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Efficacy of *moringa oleifera* leaf extract as a phytogenic additive in finisher broiler chickens

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ABSTRACT

Plant and leaf extracts are commonly used in animal production to enhance health and performance. *Moringa oleifera* leaves are rich in nutrients and bioactive compounds with great potential as a broiler feed additive. This study evaluated the effects of varying levels of *Moringa oleifera* leaf extract (MOLE) on the physiological parameters of finisher broiler chickens. We randomly distributed a total of 120 unsexed, four-week-old Anak broiler chickens into 4 treatment groups of 3 replicates in a completely randomized design, with 30 birds per group. Each group (T_1, T_2, T_3, and T_4) received MOLE at different graded levels of 0ml, 20ml, 40ml, and 60ml in drinking water, respectively. We repeated the treatments at 3-day intervals. Feed and water were served *ad libitum*. The study lasted for 28 days. The results showed that weight gains were significantly higher *(P<0.05)* in T_4(60ml), and had the best feed conversion ratio. MOLE significantly increased *(P<0.05)* carcass characteristics parameters, with T_4(60ml) outperforming the other groups. Blood analysis showed significant differences *(P<0.05)* in most parameters and values remained within normal ranges for healthy broilers. We did not observe significant differences *(P>0.05)* in economic parameters. However, the T_4(60ml) group gave better sales revenue and gross margin performance. In conclusion, the broiler chickens took the test ingredient satisfactorily without any adverse effects on their health. Growth performance (weight gains and feed conversion ratio), carcass traits (dressed weight, dressing percentage and drumstick), and economic viability (cost/kg weight gain, cost of production, revenue and gross margin) improved at inclusion level up to 60 mL/L in drinking water. These findings support its potential as a sustainable feed additive in poultry production.

Keywords: Finisher broiler chickens / Growth promoter / Leaf extract / *Moringa oleifera* / Phytogenic additive

1. INTRODUCTION

Poultry production remains one of the best ways to reduce the persistent shortage of animal protein in developing countries. Nevertheless, the high costs of feed remain a

major impediment from achieving this goal (Essen et al., 2025; Voemesse et al., 2025). Verma et al., (2024) documented that nutrition takes about 60–70% of total production costs, lowering nutrition outlay is necessary for decreasing overall cost. Consequently, efforts to create least-cost feed formulations have focused on replacing costly feed resources with affordable, locally available, non-conventional alternatives (Wagh et al., 2021). Embracing the use of novel resources, lowers feed costs and makes poultry products more affordable for consumers.

A tropical plant called *Moringa oleifera,* belonging to the monogeneric family Moringaceae, has been identified as a sustainable, cost-effective feed additive alternative widely grown around the world. From the beginning, *M. oleifera* has been used to treat, and or cure many infections (Eyayu, 2021). Farmers serve the leaves as fodder, leaf meal, and extract to farm animals. *M. oleifera* flourishes in tropical climates and as such, it gives outstanding nutritional and phytochemical properties. According to reports of Muremera et al., (2022) and SciELO (2023), *M. oleifera* contains high carotene, which enhances pigmentation in egg yolks and broiler meat. As a feed additive, its use in broiler chickens resulted to lower feed costs, more sustainable environment, beneficial production performance, heightened immunity, mutualistic intestinal flora, and hematological profile values which dropped within the standard range (Modisaojang-Mojanaga et al., 2019; Abdelghani et al., 2024; Carlos et al., 2024). As well, *M. oleifera* has bioactive compounds which display couple of advantageous effects, including anti-oxidant, anti-inflammatory, anti-microbial, anti-hypercholesterolemic, anti-mutagenic, and anti-cancer properties. It also has plenty of nutrients, and zeatin, successfully making it a flawless growth enhancer (Olugbemi et al., 2010; Verma et al., 2022; Saranya et al., 2023; Verma et al., 2024; Divya et al., 2024).

However, researchers are yet to scrupulously scrutinize the use of MOLE via drinking water, specifically throughout the last two phases of broiler production, and no studies have related its impact on economic viability in the Anak broiler breed. Our research under-seeks most favorable inclusion level of the test ingredient to heighten performance. We also examine whether MOLE can reduce feed costs and increase farmers' income, thereby addressing both scientific and practical gaps in poultry production. The study spanned between 2nd to 30th January, 2025.

2. MATERIALS AND METHODS

Study area

Researchers conducted the study at the center described by Essen et al., (2024; 2025).

Sourcing, processing, and preparation of the test ingredient

We harvested young, fresh leaves of *Moringa oleifera* from farms in Ishiagu, Ebonyi State, Nigeria. We identified the plant material using the Flora of West Tropical Africa (Hutchinson and Dalziel, 1954), and a plant taxonomist from the Department of Crop Production Technology at FCAI, Ebonyi State, Nigeria, authenticated it. We deposited a voucher specimen (FCAI/CPT/MO/2015-015) in the herbarium of FCAI for future reference.

We manually separated the freshly cut *M. oleifera* leaves with stalks from the stems, washed them with clean water to remove dirt and sand, drained, chopped, and weighed 100 g. We weighed the leaves, then crushed them using an electronic blender (Kayue Electric Company, Hong Kong), mixed the crushed material with 500 mL of water, and filtered the mixture through Whitman filter paper (Grade 1, 11 μm) to obtain a homogenous aqueous extract at a concentration of 0.2 g/mL. The extract was diluted in 1 liter of water and served freshly to the birds at three (3) day intervals.

We spread freshly harvested *M. oleifera* leaves on a flat wooden platform and allowed them to air-dry for five days under shady, well-ventilated conditions. After drying, we milled the leaves to produce *Moringa oleifera* leaf meal (MOLM) and packaged it in a container for proximate analysis. Throughout the trial, 50 g of feed from each opened bag of commercial vital broiler finisher feed (VBFF) was set aside and combined at the end of the study for proximate analysis. All feed samples (MOLM and VBFF) were analyzed for proximate composition using the AOAC method (Association of Official Analytical Chemists, 2023).

Experimental animal and management

We obtained a total of one hundred and twenty (120) four-week-old unsexed Anak broiler chickens (900 ± 50 g) from Floramos Farms and Hatcheries Limited, Ibadan, Oyo State. We weighed and randomly assigned the broiler chickens to four treatments in an experimental design called CRD. Each treatment had three replicates, with ten birds per replicate.

