniel, 2024) and increasing the concentration of polyunsaturated fatty acid in the carcass of animals (Alagbe, 2023).

The dose of medicinal plants is the major determinant of their therapeutic or toxic activity (Ojelere, 2014). However, there is a dearth of information on the effect of coconut shell extract on the performance of broilers. Evaluating its effect will give a clue on whether it can be beneficial for all stages of growth or development of birds, promote food safety and establish a tolerable dose for birds. Therefore, this study was carried out to ascertain the effect of coconut shell extract on the growth performance and some haemato-biochemical parameters of broiler chicken.

2. Materials and Methods

2.1 Experimental location, ethical approval and preparation of coconut shell extract

The research was conducted at Sumitra Institute's poultry unit situated between 23o 13' N and 72o 41' E. Study was done in accordance with the guidelines and requirements of procedures that had been authorized by ethics council of the Institute (BN/008D/2023).

Fresh coconuts were purchased from a local market in Gujarat, India and sent to Sumitra Research Institute for proper identification and authentication by a certified taxonomist. Coconuts were opened mechanically with a knife to remove its epicarp, while the mesocarp was removed with the aid of a wooden hammer by firmly tapping each coconut in order to loosen the coconut endocarp from the shell. Thereafter its shells were collected into a clean container dried for 7 days and powdered into powder using a hammer mill.

200 g of coconut shell powder was soaked into 1000 mL of ethanol, stirred intermittently and kept for another 48 h. Extracts from the shell was sieved, collected into a clean container and kept in the refrigerator at 4 ºC. 200 mL of the extract was also sent to Sumitra Research laboratory in Gujarat for phyto-constituent evaluation.

2.2 Management of experimental birds (Housing, health and diet)

240 – 1 day old Hubbard broiler chicks of mixed sex were used in a 56 days' trial carried out at the poultry unit Sumitra Research Institute, Gujarat, India to examine the effect of coconut shell extract on their performance. Chicks were purchased from a reputable source in Gujarat and transferred early in the morning to the institute's poultry section.

On arrival, birds were unboxed, and their average initial weight was recorded using a digital scale before they were distributed into a galvanized battery cage measuring 150 cm by 140 cm by 100 cm (length × breath × width) which was properly disinfected with Morigad® two weeks before the commencement of the experiment. Cages were properly labelled and equipped with automatic feeders and nipple drinkers placed in a semi-closed pen. Feed and water were offered un-restricted and other management practices were strictly carried out.

Sixty birds were allocated to each treatment and each treatment had six replicates (10 birds per replicate) in a completely randomized design. Corn-soya meal diet (standard diet) were formulated based on recommendations for broilers (Nutritional Research Council, 1994) (Table 1).

Table 1. Ingredient and chemical composition of experimental diet expressed in dry matter basis.

	Phase 1	**Phase 2**
Ingredients	Starter diet (0- 21 d)	Finisher diet (22 – 56 d)
Corn	50.00	57.00
Soy bean meal	40.00	32.05
Fish meal (65%)	4.03	2.01
Oyster shell	2.30	2.42
Bone meal	4.20	5.00
Lysine	0.20	0.20
Methionine	0.20	0.22
*Premix	0.25	0.20
Salt	0.37	0.42
Total	100.0	100.0
Determined analysis		
Crude protein	23.04	21.00
Crude fibre	3.60	3.76
Ether extract	3.80	3.90
Calcium	1.49	1.48
Phosphorus	0.52	0.57
Ash	2.70	2.30
Energy (Mj/kg^{-1})	12.11	11.60

Note: The results are expressed as a percentage (%). Results with average values are represented through three replications.*Min/vitamin premix used contained: vitamin A, 15,000 I.U; vitamin E, 25.0 mg; vitamin D 5,000 I.U, vitamin K, 6.00 mg; vitamin B2, 6.0 mg; Niacin, 100 mg; vitamin B12, 30 mg; choline chloride, 120 mg; Manganese, 12.0 mg; Zinc, 45.1 mg; Copper, 8.5 g; folic acid, 4.0 mg; Iron, 5.5 g; pantothenic acid, 40 mg; biotin, 35 g and antioxidant, 80 mg. Source: Authors, 2024.

