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Performance and Blood Characteristics of Broiler Chickens Fed Graded Levels of *Moringa oleifera* Leaf Meal Diets

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Abstract

This study investigated the effects of Moringa oleifera leaf meal (MOLM) on the growth performance and blood characteristics of broiler chickens. 180 day-old Arbor acre chickens used in this experiment were subjected to five dietary treatments as follows; Diet 1-the control devoid of Moringa oleifera leaf meal (0%MOLM), diets 2, 3, 4, and 5 with –MOLM at graded inclusion levels of 2.5, 5.0, 7.5 and 10.0% level respectively in a Completely Randomized Design. Each treatment was replicated thrice with 12 birds per replicate. The experiment lasted 56 days. The results indicated that daily weight gain, daily feed intake, and feed conversion ratio were significantly (p <0.05) affected by the inclusion levels of MOLM. Birds fed a diet containing 2.5% MOLM showed the highest values for these parameters: Daily weight gain (66.05 g), daily feed intake (118.45 g), and feed conversion ratio (1.73). There was better performance up to 2.5% MOLM but the performance declined significantly at a higher inclusion level. There was an improvement in the haematological ((PCV, RBC, HB) parameters up to 10% MOLM inclusion. The AST and ALP increased significantly with the increased level of MOLM while the total protein, albumin, and glucose decreased. Nevertheless, there were no influence (P > 0.05) on the protein and albumin values. It can be concluded from the findings of this research that MOLM can replace soya bean meal in broiler chick diets up to 10% without deleterious effect on the growth performance and blood profile.

Keywords: Moringa, leaf-meal; broiler chickens; performance; biochemical; haematological.

Introduction

Moringa oleifera (syn. *M. pterygosperma*), a member of the family *Moringaceae,* is widely distributed across tropical regions. It is a small, graceful tree characterized by sparse foliage, white flowers, and elongated pods. In northern Nigeria, it is commonly planted on farms, in compounds, and used as live fencing due to its multipurpose nature. Various parts of the tree such as the leaves, fruits, immature pods, and flowers are edible and form part of traditional diets in many tropical and subtropical countries.

According to Olugbemi *et al*. (2010), the leaves of *Moringa oleifera* possess antimicrobial properties and are a good source of fats, proteins, and minerals. As commercial poultry production continues to expand in Nigeria, there is a growing need to explore cost-effective feed alternatives. Feed accounts for about 80% of the total cost of poultry operations, and recent hikes in the prices of conventional feed ingredients have negatively impacted profit margins. Consequently, animal nutritionists are increasingly investigating the use of non-conventional feedstuffs to reduce feed costs and minimize competition between humans and livestock nutrition.

One promising approach is the use of leaf protein sources, which are gaining popularity due to their availability, abundance, and relatively low cost. Onyemonyi and Onu (2009) noted that incorporating leaf meals into broiler diets not only provides protein but also supplies

essential vitamins, minerals, and oxycarotenoids-compounds that enhance the yellow coloration of broiler skin, shanks, and egg yolks. In addition to its nutritional benefits, *Moringa oleifera* is also valued for its water purification properties. The seed powder contains natural polyelectrolytes, which are active ingredients in water treatment. Studies have demonstrated that the efficiency of *Moringa oleifera* in treating hard water improves with increased dosage, making it a valuable resource for both agriculture and environmental management. The purpose of this study was to investigate the effects of *Moringa oleifera* Leaf Meal on the growth performance and blood characteristics of broiler chickens.

Materials and Methods

The poultry unit of the Teaching and Research Farm at Kwara State University, Malete, Nigeria, served as the experimental site for the feeding trial. Fresh *Moringa oleifera* leaves were harvested manually by hand-plucking from trees located within the Ilorin metropolis, Kwara State, Nigeria. The harvested leaves were air-dried under shade to preserve nutrient content, after which they were milled and pulverized to a fine consistency suitable for dietary inclusion. The resulting material was sieved using a 1-mm mesh to produce Moringa Leaf Meal (MOLM), in accordance with the particle size requirements for day-old chicks as recommended by the NRC (1994). Five experimental diets were formulated: a corn-soybean meal-based reference diet (serving as the control) and four additional diets containing graded levels of MOLM.