Before the birds arrived, the rearing facility and equipment were thoroughly washed, dried, cleaned, and disinfected to prevent disease. We spread the litter material specifically wooden shavings on the floor of each pen adequately. Upon arrival, the birds were

placed on the litter and provided with a commercial standard pelleted vital broiler finisher feed (19% crude protein and 3000 kcal/kg metabolizable energy) from Vital Feed, Grand Cereals Limited, Jos, Plateau State, Nigeria. Feeding continued for five to eight weeks. The birds were allowed to acclimatize to the environment for 3 days, after which the test ingredients were introduced into their drinking water at three-day intervals throughout the experiment. Birds received feed *ad libitum*. We administered routine medications based on the signs and symptoms displayed by the birds during the experimental period. We strictly observed other management practices, including proper sanitation, pest and rodent control, lighting (16-18 h), and litter management. We included MOLE in the drinking water of the broiler chickens at 0 ml (experimental control), 20 ml, 40 ml, and 60 ml per liter. The trial lasted for 28 days.

Data collection

Growth performance traits

We recorded the birds' body weights at the start and end of the experiment, and weekly throughout. We measured total feed intake by subtracting the leftovers from the feed provided. To obtain daily feed intake, we divided the total feed intake by the number of experimental days. We calculated weight change as the difference between the final and initial body weights. Average daily weight gain was obtained by dividing the weight change by the number of experimental days. Finally, we calculated the feed conversion ratio (FCR) as the total feed consumed per bird divided by the total weight gain per bird.

Blood profile

We randomly selected 24 birds (2 per replicate) for blood analysis at the end of the 8th week. In the morning, we collected blood samples from the wing vein using a 5 ml sterile syringe fitted with a 21-gauge needle. From each bird, we obtained 3 ml of blood and divided it into two labeled sterile bottles: 1 ml for hematological analysis and 2 ml for serum biochemistry. One set of bottles contained anticoagulant (EDTA, Ethylenediaminetetraacetic acid powder), while the other did not. We used the EDTA-treated samples for hematological assessments and the untreated samples for serum biochemistry tests.

We allowed the blood samples without anticoagulant to clot at room temperature for 30 minutes, then centrifuged for 10 minutes at 3000 rpm using a table centrifuge to separate the serum. We carefully and gently removed the clear supernatant with an automatic pipette and stored it in clean sample bottles. We analyzed hematological and serum biochemistry parameters following standard procedures described by Ewa et al., (2023) and Essen et al., (2025).

Carcass evaluation

After recording the final body weights at 8 weeks, we withheld feed from the broiler chickens overnight to empty their gastrointestinal tract (GIT). We then randomly selected 24 birds (2 per replicate) for carcass evaluation. Before slaughter, we recorded the live weights of the elected broiler chickens. Slaughter happened by cutting off their neck one time, after which the birds were sank in hot water, feathers plucked, and let out the bowels. We weighed the body of the slaughtered birds to get hold of the dressed weight, then chop them into components (lap, drumstick, chest, wing, and backcut). We weighed each component individually in a set order outlined by Obike et al., (2023). Finally, we expressed the dressed weight, slaughter weight, cut parts, internal organs, and offal as percentages of the live weight to determine their relative weights.

Economics of production indices

At the end of the finisher phase, we carried out a cost analysis to determine and compare production profitability, following the method described by Obike et al., (2023). We calculated the following parameters:

Cost/kg feed = proportion of each ingredient in the diet × cost per kg of ingredients ÷ 100.
Total cost of feed consumed = total quantity of feed consumed × cost/kg feed.
Feed cost/weight gain = cost/kg feed × feed conversion ratio (FCR).
Cost of production = cost/kg weight gain × mean weight gain.
Revenue = price of 1 kg of meat × mean weight gain.
Gross margin = revenue – cost of production.
Cost-benefit ratio (CBR) = Benefits (revenue) ÷ cost of production

Statistical analysis of the Anak broiler chickens fed graded levels of MOLE in their drinking water

We analyzed all generated data using a one-way analysis of variance (ANOVA) as described in the work of Essen *et al.*, (2025). Duncan multiple range test comparisons at *P<0.05* level of significance, were applied to separate means.

3. RESULTS & DISCUSSION

Results

We acquired the acute toxicity and phytochemical information of *M. oleifera* leaf extract (MOLE) from the literature (Odumeru et al., 2023; Verma et al., 2024; Divya et al., 2024).

Table 1 presents the proximate composition of the test ingredient and experimental diet. The results show that *Moringa oleifera* leaves contain significant amounts of dry matter (91.56%), crude protein (28.26%), crude fiber (10.16%), ether extract (7.62%), ash (12.36%), moisture (5.09%), carbohydrates (53.11%), and nitrogen-free extract (39.51%). The commercial experimental diet showed dry matter (83.46%), crude protein (16.89%), crude fiber (5.6%), ether extract (4.51%), ash (10.05%), moisture (9.12%), and nitrogen-free extract (53.41%).

Table 2 presents the performance of finisher broiler chickens fed graded levels of MOLE in their drinking water. The results showed significant differences *(P<0.05)* among the treatment groups, with T_4 (60ml MOLE) always maintaining the highest values throughout the experimental period.

Table 1. Proximate composition of test ingredients (*Moringa oleifera* leaf meal) and experimental diet (commercial vital broiler finisher feed)

Nutrients (%)	*Moringa oleifera* leaf meal	Vital broiler finisher feed
Dry matter	91.56	83.46
Crude protein	28.26	16.89
Crude fiber	10.16	5.6
Ether extract	7.62	4.51
Ash	12.36	10.05
Moisture	5.09	9.12
Nitrogen-free extract	36.51	53.83

Table 2. Growth performance of finisher broiler chickens administered graded levels of *Moringa oleifera* leaf extract (MOLE) in the drinking water at 8 weeks

Parameters	T_1(0ml)	T_2(20ml)	T_3(40ml)	T_4(60ml)	SEM	*P-value*
IBW (g)	1198.33±8.69^{a}	1286.00±8.71^{b}	1396.67±9.28^{c}	1331.67±7.96^{bc}	36.09	<0.0001
FBW (g)	2081.30±21.12^{a}	2381.00±14.02^{c}	2218.37±20.45^{b}	2444.30±18.77^{c}	90.91	<0.0001
ADWG (g)	31.53±3.11^{ab}	39.11±2.80^{c}	29.35±3.45^{a}	39.74±2.33^{c}	2.28	<0.0001
AWG (g)	882.97 ± 9.31^{b}	1095.00±9.45^{c}	821.70±7.60^{a}	1112.63±8.26^{c}	63.87	<0.0001
TFI (g)	4025.00±99.35^{a}	4311.70±87.51^{ab}	4485.30±86.57^{b}	4147.70±98.40^{c}	86.28	<0.0002
ADFI (g)	143.75±7.06^{a}	153.99±8.68^{ab}	160.19±6.53^{b}	148.13±6.87^{ab}	3.10	<0.0001
FCR (%)	4.56±0.55^{b}	3.96±0.85^{ab}	5.46±0.67^{c}	3.73±0.72^{a}	0.34	<0.0076
ADWI (g)	214.33±0.52^{d}	212.02±0.43^{c}	209.26±0.32^{b}	199.19±0.22^{a}	2.89	<0.0010
TWI (g)	6001.36±0.56^{d}	5936.57±0.31^{c}	5859.41±0.25^{b}	5577.39±0.14^{a}	80.87	<0.0001

^{a,b,c,d,} means within the row with different superscripts differ significantly (P<0.05) from each other. IBW=Initial weight; FBW=Final weight; ADWG=Average daily weight gain; TFI=Toal feed intake; ADFI=Average daily feed intake; AWG=Average weight gain; ADWI=Average daily water intake; TWI=Total water intake; SEM=Standard error of mean

Table 3 presents the hematological indices of Anak broiler chickens administered graded levels of MOLE in their drinking water. Significant effects *(P<0.05)* occurred across all evaluated parameters except RBC, with treated groups showing higher values than the control.