Feed consumption per treatment was recorded during the trial. It was estimated as the difference between the feed offered and the remnants. Average daily weight gain, average daily feed intake and feed conversion ratio were all calculated.

Calculations

Average daily feed intake = Total feed intake ÷ number of experimental periods

Average daily weight gain = Total weight gain ÷ number of experimental periods

Feed conversion ratio = Average daily feed intake ÷ average daily weight gain

2.3 Experimental set-up

Birds in treatment 1(T1) was fed standard diet with no coconut shell extract; (2) T2: Standard diet with 1.0 mL coconut shell extract per liter of water; (3) T3: Standard diet with 2.0 mL coconut shell extract per liter of water and (4) T4: Standard diet with 3.0 mL coconut shell extract per liter of water.

2.4 Phytochemical properties analysis and proximate evaluation

The laboratory procedures recently published by Alagbe (2024) were used for the determination of total phenols, tannins, alkaloids, saponins, flavonoids and steroids. Each sample were measured at different optical density for quantification using a gas chromatography-mass spectrometry (GC-MS 6800). To ensure accuracy in outcome gas chromatography column is adjusted to a heating temperature (120 ºC), inlet temperature (max 450 ºC), pressure range (100 psi) and temperature programming (7 stages/8 platforms) while the mass spectrometry is maintained at an EI source ionization energy (5-250 eV), mass range (1.5-1000 amu), filament emission current (0-350 µA), stability (± 0.10 amu/48 h) and scan rate (10,000 amu/s).

Proximate analysis of experimental diet was carried out using the near infra-red innovative kit (Model: DS3 NIRSTM). 200 g of experimental diet is passed through the plastic sample collector which possess an inbuilt detector (Silicon and lead graphite at 1100 nm and 2500 nm) and the machine operated according to the manufacturers recommendation. Wavelength is adjusted to 400-2500 nm, optical band (8.75 nm) and data resolution (0.5 nm), before result was displayed on the monitor (output device) in analysis time less than 1 minutes for 32 scans.

2.5 Analysis of blood parameters

On the 21st and 42nd day of the experiment, blood samples were collected for 6 randomly selected birds per treatment for haematological and serum biochemical analysis. 4 mL of blood was collected from the wing web of birds, sample meant for haematology was collected with a sterile syringe into a clean sample bottle containing an anticoagulant while the remaining 2 mL of blood for serum biochemical analysis was collected into a plain sterile bottle. Samples were transferred to Sumitra research laboratory using appropriate machines.

Haematological examination was carried out using H360 fully automated 3 part haemtological analyzer adjusted at an operating system of 15-30 ºC and open vial stability 2-8 ºC while serum biochemical indices was carried out using SMT-120 chemistry analyzer, adjusted to a resolution (0.001 Abs), absorbance (0-3 Abs) and humidity less than 30-70% and sample value of 90-120 µL, temperature (37 ºC) and testing time of 12 min per sample.

2.6 Statistical analysis

The results were analyzed statistically using Statistical Package for Social Science (SPSS for Windows (Version 21.0). The data were analyzed by using one-way ANOVA and subsequent *Duncan's* multiple range test to determine the differences between the treatments. Results are expressed as means ± SEM. Probability values of less than 0.05 ($p < 0.05$) were considered significant.

3. Results

The presence of phenols (410 mg/g^{-1}), tannins (98 mg/g^{-1}), alkaloids (100 mg/g^{-1}), flavonoids (309 mg/g^{-1}), saponins (71 mg/g^{-1}) and steroids (28 mg/g^{-1}) were identified coconut shell extract as presented in (Figure 1). Phenol had the highest concentration while steroids had the lowest concentration.