Diets formulation

Five experimental diets were formulated for the study. Diet 1 served as the control and contained no *Moringa oleifera* leaf meal (MOLM), while diets 2, 3, 4, and 5 included MOLM at graded levels of 2.5%, 5.0%, 7.5%, and 10.0%, respectively. In these experimental diets, *M. oleifera* leaf meal was used to partially replace soybean meal at the corresponding inclusion levels. The ingredient composition and the calculated nutrient content of the experimental diets, presented on an as-fed basis, are detailed in Table 1.

Table 1: Composition (%) of the Experimental Diets

	Inclusion levels (%)				
Ingredients	**0**	**2.5**	**5.0**	**7.5**	**10.0**
Maize	58.25	58.25	58.25	58.25	58.25
SBM	38.40	35.90	33.40	30.90	28.40
MOLM	0.00	2.50	5.00	7.50	10.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Oyster shell	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50
Lysine	0.10	0.10	0.10	0.10	0.10
DL-methionine	0.25	0.25	0.25	0.25	0.25
*Vit/Min premix	0 .50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
ME (Kcal/kg)	2954	2959	2943	2958	2946
Crude protein (%)	23	23	23	23	23
Crude fibre (%)	3.20	4.11	3.13	3.58	4.23
Crude fat (%)	4.65	9.13	5.85	6.23	4.67
Methionine (%)	0.49	0.58	0.35	0.48	0.45
Lysine (%)	1.25	1.50	1.10	1.45	1.10

SBM= soya bean meal, MOLM= *Moringa oleifera* leaf meal, 0.50 premix supplied, per kilogram of diet: vitamin A, 12,000 IU; vitamin D3, 2,000 IU; vitamin E, 50 IU; vitamin B1, 1 mg; vitamin B2, 3 mg; vitamin B6, 1 mg; vitamin B12, 10 µg; vitamin K, 2 mg; copper (cupric sulphate), 75 mg; nicotinic acid, 12 mg; pantothenic acid, 10 mg; iron, 200 mg; cobalt, 0.5 mg; manganese, 40mg; zinc, 90 mg, iodine, 1 mg; selenium, 0.2 mg; calcium, 31.25 g; sodium,10g.

Test animals and feeding trial

A total of 180 Arbor Acre broiler chicks were utilized for this study. The experiment was arranged in a one-way classification design comprising five dietary treatments. Each treatment group consisted of three replicates, with twelve (12) chicks per replicate. Prior to the commencement of the feeding trial, all chicks were fed a conventional starter diet for one week to allow for acclimatization to the new environment. Following this period, the birds were provided with the respective experimental diets *ad libitum* for a duration of 56 days.

Nutrients Digestibility trial

At the conclusion of the feeding trial, a digestibility study was conducted following the INRA reference protocol (INRA, 2004). Fifteen broiler chickens, one bird per replicate from each dietary treatment, were randomly selected and transferred to individual metabolic cages specifically designed for digestibility assessment. Birds of statistically similar body weight ($p > 0.05$) were used to minimize variability.

An acclimatization period of three days was allowed, followed by a 24-hour fasting period to clear the digestive tract. Subsequently, each bird was offered 200 grams of its respective experimental diet daily for three consecutive days, after which another 24-hour fasting period was observed.

During the feeding and final fasting days, total excreta were quantitatively collected from each bird. The amount of feed offered and orts (refusals) were recorded. Proximate analyses were performed on both the feed and fecal samples to determine nutrient composition.