Table 4 shows the effects of varying MOLE levels in drinking water on blood biochemical parameters of Anak broiler chickens. We found significant differences *(P<0.05)* across treatments for most serum biochemical parameters, except total protein and albumin. Most of the parameter's values did not follow a consistent pattern, that is, it did not increase regularly from control to the biggest inclusion level of the test ingredient, vice versa, as noticed in glucose, urea, creatinine, and cholesterol. Control group (T_1) recorded bigger value only in globulin, whereas treated groups (T_2 – T_4), primarily treatment 4 (60 ml/L MOLE) recorded higher values in most parameters compared to the control.

Table 3. Hematological indices of finisher broiler chickens administered graded levels of *Moringa oleifera* leaf extract (MOLE) in the drinking water at 8 weeks

Parameters	T_1(0ml)	T_2(20ml)	T_3(40ml)	T_4(60ml)	SEM	*P-value*
PCV (%)	30.67±0.18^a	31.33±0.40^{ab}	32.00±0.86^b	30.33±0.14^a	0.87	<0.0026
RBC (x10^6/L)	4.09±0.40	4.23±0.60	4.26±0.90	4.24±0.70	0.17	>0.9416
WBC (x10^6/L)	10.80±0.06^a	9.23±0.03^c	10.13±0.10^b	9.07±0.016^c	0.43	<0.0001
Hb (g/dL)	10.43±0.17^{ab}	10.63±0.14^a	10.73±0.44^a	10.37±0.28^b	0.20	0.0027
MCHC (g/dL)	34.04±0.37^{ab}	33.93±0.29^{ab}	33.53±0.40^b	34.18±0.31^a	0.12	0.0075
MCH (pg)	25.63±0.44^a	25.18±0.56^{ab}	25.30±0.19^b	24.55±0.51^b	0.39	0.0423
MCV (fL)	75.25±0.13^a	74.18±0.36^b	75.46±0.40^a	71.82±0.77^c	1.04	<0.0001

^{a,b,c} means within the row with different superscripts differ significantly (P<0.05) from each other. PCV=Pack cell volume; RBC=Red blood cell; WBC=White blood cell; Hb=Hemoglobin; MCHC=Mean corpuscular hemoglobin concentration, MCH=Mean corpuscular hemoglobin; MCV=Mean corpuscular volume; SEM=Standard error of mean

Table 4. Serum biochemistry of finisher broiler chickens administered graded levels of *Moringa oleifera* leaf extract (MOLE) in the drinking water at 8 weeks

Parameters	T_1(0ml)	T_2(20ml)	T_3(40ml)	T_4(60ml)	SEM	*P-value*
Total protein (g/dL)	3.24±0.34	3.70±0.04	3.82±0.28	3.87±0.23	0.14	0.3605
Albumin (g/dL)	2.27±0.11	2.33±0.11	2.43±0.02	2.97±0.15	0.16	0.227
Globulin (g/dL)	1.88±0.22^a	1.45±0.20^b	1.44±0.25^b	1.24±0.21^b	0.14	0.0010
Glucose (mg/dL)	193.32±4.69^b	237.6±4.81^a	173.82±2.46^c	163.08±5.19^c	16.43	< 0.0001
Urea (mg/dL)	5.12±0.02^b	3.69±0.05^c	4.71±0.02^b	6.13±0.03^a	0.51	< 0.0001
Creatinine (mg/dL)	2.27±0.00^b	2.09±0.01^c	2.61±0.01^a	2.53±0.00^{ab}	0.12	< 0.0001
Cholesterol (mg/dL)	106.41±6.76^c	135.64±5.03^b	117.94±4.94^c	153.07±6.44^a	10.23	0.0003

^{a,b,c,} means within the row with different superscripts differ significantly (P<0.05) from each other.

Table 5. Carcass and organs characteristics of finisher broiler chickens administered graded levels of *Moringa oleifera* leaf extract (MOLE) in the drinking water at 8 weeks

Parameters	T_1(0ml)	T_2(20ml)	T_3(40ml)	T_4(60ml)	SEM	*P-value*
LW (g)	2310.00^a	2100.00^c	2200.00^b	2216.70^b	70.24	<0.0159
DW (g)	1647.00^b	1503.30^c	1530.00^c	1790.00^a	56.64	<0.0007
DP (%)	74.37^b	71.41^c	69.83^d	77.95^a	1.55	<0.0005
Premium cuts						
Breast (%)	30.41^a	30.36^a	27.67^c	30.65^a	0.61	<0.0036
Thigh (%)	13.98^c	15.59^b	16.98^a	15.17^b	0.54	<0.0012
Drumstick (%)	12.46^c	16.32^a	15.03^b	14.38^b	0.70	<0.0002
Wings (%)	10.79^d	13.49^a	12.85^b	12.99^b	0.52	<0.0021
Backcut (%)	19.78^c	18.16^d	20.48^b	21.01^a	0.96	<0.0008
Neck (%)	5.41^a	5.35^b	4.79^c	4.63^d	0.36	<0.0004
Internal organs and offal						
Gizzard (%)	2.12^b	1.86^c	1.82^d	2.22^a	0.11	<0.0001
Heart (%)	0.47^c	0.51^a	0.49^b	0.48^c	0.01	<0.0003

Liver (%)	2.82[a]	1.86[d]	2.50[b]	2.04[c]	0.28	<0.0001
GIT (%)	5.26[c]	5.99[a]	5.98[a]	5.67[b]	0.40	<0.0001
Spleen (%)	0.13[c]	0.13[c]	0.15[a]	0.14[b]	0.01	<0.0108
Kidney (%)	0.62[b]	0.66[a]	0.50[c]	0.47[d]	0.04	<0.0001
Lungs (%)	0.60[c]	0.62[b]	0.73[a]	0.79[a]	0.04	<0.0001
Head (%)	3.01[c]	3.02[c]	3.09[b]	3.26[a]	0.06	<0.0001
Shank (%)	4.64[c]	4.70[b]	4.72[b]	4.73[a]	0.75	<0.0474