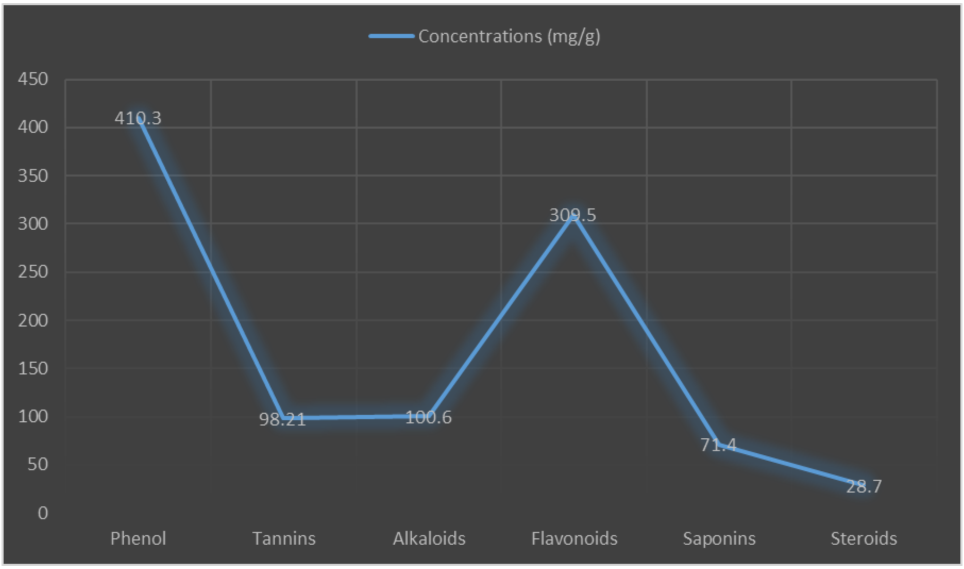

Figure 1. Composition of phyto-constituents in coconut shell extract. Source: Authors, 2024.

Growth performance of Hubbard broiler chickens fed coconut shell extract is presented in (Table 2). Weight gain and average daily weight gain of birds fed diet 3 (2.0 mL coconut shell extract per liter of water) was similar ($p > 0.05$) to treatment 4 (3.0 mL coconut shell extract per liter of water) but significantly higher ($p < 0.05$) than those fed treatment 2 (1.0 mL coconut shell extract per liter of water) and treatment 1 (no coconut shell extract). Average daily feed intake in broilers fed diet 2 (1.0 mL coconut extract) were similar ($p > 0.05$) to those fed treatment 3 (2.00 mL per liter of water) and treatment 4 (3.00 mL coconut extract per liter of water) at the starter phase. Similar pattern was observed in the finisher phase and the total production cycle where average daily weight gain and average daily feed intake were higher in treatment 3 and 4, intermediate in treatment 2 and lowest in treatment 1 ($p < 0.05$). Mortality was recorded only among birds fed treatment 1 (2.00%) ($p < 0.05$).

Table 2. Growth performance of Hubbard broiler chickens fed coconut shell extract.