Nutrient digestibility was calculated using the formula:

$$\% \text{ Nutrient digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient in excreta}}{\text{Nutrient intake}} \times 100$$

Data Collection

At the end of the experiment, one broiler was randomly selected from each replicate across all treatment groups for blood collection via decapitation. Blood samples intended for biochemical analysis were collected into bottles without ethylene diamine tetra-acetic acid (EDTA). These samples were analyzed for biochemical parameters, including total protein, albumin, globulin, urea, and the activities of serum enzymes such as aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP).

For haematological analysis, blood samples were collected into EDTA-treated tubes to prevent coagulation. The haematological indices evaluated included White Blood Cell (WBC) count, Red Blood Cell (RBC) count, Packed Cell Volume (PCV), and Haemoglobin concentration (Hb). Derived erythrocyte indices, Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Haemoglobin Concentration (MCHC) were calculated using the values of RBC, PCV, and Hb in accordance with the method described by Jain (1986).

$$MCV = \frac{PCV \times 10}{RBC}$$

$$MCH = \frac{Hb \times 10}{RBC}$$

$$MCHC = \frac{Hb \times 100}{PCV}$$

MCHC = Mean Corpuscular Hemoglobin Concentration
MCH = Mean Corpuscular Hemoglobin
MCV = Mean Corpuscular Volume
Hb = Haemoglobin concentration
PCV = Packed Cell Volume
RBC = Red Blood Cell count

Data analysis

The data obtained from the study were analyzed using One-way ANOVA using the General Linear Model procedure of the Statistical Analysis System (SAS,

2003). Differences between treatment means were separated using Duncan's multiple range test.

Results

Results presented on Table 2 revealed that broilers fed with 2.5% MOLM based diet exhibited significantly (P < 0.05) higher feed intake and weight gain compared to those fed with higher levels of MOLM-based diets and the control. Although birds on treatments diets T2, T3 and T4 showed similar average daily feed intake and weight gains, a progressive decline in weight gain was observed as the inclusion level of MOLM increased. The feed intake values was very significantly (p <0.05) affected by the dietary replacements of soya bean with MOLM. There was a linear decrease in the feed intake values per day as the level of MOLM increased in the diet. The feed conversion ratio of the birds was significantly (p <0.05) affected by the increase in the dietary inclusion of MOLM in the diet of the birds. The feed conversion ratio favoured the birds on the 2.5% diet. There was no mortality recorded during the course of this trial. Digestibility of nutrients (crude protein, fat and fibre) in these experimental birds is presented on Table 3. The digestibility of nutrients on the control diet was comparable with that containing 2.5% MOSM (p > 0.05) while digestibility of the nutrients for birds on higher levels of inclusion (10 or more %) was lower (p > 0.05).

Table 2: Performance Characteristics of Broiler Chickens Fed *Moringa oleifera* leaf Meal based Diets

	Inclusion levels of MOLM (%)					
Parameters	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**SEM**
Daily weight gains (g/bird/day)	51.92^{c}	66.05^{a}	65.35^{ab}	61.04^{b}	57.26^{b}	1.72
Feed intake(g/bird/day)	108.62^{c}	118.45^{a}	113.22^{ab}	110.78^{b}	104.30^{c}	1.65
Feed conversion ratio	1.87^{b}	1.73^{a}	1.83^{ab}	1.84^{a}	1.84^{a}	0.05

SEM= Standard error of mean*=P <0.05Means with different superscript along the same rows are significantly (P <0.05); MOLM= *Moringa oleifera* Leaf meal

Table 3: Nutrient Digestibility of broilers Fed Different levels of *Moringa oleifera* Leaf Meal Diets

	Levels of MOLM					
Indices (%)	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**SEM**
Crude protein	78^{a}	77^{a}	76^{a}	75^{a}	61^{b}	2.6
Crude fat	73^{a}	76^{a}	73^{a}	73^{a}	58^{b}	2.4
Crude fibre	66^{a}	66^{a}	65^{a}	64^{a}	52^{b}	2.2

SEM= Standard error of mean*=P <0.05Means with different superscript along the same rows are significantly (P <0.05); MOLM=*Moringa oleifera* Leaf meal