[a,b,c,d] means within the row with different superscripts differ significantly (P<0.05) from each other. LW=Live weight; DW=Dressed weight; DP=Dressing percentage; GIT=Gastrointestinal tract; SEM=Standard error of mean

Table 6. Economic production indices of finisher broiler chickens administered graded levels of *Moringa oleifera* leaf extract (MOLE) in the drinking water at 8 weeks

Parameters	T_1(0ml)	T_2(20ml)	T_3(40ml)	T_4(60ml)	SEM
Cost/kg feed	115.75±0.00	115.75±0.00	115.75±0.00	115.75±0.00	0.00
TCFC	465.89±12.55[a]	499.08±14.00[c]	519.17±15.82[d]	480.10±13.31[b]	11.58
Cost/kg WG	527.82±32.56[b]	458.37±25.23[c]	632.00±36.66[d]	431.75±23.05[a]	44.72
CoP	466.05±23.54[a]	501.92±32.65[c]	519.31±35.45[d]	480.38±30.65[b]	11.74
Revenue	1324.46±0.01	1642.50±0.10	1232.55±0.00	1668.95±0.21	110.57
Gross margin	858.41±23.56	1140.58±23.69	713.24±30.76	1188.57±30.45	113.69
CBR	2.84	3.27	2.37	3.47	0.29

[a,b,c,d,] means within the row with different superscripts differ significantly (P<0.05) from each other. TCFC=Total cost of feed consumed; WG=Weight gain; CoP=Cost of production; CBR=Cost-benefit ratio

Table 5 illustrates the carcass and organ characteristics of Anak broiler chickens given varying levels of MOLE in their drinking water. Significant differences ($P < 0.05$) occurred across treatment groups. Treated groups (T_2 – T_4), especially T_4 (60 ml/L MOLE), recorded higher values in several parameters compared to the control. Overall, the values did not follow a consistent pattern across treatments.

Table 6 shows the economic performance indices of finisher broiler chickens administered varying levels of MOLE in their drinking water. The analysis showed statistically significant differences *(P<0.05)* across most of the evaluated cost-analysis parameters. The values recorded were ranged as follows: total feed cost (₦465.89–₦519.17), cost/kg weight gain (₦431.75–₦632.00), cost of production (₦466.05–₦519.31), revenue (₦1232.55–₦1668.95), gross margin (₦713.24–₦1188.57), cost-benefit ratio (1:2.37–1:3.47), and cost/kg feed (₦115.75), which remained invariably amongst the treatment groups.

Discussion

Odumeru et al., (2023) and Divya et al., (2024) performed phytochemical analysis of *M. oleifera* leaf extract (MOLE). They affirmed that it has bioactive compounds in abundance, and explicitly outlined the compounds as follows: flavonoids, tannins, saponins, alkaloids, reducing sugars, phenolics, triterpenoids, carotenoids, glucosinolates, sterols, steroids, resins, terpenes, polyphenols, fatty acids, glycosides, chlorophylls, tocopherols, anthraquinones, anthocyanins, oxalates, amino acids, carbohydrates, minerals, vitamins, and polysaccharides. They further claimed that these compounds contribute to the plant's broad therapeutic and nutritional potential, combined with a relative absence of harmful components, making *M. oleifera* a promising nutritional alternative for both man and animals.

Verma et al., (2024) reared broiler chickens for 16 weeks to determine the safety of MOLE. They recorded a lower mortality rate of 3% in the group that received MOLE, whereas the control showed 4%, although feed consumption stayed consistent among groups (6611.52–6799.49 g). With this study's outcomes, it points out that the extract was well tolerated and the amount of dose given did not cause harm.

According to Divya et al., (2024), *M. oleifera* leaf aqueous methanol extract given in drinking water at a dose of 2000 mg/kg did not show harmful effect on female albino Wistar rats that is not pregnant. They monitored blood parameters (Aspartate aminotransferase (AST), alanine aminotransferase (ALT), and total bilirubin levels), and the lethal dose went beyond 2000 mg/kg, displaying a good

safety margin. A number of different extensive trails confirmed this safety, displaying no hostile consequences and upholding the use of MOLE within the specified dosage limit.

Moringa oleifera is a tree that is extremely capable of providing nutrients and promoting healing when ingested. From the tree, a worthy source of nourishment that promotes development, growth, and fight against undernutrition are acquired (Ndayankpa et al., 2024). The higher values for proximate composition obtained in this study indicate that *M. oleifera* is a good source of nutrients for both humans and animals. In poultry nutrition, where protein is costly and represents the second-largest dietary component, MOLM can substitute other cereal ingredients. This substitution reduces competition and production costs while increasing farmers' income by promoting rapid, uniform weight gain in broilers (Imma et al., 2023).

Ndayankpa et al., (2024) determined the proximate composition of the *M. oleifera* leaves and reported higher values for crude protein (35.46%) and carbohydrate content (64.70%), lower crude fiber (8.2%), and similar ash content (12.95%) likened to our work. Ahmed et al., (2023) documented dry matter (92.06 ± 0.10%), crude protein (28.59 ± 0.11%), and ash (11.65 ± 0.54%) contents for *M. oleifera* leaves. These parameters values are the same as we noticed in our work.

We noticed bigger value for dry matter and very small value for moisture content in our work, likened to the moisture content of 7.94 ± 0.10% documented by Ahmed et al., (2023), manifest that the test ingredient provides nourishment, last for a longer period of time, and higher nutrient concentration. The crude fiber value obtained in this study was much lower than the value 32.15 ± 1.87% reported by Ahmed et al., (2023), but higher than 6.13% reported for *M. oleifera* leaf by Mikore and Mulugeta (2017), suggesting better feed breakdown, taste, and overall well-being.

The importance of dietary fiber cannot be overemphasized as it is essential in keeping the digestive tract unimpaired, improving feed breakdown and encouraging the growth of helpful bacteria (Lattimer and Haub, 2010). In our study, we observed higher nitrogen free extract compared to 14.05 ± 2.68% reported by Ahmed et al., (2023), and this indicates a good energy source made available for the experimental birds. Nitrogen-free extract depicts the absence of fiber, nitrogenous, fat, and mineral piece of a feed sample, indicating its energy-providing value required for animals' metabolic and daily activities. Based on these results, MOLM is a good feedstuff for rearing domestic fowl, especially broiler chickens. Disparities in proximate constitution may come from factors like place, yeartime, gathering phase, and series of steps taken to accomplish the end product, as noted by Essen et al., (2024). Additionally, in our study, we noticed bigger ether extract content in *M. oleifera* leaves likened to 6% documented by Gopalakrishnan et al., (2016), which could be caused by nutrient content of the soil and genotypic variations. The carbohydrate content in this study exceeded the 40.4% reported by Mikore and Mulugeta (2017).