Indices	Treatment 1	Treatment 2	Treatment 3	Treatment 4	*P-value*
Starter phase (0-21days)					
No of birds	60	60	60	60	
Initial body weight (g/bird)	56.15±0.01	56.05±0.00	56.08±0.01	56.02±0.01	0.0001
Final body weight (g/bird)	751.6^{b}±14.10	752.9^{b}±12.91	860.6^{a}±13.42	872.1^{a} ±12.77	0.20
Weight gain (g/bird)	695.5 ^{b}±9.38	696.9^{b}±7.26	804.5^{a}±8.02	816.1^{a}±9.42	0.25
Average daily weight gain (g/b)	33.12^{b}±0.94	33.18^{b}±0.88	38.31^{a}±0.50	38.86^{a}±0.36	0.02
Feed intake (g/bird)	1112.5^{b}±28.5	1205.6^{a}±25.9	1211.4^{a}±24.9	1212.6^{a}±25.0	0.58
Average daily feed intake (g/b)	52.98^{b}±0.28	57.41^{a}±0.33	57.69^{a}±0.21	57.74^{a}±0.26	0.09
Feed conversion ratio	1.60^{a}±0.04	1.73^{b}±0.08	1.50^{c}±0.05	1.49^{c}±0.06	0.001
Mortality (%)	1.00±0.00	-	-	-	0.0001
Finisher phase (22-42 days)					
Weight gain (g/bird)	1300.6^{b}±25.6	1504.1^{b}±28.5	1701.8^{a}±23.1	1711.5^{a}±21.5	0.98
Average daily weight gain (g/b)	61.93^{b}±3.03	71.62^{b}±2.94	81.03^{a}±3.12	81.50^{a}±2.50	0.01
Feed intake (g/bird)	2711.8^{b}±31.6	2800.3^{b}±34.0	2810.3^{a}±38.2	2812.1^{a}±31.2	1.33
Average daily feed intake (g/b)	129.13^{b}±0.03	133.35^{b}±0.06	133.82^{a}±0.07	133.91^{a}±0.04	0.21
Feed conversion ratio	2.08^{a}±0.62	1.86^{b}±0.55	1.65^{c}±0.23	1.64^{c}±0.19	0.001
Mortality (%)	1.00±0.00	-	-	-	0.0001
Total period (0-42 days)					
Weight gain	1996.1^{c}±39.1	2210.0^{b}±40.9	2506.3^{a}±40.2	2527.6^{a}±43.5	0.92
Average daily weight gain (g/b)	47.53^{c}±0.20	52.40^{b}±0.16	59.67^{a}±0.10	60.18^{a}±0.17	0.01
Feed intake (g/bird)	3824.3^{c}±58.9	4000.9^{b}±51.2	4021.7^{a}±60.7	4024.7^{a}±59.6	4.82
Average daily feed intake (g/b)	91.05^{c}±0.91	95.38^{b}±0.88	95.75^{a}±0.72	95.83^{a}±0.60	0.02
Feed conversion ratio	1.91^{a}±0.92	1.82^{b}±0.92	1.60^{c}±0.85	1.59^{c}±0.55	0.001
Mortality (%)	2.00±0.02	-	-	-	0.0001

Note: Means on the same row having different superscripts are significantly different ($p < 0.05$). Source: Authors, 2024.

Haematological and serum biochemical indices of Hubbard broilers fed coconut shell extract at starter phase is presented in (Table 3). Haematological parameters such as: red blood cell values varied from 1.51-2.21 (×1012/L) were similar ($p > 0.05$) among birds fed treatment 3 and 4 but significantly higher than those fed treatment 1 and 2. Haemoglobin concentrations (8.77-10.56 g/dL), pack cell volume (27.83-30.53%), mean corpuscular haemoglobin concentration (29.76-33.60 g/dL), mean corpuscular haemoglobin (33.21-39.11 pg), mean corpuscular volume (98.90-120.4 fl) and white blood cell [(9.41-13.94 (×109/L)] were significantly ($p < 0.05$) influenced by the treatment. Values were higher among birds fed treatment 3 and 4, intermediate in treatment 2 and lower in treatment 1 ($p < 0.05$).

Values of albumin, globulin, total protein, alanine phosphatase, aspartate transaminase and alanine transaminase which ranged from 2.00-2.65 g/dL, 1.83-2.15 g/dL, 3.83-4.80 g/dL, 35.00-36.50 U/L, 24.82-26.90 U/L and 50.72-53.11 U/L respectively were similar ($p > 0.05$) among birds fed treatment 2, 3 and 4 but significantly higher ($p < 0.05$) than those fed treatment 1 except for alanine phosphatase, aspartate transaminase and alanine transaminase values which were not affected by the treatment ($p > 0.05$). Conversely, cholesterol (76.00-100.8 mg/dL) were higher ($p < 0.05$) in treatment 1 and lower in the other treatments.

Table 3. Haematological and serum biochemical indices of Hubbard broilers fed coconut shell extract at starter phase.