In Gaborone, Botswana, Eng et al., (2024) picked six different varieties of *M. oleifera* leaf samples and carefully considered their proximate compositions. They reported crude protein, moisture content, ether extract, ash, crude fiber, and carbohydrates with values ranging from 24.9 ± 0.43-29.4 ± 0.06%, 6 ± 0.3-7.8 ± 0.46%, 7.1-8.4%, 5.6 ± 0.18-9.1 ± 0.26%, 9.6-12.3%, and 36.6 ± 5.92–59.8 ± 2.92%, respectively. Our results were within these ranges, which also aligns with the author's findings. Ogbe and John, (2011) reported a higher moisture content (11.76%) for *M. oleifera* leaves grown in Nasarawa State, Nigeria. Variations in moisture content may result from differences in leaf maturity, plant age, and drying methods taken. Yang et al., (2023) compared both dry and fresh *M. oleifera* leaves and observed crude protein content of 27.1 g/100 g (DW) and 6.7 g/100 g, respectively. Our result is in line with the author's findings.

Sanchez-Machado et al., (2010) and Sultana (2020) reported variable crude protein contents ranging from 19–29%. In our study, we noticed bigger crude protein content than the values of 22.8% and 24.8% documented by Sanchez et al., (2006) and Mikore and Mulugeta (2017), respectively. The very elevated protein content insinuates that *M. oleifera* leaves can evidently boost nutritional values in chicken rearing and fortify cereal-based ingredients (Peñalver et al., 2022). Trigo et al., (2023) point out that adding *M. oleifera* leaf products into feed raises the protein, essential amino acids, minerals, and fiber contents, making the nutritional status of animal diets better. Not the same in protein content may be manipulated by differences in varieties, fertility of the soil, leaf maturity, and water availability.

The ash content in this study is higher than the mean values reported by Busani et al., (2011) (10.6%) and lower than the 15.6% reported by Mikore and Mulugeta (2017). The high ash content, as reported by Sultana (2020), indicates the availability of essential minerals that contribute to production performance, suggesting that *Moringa* leaves have high concentrations of important mineral elements for human and animal nutrition. These differences may be due to varietal differences, soil type, climatic variations, and provenance differences.

The weight gains significantly moved upward amongst chickens that received MOLE. Among the inclusion levels, treatment four (60ml/L) gave the very elevated performance, compared to the control. These findings point out that MOLE heightens weight gain,

possibly due to its higher protein content. Jasper (2020) reported similar results. He observed FBW of 1476.70 g, AWG of 1442.90 g, and ADWG of 45.09 g in Cobb 500 broilers given Malunggay MOLE at 0.5kg/2L of water for 42 days, compared to the control group with FBW (1421.00 g), AWG (1391.70 g), and ADWG (43.49 g).

Verma et al., (2024) recounted an increased FBW and total body weight gain of 1426.22±20.12 and 1149.38±21.89, respectively, in Ankleshwar birds given 90 ml MOLE between 4-20 weeks. Alwaleed et al., (2020) discovered that Cobb broilers subjected to 3% *M. oleifera* leaf meal (MOLM) had the biggest body weight (2564±9.53) among all concentrations. Contrarily, Alabi et al., (2017) reported the highest FBW (2392.00 g) and growth rate (53.61 g) among the control birds, with the least values (2042.00 g and 45.37 g, respectively) in birds given 150ml/L aqueous MOLE.

Feed intake in birds administered varying levels of MOLE was significantly different *(P<0.05)* among the treatment groups. However, this finding contrasts with the reports of Obike et al., (2023) and Verma et al., (2024), who observed no effect of the extract on feed intake. Higher feed intake was observed in treated groups, particularly T_3 40 ml/L MOLE, followed by T_2 20ml/L MOLE, and T_4 60ml/L MOLE, compared to the control group. This result contradicts Sule et al., (2024), who documented higher feed intake in control treatment when Ross 308 broiler chickens were subjected to MOLM-based rations.

At any time that the feed conversion ratio (FCR) value appears to be small, it points to better feed utilization (Ezeibe et al., 2024). It is obviously true from the outcome of the study that the consumption of MOLE at inclusion of 60ml/L increased total weight gain and FCR. FCR noticeably lower/better in treatment 4, whereas treatment 3 took the higher value and can be represented in ascending order: $T_4 < T_2 < T_1 < T_3$. The treated groups showed better values than the control group, possibly due to improved digestion and metabolism *from M. oleifera* bioactive agents. Meel and Sharma (2021) reported that a diet supplemented with 1.5% MOLM improved the FCR in Vencobb-400 broiler chicks over 42 days. Similarly, Alwaleed et al., (2020) found that broilers fed a diet containing 3% MOLM achieved a better FCR (1.59; *P<0.001*) compared to other groups in Cobb broilers for 42 days. Alabi et al., (2017) conducted an experiment for 6 weeks using Hubbard broiler chicks and observed significantly improved FCR with the inclusion of 90 ml/L and 120 ml/L (1.46 and 1.50, respectively), compared to the control 0 ml/L (1.58). Verma et al., (2024) and Essen et al., (2025) established lower/better FCR (6.12 and 3.38) when supplementing with 90ml MOLE and 30ml of SLE, respectively compared to other treatment groups.

Significant differences *(P<0.05)* in water consumption results do not support the reports of Essen et al., (2025). We noticed a continuous reduction in water consumption as the MOLE inclusion levels went upwards. Broiler chickens in group one that received 0ml of the treatment, consumed highest quantity of water, while 60ml (group four), had the lowest water intake. The reduction in water intake with higher MOLE concentrations may be due to phytochemicals affecting the water taste and the bird's willingness to drink (Charles, 2012). Charles (2012) claims contradicts the findings of Jasper (2020), who reported increased water intake with higher Malunggay MOLE levels. Reports have shown that salt and other substances affect the water consumption of broiler chicks (Huang et al., 2011). Factors affecting water intake include breed, sex, age, diet, feeding management, and environmental conditions. In fact, (Manning et al., 2007; Virden et al., 2009; Balogun et al., 2013; Huang et al., 2011) reported a high correlation of 98% between water drinking and feed intake, indicating that birds consuming more feed also tend to drink more water, and that water consumption is interdependent with the overall nutrient utilization and growth performance. Huang et al., (2011) stated that there is a 1:2 ratio between feed and water intake in layers. Birds drink twice as much water as the feed they consume at normal house temperatures. However, whenever the temperature went up, water consumption rate doubles times four (Balogun et al., 2013).

Our results on hematological parameters oppose the work of Singh et al., (2022), who documented no significant impact *(P>0.05)* from dietary supplementation of different phytogenic products on Cobb 400 broiler chickens. Nevertheless, it supports Anyanwu et al., (2023), who documented a significant impact *(P<0.05)* in all the blood profiles measured after subjecting three distinct parts of M. *oleifera* to Cobb 500 broiler chickens for the period of 28 days, respectively.

Hematological examinations give the necessary details for disease prediction, noting and recording health changes, and weigh the feed consequences. Alimentation meaningfully regulates hematological values like PCV, Hb, and RBC (Odetola et al., 2016). In our work, nearly all the hematological indices ascertained dropped within the established range for broiler chickens that have good health status, as suggested by Ewa et al., (2023). Our hematological indices result supports the work of Odetola et al., (2016), who documented that hematological values within the standard range reveal that diets do not negatively alter hematological parameters. On the other hand, values falling below the normal range suggest anemia.

Packed cell volume (PCV) is an indicator of blood toxicity and may suggest the presence of toxic factors that adversely affect blood (Oyawoye and Ogunkunle, 1998). Birds in the treated groups had higher PCV values than those in the control group. The PCV values obtained in this study were higher than the 26.78 – 29.33% documented by Antyev et al., (2016).

PCV marks nutritional sufficiency in all the treatment groups, as the values did not hint lack of adequate nourishment. Kenneth-Chukwu et al., (2024) claim affirms that introducing MOLE into the broiler ration had little to no outcome on the amount of blood cells compared to the total blood volume (Onyekwere et al., 2016). The PCV values in this study fell within the normal physiological range of 25 – 41% reported by Mitruka and Rawnsley (1977) and 31.86 – 38.00% reported by Nonye et al., (2021) for Arbor Acres broiler chickens fed diets prepared with *Curcuma longa* and *Xylopia aethiopica* mixture for a period of 48 days.

Nonetheless, these results do not support the work of Shivappa-Nayaka et al., (2013), who claimed that adding *Curcuma longa*, *Azadirachta indica,* and Alpha-tocopherol in broiler diets significantly influenced PCV values. Researchers often use PCV as a quick and reliable indirect method to evaluate red blood cell values in circulation, and it serves as a basic screening test for anemia.

Red blood cells (RBC) develop in the long bones, and their production depends on iron absorbed from digested food. Their primary function is to transport hemoglobin, which carries oxygen from the lungs to the tissues. The RBC values in this study fall within the normal range of 4.10-6.50 x10^^{12}/L for healthy broilers (Essen et al., 2024), but are higher than the normal physiological range of 1.5-3.9 x10^^{12}/L reported by Mitruka and Rawnsley (1977). Our RBC result proves that the experimental diets met the nutritional needs of the broiler chickens and enhanced their high-oxygen-carrying capacity.

When the RBC values increase, it speaks of better health and greater potential for oxygen and carbon dioxide transport, as well as hemoglobin synthesis (Olugbemi et al., 2010). Kenneth-Chukwu et al., (2024) documented that dilated RBC values are affiliated with reasonable quality dietary protein and healthy animals. A chemical element called iron (Fe, 23 mg/100g) is noticed in MOLE, which remain requisite for hemoglobin and myoglobin formation.

Jiwuba et al., (2017) noted that WBCs fight infections, defend the body against foreign organisms, and produce or transport antibodies in the immune response. *Moringa oleifera* has been reported to enhance immunity (Divya et al., 2024). The WBC count, which showed a significant difference *(P<0.05),* may be attributed to MOLE's ability to supply and maintain essential minerals and amino acids for normal blood cell functioning. Antyev et al., (2016) reported that granulocyte-macrophage colony-stimulating factor regulates the proliferation, differentiation, and maturation of committed stem cells that give rise to WBCs. Their claim suggests that *Moringa oleifera* leaf extract has immunostimulatory properties.

The WBC values in this study fall within the normal physiological range of 9.7–31.0×10^9/L for healthy birds (Mitruka and Rawnsley, 1977; Bounous and Stedman, 2000), indicating no microbial infections or foreign bodies in the circulatory system. Our WBC result suggests that MOLE in the diet does not negatively affect the immune system, corroborating the finding of Aikpitanyi and Egweh (2020), who fed broiler chickens diets containing ginger and black pepper. The normal WBC values observed in this study may imply a highly developed immune system in broiler chickens.

Mitruka and Rawnsley (1977) established 7.5–13.1 g/dL as the standard reference range of Hb. The Hb values we obtained in our study drops inside this range documented by these Authors, proving distinctly that MOLE consumption encourages sufficient hemoglobin role for oxygen and carbon dioxide transport.

Our results disagree with the work of Shivappa-Nayaka et al., (2013), who noticed that adding *Curcuma longa*, *Azadirachta indica,* and Alpha-tocopherol in broiler diets significantly influenced Hb values. The observed increases in PCV, Hb, and RBC in broiler finishers subjected to varying inclusion levels of MOLE imply better health conditions, likely due to the antioxidant properties of *M. oleifera.*

MCV calculates the average erythrocyte size; MCH measures the hemoglobin amount per blood cell, and MCHC indicates the amount of hemoglobin relative to the size of the cell per red blood cell. The MCH and MCHC values reported in this study were within the physiological range of 25.35–33.45 pg and 25.35–35.37 g/dL, respectively, as reported by Mitruka and Rawnsley (1977). However, these values obtained in this study were lower than the normal ranges reported by Bounous and Stedman (2000) for MCV (90–140), MCH (33–47 pg), and MCHC (26–35 g/dL). The MCH and MCHC values within the normal physiological range indicate that the birds were not anemic, proving that MOLE were nutritious and encourage RBCs formation in the bone marrow. Before now, researchers documented changeable values in MCV, MCH, and MCHC. They all attributed the fluctuations to differences in the state of the environment and genetic mutable, since most reference values came from studies researched in temperate nations.

Antyev et al., (2016) and Alwaleed et al., (2020) also did not observe significant differences for feeding MOLM to Anak 2000 and Cobb 500 for 56 and 42 days, respectively, and their findings are in line with our results on total protein and albumin. Not with standing, Kenneth-Chukwu et al., (2024) documented a significant *(P<0.05)* difference in serum biochemistry parameters for feeding MOLM to broiler birds for 56 days. Their results remain in harmony with ours.

Serum biochemical parameters provide functional information for the evaluation of the health status of birds and reflect many metabolic alterations of organs and tissues when feeding unconventional feed materials (Jain et al., 2010).

Total serum protein consists of albumin and globulin. The increase in serum protein of the experimental birds in T_3 (40ml/L MOLE) suggests that the quantity of MOLE added into the drinking water of the experimental birds increased protein digestion and utilization in broiler birds. However, supplementation with *Moringa* leaves increased total protein, which reflects the ability of *Moringa* leaves to enhance protein metabolism and stimulate hepatic tissue regeneration in broiler birds. This, in turn, promotes protein synthesis in the liver and improves liver cell function. This mechanism of action highlights its role in maintaining the health and integrity of liver cells. Low levels of serum protein in T_4 (31.70 g/dl) could be due to interference with normal protein metabolism (Kenneth-Chukwu et al., 2024). This protein metabolism interference could be ascribed to the presence of residual anti-nutritional factors in *Moringa* leaf. *Moringa* leaf has phytotoxins such as lecithin, alkaloids, tannins, oxalate, and phytate (Odumeru et al., 2023). The serum protein levels obtained in this study were within the normal range for (3.0 -4.9 g/dL and 3.72-4.20 g/dL) as reported by (Bounous and Stedman, 2000; Ewa et al., 2023).