Indices	Treatment 1	Treatment 2	Treatment 3	Treatment 4	*P-value*
Starter phase (Day 21)					
No of birds	60	60	60	60	
Haematological indices					
Haemoglobin (g/dL)	$8.77^{c} \pm 0.06$	$10.05^{b} \pm 0.08$	$10.22^{a} \pm 0.02$	$10.56^{a} \pm 0.09$	0.497
Pack cell volume (%)	$27.83^{c} \pm 1.20$	$30.05^{b} \pm 1.01$	$30.21^{a} \pm 0.09$	$30.53^{a} \pm 1.00$	0.25
Red blood cell ($\times 10^{12}$/L)	$1.51^{c} \pm 0.03$	$2.00^{b} \pm 0.02$	$2.18^{a} \pm 0.01$	$2.21^{a} \pm 0.02$	0.001
Mean corpuscular volume (fl)	$98.90^{c} \pm 10.5$	$102.6^{b} \pm 11.2$	$119.6^{a} \pm 10.8$	$120.4^{a} \pm 10.3$	1.77
Mean corpuscular heamoglobin (pg)	$33.21^{c} \pm 4.12$	$37.36^{b} \pm 3.60$	$38.50^{a} \pm 5.15$	$39.11^{a} \pm 4.80$	0.182
Mean corpuscular heamoglobin conc. (g/dL)	$29.76^{c} \pm 1.77$	$31.00^{b} \pm 1.58$	$33.48^{a} \pm 1.50$	$33.60^{a} \pm 1.84$	0.10
White blood cell ($\times 10^{9}$/L)	9.41±0.95	12.22±0.83	13.73±0.72	13.90±0.70	0.23
Serum biochemical indices					
Albumin (g/dL)	$2.00^{b} \pm 0.02$	$2.53^{a} \pm 0.01$	$2.61^{a} \pm 0.00$	$2.65^{a} \pm 0.02$	0.001
Globulin (g/dL)	$1.83^{b} \pm 0.01$	$2.10^{a} \pm 0.00$	$2.13^{a} \pm 0.01$	$2.15^{a} \pm 0.01$	0.0001
Total protein (g/dL)	$3.83^{b} \pm 0.03$	$4.63^{a} \pm 0.04$	$4.74^{a} \pm 0.02$	$4.80^{a} \pm 0.02$	0.11
Cholesterol (mg/dL)	$100.8^{a} \pm 11.8$	$80.55^{b} \pm 10.6$	$76.85^{b} \pm 11.4$	$76.00^{b} \pm 10.2$	0.654
Alanine phosphatase (U/L)	36.50 ± 0.04	35.10 ± 0.01	34.93 ± 0.02	35.00 ± 0.01	0.210
Aspartate transaminase (U/L)	24.82 ± 0.00	26.00 ± 0.00	25.77 ± 0.00	26.90 ± 0.00	0.117
Alanine transaminase (U/L)	52.03 ± 0.18	53.11 ± 0.10	50.72 ± 0.15	51.60 ± 0.18	0.124

Note: Means on the same row having different superscripts are significantly different ($p < 0.05$). Source: Authors, 2024.

At the finisher phase (day 56), haemoglobin, pack cell volume, red blood cell, mean corpuscular haemoglobin concentration, mean corpuscular haemoglobin, mean corpuscular volume and white blood cell values which varied from 10.13-14.56 g/dL, 29.00-35.11 (%), [1.92-3.40 (×1012/L)], 28.40-39.10 g/dL, 35.88-42.09 pg, 100.1-122.3 fl and [11.20-20.37 (×109/L)] respectively were higher in treatment 3 and 4 relative to the other treatment ($p < 0.05$). Total serum protein, albumin, globulin and cholesterol level where values were significantly ($p < 0.05$) affected by the treatment while alanine phosphatase, aspartate transaminase and alanine transaminase values were not significantly ($p > 0.05$) different among the treatment (Table 4).

Table 4. Haematological and serum biochemical indices of Hubbard broilers fed coconut shell extract at finisher phase.