According to Nonye et al., (2021), serum albumin aids in the movement of molecules and the maintenance of blood pressure. A high albumin concentration usually indicates dehydration, whereas a low concentration indicates poor liver function owing to malnutrition or infection. The results of our study remain in agreement with those documented by Nonye et al., (2021) and Ewa et al., (2023) for evidently healthy broilers, which ranged from 2.03-2.62 g/dL and 1.77-2.37 g/dL, respectively. The fact that albumin levels drop inside the standard reference ranges implies that the liver and other extrahepatic organs involved in protein synthesis are in good condition. Serum albumin and globulin depend on the availability of dietary protein. Globulin values obtained in the study fell within the reference range of 1.40 - 1.88 mg/dL reported by Nonye et al., (2021) for broiler chickens. Since the liver is the site of serum protein production, this could indicate a stronger immune system and better hepatic function.

The cholesterol levels of birds in T_4 were higher than those in other treated groups. Cholesterol values increased progressively as MOLE inclusion rose from T_1 (control) to T_4 (40 ml/L). This result is in line with the findings of Alwaleed et al., (2020), who assessed the effect of MOLM on broiler birds, but disagrees with the reports of Olugbemi et al., (2010) and Antyev et al., (2020), who reported a reduction in serum cholesterol level with increasing level of MOLM inclusion in the diet of rats and broilers, respectively. Again, the cholesterol result obtained in this study counters the claims of Jain et al., (2010), who reported that *M. oleifera* leaf extracts exhibit a cholesterol-lowering activity due to the presence of active substances that could reduce the intestinal uptake of dietary cholesterol. The increased cholesterol content observed among the birds administered MOLE as compared to those birds in the control group could be as a result of the antioxidant properties of MOLE included in their drinking water (Odumeru et al., 2023) which tends to alter the synthesis, absorption, and utilization of lipids in the body, leading to changes in cholesterol levels, and can influence the regulation of cholesterol synthesis and degradation. Also, according to Mahfuz and Piao (2019), the reduction in blood cholesterol could be linked to increased lipid metabolism in broilers, which is induced by the greater fiber content of MOLM. However, the cholesterol was within the reported range of 52.00–155.00 mg/dL by Mitruka and Rawnsley (1977). Our result on cholesterol parameter suggests that MOLE in the treatment diets may promote liver and vascular function by increasing cholesterol transfer to the liver. Ademola et al., (2009) emphasized that maintaining optimal cholesterol levels supports animal welfare. The liver enzymes are vital indicators of liver function (Jiwuba et al., 2017).

Glucose is the primary carbohydrate precursor for energy, and is efficiently utilized by most body cells (Klasing, 2000). Blood glucose level obtained in this present study showed an anti-diabetic effect through decreasing the values among the treated groups as the MOLE inclusion increases. Jaiswal et al., (2009) reported similar result during evaluations of *M. oleifera* leaf effects in rats. On the other hand, blood glucose level was not affected when fish meal was replaced by MOLM in broilers (Zanu et al., 2012). The glucose levels obtained in this study were within the normal range reported (172.70 -256.70 mg/dL) by Alwaleed et al., (2020).

An increase in serum urea concentration usually suggests an increase in activities of urea enzymes, ornithine carbonyl transferase, and arginase, which may also indicate kidney damage (Ewa et al., 2023). The serum urea values recorded in this study remained within the normal serum urea range of 8.85–10.25 mg/dL reported by Ewa et al., (2023), suggesting proper kidney function and adequate metabolism supported by the various brands of commercial animal feed sold, like Vital feed utilized in our study.

According to Marcela et al., (2025), creatinine plays a remarkable role in muscle metabolism and most of the time used as a standard yardstick in knowing kidney function. In our study, creatinine references differed significantly among treatment groups. Treatment 3 gave the very elevated value, significantly bigger than treatment 2 and treatment 1, while treatment 4 did not differ significantly from either treatment 1 or treatment 3. These values went above the standard reference range of 0.81–1.04 mg/dL documented by Kenneth-Chukwu et al., (2024), but dropped inside the normal reference range of 2.09–2.67 mg/dL published by Essen et al., (2025).

The increased creatinine levels obtained in our study are not necessarily pathological, but could be as a result of some environmental conditions (stress, breed, and sample population etc). Furthermore, greater muscle turnover and better metabolic

activity seen among exotic broiler breeds can raise serum creatinine without causing renal dysfunction. Since researchers observed no clinical signs of toxicity or renal disability, the recorded values are considered physiologically safe within the context of our study.

Alwaleed *et al.,* (2020) and Antyev et al., (2020) conducted a trial that lasted for 6 and 8 weeks, using Cobb 500 and Anak broiler chickens, respectively. They subjected the experimental birds to 3% MOLM, and their outcome showed significantly higher dressed weight and dressing percentage. On the contrary, Obike et al., (2023) and García-García et al., (2024) observed no significant impact on carcass parameters in broiler chickens. The results are consistent with the works of El-Tazi (2010) and Antyev et al., (2020). Their results revealed that the body of the slaughtered animal, dressing yield and chopped parts increased in broiler chickens given MOLM-supplemented diets compared to the control group. However, the carcass characteristic values in this study were higher than those reported by Alwaleed et al., (2020) and Antyev et al., (2020) for broiler chickens after 42 and 56 days of rearing, respectively.

Organ weight results showed similar values for the gizzard, heart, liver, GIT, spleen, kidneys, and lungs. This study demonstrates that MOLE supplementation can improve carcass yield in broilers. The gizzard, liver, and spleen values in this study were higher than those reported by Odetola (2016) when *Petiveria alliacea* root meal was included in the diet of Cobb broiler chickens for 56 days, with ranges of 2.40% to 3.57% (gizzard), 1.67% to 2.00% (liver), 0.08% to 0.10% (spleen), 0.47% to 1.97% (lung), and 0.40% to 0.67% (heart), respectively.

When we compared our results on carcass and organ characteristics with other works, we noticed huge disparities and attributed it to environmental conditions including breeds, nutrition, age, sex, processing and carcass cutting patterns adopted.

Cost per kilogram of feed entails the money spent on one kilogram of diet eaten by the broiler chickens during the study duration. We make sure all treatment groups received equal value (₦115.75).

All the money we spent on food starting from the beginning of the trial to the end is known as total cost of feed consumed. The money spent to obtain a kilogram of weight gain determines the money spent to realize a kilogram of live weight gain in broilers, a yardstick for measuring the profitability of production.

Cost of production encompasses all expenses required to produce the broilers. In T_3 (40 ml), higher values were recorded for total feed cost (₦519.17), cost/kg weight gain (₦632.00), and cost of production (₦519.31). Conversely, lower values were observed in T_1 (0 ml) for total feed cost (₦465.89), in T_4 (60 ml) for cost/kg weight gain (₦431.75), and again in T_1 for cost of production (₦466.05). For revenue and gross margin, T_4 (60 ml) had the highest values (1668.95 and 1188.57), whereas T_3 (40 ml) gave the smallest (1232.55 and 713.24), respectively.

Revenue is the fund acquired after selling off all our produce, while gross margin shows total income minus expenditures. In our study, broiler chickens that we subjected to 60 ml/L of MOLE give the biggest revenue (₦1668.95) and gross margin (₦1188.57), pointing out well utilized resources and gain. Onu (2009) noted that profit is the money or services that is considered fair equivalent for raising domestic fowl. Obviously true by simple observation, our results clearly revealed that broiler chickens that received 60 ml/L of MOLE bring about extra fund and biggest gross margin than other groups, making production expenses small and hiking growth and gain. Work of Mba et al., (2024) defended our claims for they documented comparable findings. Okedere et al., (2020) ascertained cost benefits in producing Isa Brown layers and discovered that the deep litter system produced the biggest revenue (₦1384.56).

CBR, a standard way of weighing gain, computes the balance between benefits and costs to determine profit. Babale (2016) and Mba et al., (2024) elucidate that CBR values greater than 1 speak of gain, values equal to 1 mean a break-even point, and values below 1 indicate loss. In our study, treated groups, especially treatment that received 60ml/L of MOLE, reached biggest CBR values, therefore augmenting gain. Work of Kassu et al., (2016) corroborate our results. They documented a very small production expenses, the experimental animals converted the feed consumed to meat very well, bigger live weight, and greater net revenue amongst ginger-treated broiler groups. Kumbhar et al., (2023) documented a raised CBR values of 1.4–1.5 in commercial poultry farming during the chaotic breakdown of public health, which remained consistent with the findings of our study. These results reveal the economic merits of supplementation strategies such as treatment group four for broiler production.

Obike et al., (2023) determined the economic parameters of two broiler breeds (Anak and Marshal) for a 28-day period. They documented revenue and gross margins per bird, with values of ₦518.71 and ₦435.02, and ₦320.37 and ₦212.31, respectively. Wekhe et al., (2012) and Adeoti et al., (2013) conducted a research trial that lasted for a period of 56 days using Anak and Marshal broiler chickens. They noted gross margins ranging from ₦269.18 to ₦764.34 and $1, respectively. Our study transcends these results, speaking of better returns on investment with treatment four, which received 60 ml/L of MOLE. Ijaiya et al., (2009) clearly stated that optimized diets improve growth rate at a reasonable cost. This study corroborates their assertion by highlighting the profitability and extent to which 60ml/L of MOLE was used for the intended purpose (broiler production). Anamayi et al., (2018) served graded levels of MOLM

for the period of eight weeks to finisher broilers. Although treatment differences were not statistically significant, treatment groups that received MOLM achieved bigger gross margins (₦518.74) and net profits (₦408.54), consistent with the current results.

Study weaknesses

Admittedly, our study has some shortcomings. We noticed that the crude protein content of the experimental diet was below the perfect level. The nutritional deficiency may have tampered the physiological result (blood parameters), and strongly limit the maximum impact of the test ingredient (*M. oleifera* leaf extract).

In our study, parameters of interest considered did not comprise a direct LD_{50} assessment in poultry. We used rat data, which is widely accepted for first checks of feed safety. Rats are standard in toxicological studies because their body responses are widely known, and administrative rules established by the Organization for Economic Co-operation and Development (OECD) support their use. Supporting this approach, past work (Kim, 2023) has successfully applied rat toxicity limits to poultry, especially with plant-based additives. In our work, we gave a dose of MOLE far below the rats LD_{50} (3900 mg/kg), and no harm noticed during the experimental days. Rats and poultry share detox systems such as cytochrome P450 enzyme pathways, so their reactions to many plant-based compounds are similar. Still, we admit that species differences remain.

To close these gaps, future works should use diets with proper protein and include direct LD_{50} tests in poultry to confirm the safety profile of MOLE in birds.

4. CONCLUSION

Adding the test ingredient (*M. oleifera* leaf extract) into the drinking water of the experimental animal (Anak broiler chickens) raised growth performance (weight gains and FCR), carcass characteristics (dressed weight, dressing percentage, cut-parts and organs/offals), and economic production (cost/kg weight gain, cost of production, revenue, and gross margin). We noticed the best results in treatment four, which received the biggest inclusion level of MOLE. Importantly, adding MOLE into the drinking water of the broiler chickens did not alter blood parameters in a harmful manner, concurring it is safe for use and sustaining its role as a phytogenic growth promoter in poultry production.

Our study highlights MOLE as an economical feed additive that advances broiler performance while making feed costs very small, thereby increasing farmers' income.

We recommend that future works should focus on testing different parts of *M. oleifera* (seeds, stem bark) to see how safe they are by mapping their toxic effect; optimize the best amount of MOLE to add in drinking water for other broiler breeds; and track how it affects growth and feed use over extended periods.

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Author Contributions

We reviewed the results and approved the final version of the manuscript.

Contributions to the study were made by the authors as follows: Conceptualization, methodology, data curation, formal analysis, investigation, validation, software, resources, project administration, visualization, writing – original draft, and writing – review and editing: Essen P. O., Njoku G. N., Iwere J. I., Ewa D. O., Essen J. I., Okoro D. C., and Onya G. U.; Supervision, methodology, and writing – review and editing: Ewa U. E. and Adjei-Mensah B.

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Conflict of interest

The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval

All experimental protocols were reviewed and approved by the Ethics Committee of the Federal College of Agriculture, Ishiagu (FCAI), Ebonyi State, Nigeria, a branch of the National Ethics Committee for the control and supervision of experiments on animals.

All procedures were reviewed and preapproved by the Ethics Committee of the Federal College of Agriculture, Ishiagu (FCAI), Ebonyi State, Nigeria, which operates under the National Ethics Committee for the Control and Supervision of Experiments on Animals. Project identification number: FCAI/APT/2025/040, approval date: November 14, 2025. The research followed the "Replacement, Reduction, and Refinement" (3Rs) principles to minimize harm to animals. This article provides details on the housing conditions, care, and pain management for the animals, ensuring that the impact on the animals is minimized during the experiment.

Informed consent

Not applicable.

Data availability

All data associated with this study will be available upon reasonable request to the corresponding author.

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