Indices	Treatment 1	Treatment 2	Treatment 3	Treatment 4	*P-value*
Finisher phase (Day 56)					
No of birds	60	60	60	60	
Haematological indices					
Haemoglobin (g/dL)	$10.13^c \pm 0.22$	$14.22^b \pm 0.28$	$14.87^a \pm 0.26$	$14.56^a \pm 0.22$	0.351
Pack cell volume (%)	$29.00^c \pm 4.51$	$31.88^b \pm 3.55$	$34.09^a \pm 3.09$	$35.11^a \pm 4.00$	0.13
Red blood cell ($\times 10^{12}$/L)	$1.92^c \pm 0.01$	$2.11^b \pm 0.01$	$2.24^a \pm 0.01$	$2.30^a \pm 0.01$	0.08
Mean corpuscular volume (fl)	$100.1^c \pm 12.8$	$115.4^b \pm 12.5$	$120.3^a \pm 13.9$	$122.3^a \pm 15.1$	2.35
Mean corpuscular heamoglobin (pg)	$35.88^c \pm 2.10$	$38.05^b \pm 2.60$	$41.22^a \pm 3.80$	$42.09^a \pm 2.60$	0.12
Mean corpuscular heamoglobin conc. (g/dL)	$28.40^c \pm 1.80$	$32.39^b \pm 1.10$	$38.80^a \pm 1.00$	$39.01^a \pm 1.41$	0.09
White blood cell ($\times 10^9$/L)	11.20±3.81	15.90±2.56	19.00±2.88	20.37±3.00	0.62
Serum biochemical indices					
Albumin (g/dL)	$2.55^b \pm 0.08$	$2.81^a \pm 0.05$	$2.91^a \pm 0.00$	$2.92^a \pm 0.02$	0.01
Globulin (g/dL)	$1.92^b \pm 0.04$	$2.22^a \pm 0.03$	$2.23^a \pm 0.02$	$2.24^a \pm 0.02$	0.001
Total protein (g/dL)	$4.47^b \pm 0.03$	$5.03^a \pm 0.04$	$5.14^a \pm 0.02$	$5.16^a \pm 0.02$	0.09
Cholesterol (mg/dL)	$102.2^a \pm 12.5$	$87.40^b \pm 11.8$	$80.55^b \pm 10.2$	$78.06^b \pm 14.4$	0.135
Alanine phosphatase (U/L)	40.16 ± 8.77	41.22 ± 7.90	40.90 ± 8.13	40.22 ± 6.29	0.06
Aspartate transaminase (U/L)	30.10 ± 2.92	32.46 ± 2.00	31.80 ± 2.42	32.00 ± 1.96	0.12
Alanine transaminase (U/L)	64.11 ± 0.08	63.91 ± 0.05	62.04 ± 0.05	61.66 ± 0.06	0.40

Note: Means on the same row having different superscripts are significantly different ($p < 0.05$). Source: Authors, 2024.

4. Discussion

The result on the total production cycle (0-42 days) showed that birds fed treatment 3 (2 mL coconut shell extract) and treatment 4 (3 mL coconut shell extract) had a numerical increase in average daily weight gain and a remarkable significant improvement if feed conversion ratio from 1.92 to 1.59. This suggests that coconut shell extract has the potential to enhance the performance of birds by stimulating the activities of enzymes and improving the production of saliva (Daniel et al., 2023). This is made possible by presence of phytochemicals in coconut shell extract presented in (Figure 1).

Phytochemicals have medicinal or therapeutic properties with no side effects or withdrawal periods (Singh et al., 2022; Adewale et al., 2022). For instance, flavonoids and phenols possess antioxidant properties serving as free radical scavengers to protect the cell organelles from damage caused by free radicals induced oxidative stress either by inhibiting the initiation or propagation of oxidative chain reactions (Ghaffar; El-Elaimy, 2012; Musa et al., 2022). Tannins and alkaloids also have antimicrobial properties thereby inhibiting the activities of pathogens and promoting the activities of beneficial bacteria in the gastro intestinal flora (Cho et al., 2014).

The result obtained in this study is in agreement with the reports of Begum et al. (2014) who recorded that plant extract YGF251 positively improved the final body weight of broilers compared to the control. Similar submission was made by Abd El-Hack & Alagawany (2015) who reported a significant increase in the average daily weight of laying hens fed diets with thyme powder. All these results suggests that coconut shell extract with its phyto-constituents can prevent dysbiosis making it possible for easy absorption and utilization of nutrients in the animal's body (Al-Kassie et al., 2011; Alagbe, 2024).

This also explain reasons why mortality was not recorded in the treatment fed with coconut shell extracts. Birds fed coconut shell extract also recorded a higher feed intake compared to the control group. This indicates the extract is capable of maintaining flavor profile across the treatment and supports digestibility in birds (Alagbe, 2024). This result confirms with the earlier reports of Alhajj et al. (2015) when high levels of Chinese stars anise fruit was supplemented in the diet of broilers.

Blood analysis is used in diagnosis of an animal's state of health (Isaac et al., 2013; Alagbe, 2024). The outcome obtained in haematological indices in both phase (starter and finisher) follow similar pattern. Pack cell volume, red blood cell and heamoglobin values in starter phase were within the normal range [(26.0-31.00 %), (1.22-3.00 (×1012/L)] and 6.00-11.00 g/dL] and [(28.0-35.00%), (1.50-3.50 (×1012/L)] and 8.00-15.00 g/dL] cited by Livingston et al. (2020). Despite the fact, haemoglobin, pack cell volume and red blood cell values are within the established range, broilers fed coconut shell extract (treatment 2, 3 and 4) as compared to the control diet (treatment 1) suggest that they improved nutrient utilization and assimilation into the blood stream for use by the birds and enhanced blood formation due to availability of essential nutrients (Yonatan, 2018; Alagbe, 2023).

Generally, normal hematological values portray the nutritional and health status of the animal. Low pack cell volume can result from several factors including, iron deficiency, folate deficiency, bone marrow disorder and other chronic diseases (Shittu et al., 2023). The value obtained for red blood cell also suggests that the supply of oxygen from the lungs to different blood tissues was not compromised which gives room for efficient nutrient distribution in the body of birds (Alagbe, 2024a, 2024b). Oloruntola et al. (2022) reported that dietary supplementation of Anacardium occidentale leaf powder improved red blood cell, pack cell volume and haemoglobin values than those given antibiotics. White blood cell values in starter and finisher phase within the normal range [8.00-14.00 (×109/L)] and [9.50-21.0 (×109/L)] reported by Meluzzi et al. (1992) and Nanbol et al. (2016).

White blood cells are responsible for the production of antibodies which fights against diseases (Livingston et al., 2020; Murutala et al., 2022). In addition, coconut shell extract has more beneficial effect on immune system by stimulatory roles toward non-specific (T-cell-mediated) immune responses. Also, stimulating the non-specific immunomodulation, essentially granulocytes, macrophages and natural killer cells as well as increase phagocytosis (Rajput et al., 2013; Adewale et al., 2021). Mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentrations follow similar pattern in both starter and finisher phase.

The value of mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentrations significantly vary in different treatments ($p < 0.05$). Birds fed treatment 1 (control) had a lower mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration value than those give coconut shell extracts. However, the range of mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin. However, values did not deviate from normal values of 65.00-125.1 fl, 28.00-45.00 pg and 25.00-50.00 g/dL for birds in starter phase as well as 68.00-135.0 fl, 31.00-61.00 pg and 31.00-81.00 g/dL respectively for finisher birds reported by Nangsuay et al. (2017); Talebi et al. (2003); Ross et al. (1976).

Ouyang et al. (2016) reported with alfalfa extracts significantly improved mean corpuscular volume, mean corpuscular haemoglobin and mean corpuscular haemoglobin concentration in broiler chickens. Contrary to the current findings, Islam et al. (2004) and Alagbe (2017) reported that mean corpuscular volume and mean corpuscular volume values did not change in birds fed turmeric powder. This might be due to their level of dietary inclusion in the diet of animal as well as processing technique employed for the test ingredient.

Blood biochemical indices directly express the status of metabolism, nutrition and health of the animals (Omokore and Alagbe, 2019). Feeding birds with coconut shell extract resulted in increased total serum protein, albumin and globulin levels than the control in all the production phases. The serum total protein, albumin and globulin values obtained in this study are within the normal range cited by Thrall (2007) that is 2.5 to 7.0 g/dL, 2.0-4.0 g/dL and 1.8-3.5 g/dL respectively.

The result obtained is in agreement with the reports of Daniel et al. (2023), who reported that dietary supplementation of Papaya oil improved plasma total protein and globulin. Similarly, Alagbe (2024) reported that the total protein increased in Japanese quails fed diet supplemented with Rhamnus prinoides leaf extract. As serum protein depends on the availability of dietary protein, the result suggests that proteins in coconut shell extracts was available to the birds to support the nutritional requirements of broilers. The increase in total protein might also be as a result of phytochemicals present in coconut shell extract, especially phenols and flavonoids which have been suggested to possess antioxidant properties and capable of reducing protein oxidation (Ojediran et al., 2024).

Globulin values vary among treatments. Globulin carries essential metals through the bloodstream to the various parts of the body and helps the body to fight infections. Elevated globulin levels are often pronounced in birds with increased production of antibodies (Wakenell, 2010; Agboola et al., 2013). Contrary to the current findings, Ghazaghi et al. (2014) and Hashemi et al. (2014) reported that serum total protein was not influenced in birds fed Mentha spicata and Euphobia hirta extract. Total cholesterol level in both phase (starter and finisher) falls within the normal physiological range (60.00-250.0 mg/dL) reported healthy broiler chicken by Martin et al. (2010); AMTL (2001). Plasma cholesterol of birds fed coconut shell extract treatment 2, 3 and 4 were lower compared to the control treatment ($p < 0.05$).

This suggests that coconut shell extract possess hypocholestrolemic property due to the presence of phyto-constituents presented in figure 1. Consumption of low cholesterol products (meats and eggs) helps to prevent against coronary diseases (Omolere; Alagbe, 2021). The current result supported by Oloruntola et al. (2021), who showed that *Irvingia gabonensis* kernel powder and *Ocimum gratissimum* leaf powder lower the cholesterol level of broilers. Similarly, Ayodele et al. (2016) reported that supplementing *Alchornea cordifolia* leaf decreased the cholesterol concentrations of animals.

The value of serum enzymes (alanine phosphatase, aspartate transaminase and alanine transaminase) obtained in the present study is similar to earlier report by Campbell (2012); Meluzzi et al. (1992), who indicated that the serum alanine phosphatase, aspartate transaminase and alanine transaminase level in normal bird's ranges from 30.00-50.00 (U/L), 25.00-40.20 (U/L) and 45.80-82.00 (U/L) respectively. Values obtained in all the treatments were not significantly ($p > 0.05$) different. This result suggests that the integrity of the liver and kidney were not compromised since coconut shell extract did not contain any toxic substance that could interfere with the body system of birds. The outcome of this result is in consonance with the findings of Herrero-Encinas et al. (2023) when spice extracts was supplemented in the diet of broilers.

5. Conclusions

Coconut shell extract is loaded with both nutritional and medicinal properties which are often regarded as safe. It can also serve as natural alternative to antibiotics. It was concluded from the experiment that feeding coconut extract to broilers at up to 3 mL/L^{-1} of water had a numerical increase on the average daily weight gain and average daily feed intake. The presence of phytochemicals in the test ingredient inhibited the activities of pathogens thereby lowering the mortality when compared to the control group. Blood constituents examined were also influenced by the treatment. However, values were within the established range for broilers implying that coconut shell extract had no negative effect on the general performance of birds.

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7. Authors' Contributions

John Olujimi Alagbe: designed the experiment, collate the experimental results, statistical analysis and writing of manuscript.

8. Conflicts of Interest

No conflicts of interest.

9. Ethics Approval

Yes applicable. Study was done in accordance with the guidelines and requirements of procedures that had been authorized by ethics council of the Institute (BN/008D/2023).

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