The results of haematological parameters (Table 4) showed that the indices were affected (P < 0.05) by the inclusion of MOLM in the feed. There were more RBC, WBC and haemoglobin in birds fed 2.5 MOLM inclusion level. The result of biochemical indices (Table 5) showed that the parameters were affected (P < 0.05) by the inclusion of MOLM in the diets of the broiler chickens. The total protein was higher in birds given 7.5 and 10.0 MOLM inclusion level compared to the control group while the control group had the highest value (3.72) though statistical similar

to the values obtained in birds fed 7.5, 10 and 5 MOLM inclusion.

Table 4: Haematological Indices of Broiler Chickens Fed *Moringa oleifera* Leaf Meal based Diets

	Dietary treatment						
Parameters	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**SEM**	***Ref Value**
RBC ($\times 10^{12}$/l)	2.36^{ab}	2.52^{a}	2.30^{b}	2.18^{b}	2.24^{b}	0.106	2.50 – 3.50
Haemoglobin (g/dL)	8.75^{a}	9.30^{a}	9.00^{a}	8.50^{b}	8.70^{a}	0.415	8.00 – 13.00
PCV (%)	31.20^{a}	25.60^{a}	31.30^{a}	29.85^{a}	30.60^{a}	1.405	30.00 – 40.00
MCV (fl)	132.25^{ab}	129.60^{b}	136.10^{a}	137.00^{a}	136.55^{a}	3.372	90.00 – 130.00
MCH (pg)	37.15^{a}	36.95^{a}	39.15^{a}	39.00^{a}	38.80^{a}	1.216	30.00 – 40.00
MCHC (g/dl)	28.05^{a}	28.55^{a}	28.75^{a}	28.50^{a}	28.45^{a}	0.402	26.00 – 35.00
WBC ($\times 10^{9}$/l)	231.00^{a}	233.85^{a}	229.65^{a}	226.10^{a}	231.25^{a}	4.706	12.00 – 30.00

RBC= Red Blood Cell, PCV=Packed Cell Volume, Mean Cell Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC), WBC= White Blood Cell, Raw= untreated, SEM= Standard error of mean=P <0.05; Means with different superscript along the same rows are significantly (P <0.05). *(Kokore *et al.*, 2021; Auta *et al*. 2024)

Table 5: Serum Biochemical Indices of Broiler Chickens Fed *Moringa oleifera* Leaf Meal based Diets

	Dietary treatment						
Parameters	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**SEM**	***Ref Value**
Urea (mmol/l)	4.66^{b}	4.87^{b}	4.77^{b}	4.73^{b}	4.66^{b}	0.115	3.00 – 7.00
Total protein (g/l)	13.93^{b}	10.23^{c}	12.02^{b}	13.44^{a}	13.00^{a}	0.186	3.00 – 5.00
Albumin (g/l)	3.73^{a}	2.46^{b}	3.50^{a}	3.70^{a}	3.67^{a}	0.239	1.20 – 2.00
Aspartate Aminotransaminase (U/L)	70.00^{b}	90.03^{a}	62.11^{c}	68.84^{c}	70.84^{b}	6.779	150.00 – 250.00
Alanine Aminotransaminase (U/L)	19.48^{b}	20.44^{a}	19.87^{b}	18.04^{c}	19.46^{b}	1.059	-
Alkaline phosphatase (U/L)	35.68^{b}	36.29^{a}	34.66^{c}	32.54^{c}	30.84^{d}	3.839	-

Means with different superscript along the same rows are significantly (P <0.05), MOLM=*Moringa oleifera* Leaf meal. SEM= Standard error of mean, *(Arzour-Lahehal *et al.*, 2021; Auta *et al.* 2024)

Discussion

Results from Table 2 revealed that broiler chickens fed with 2.5% MOLM based diet exhibited significantly ($p < 0.05$) higher feed intake and weight gain compared to those fed with higher levels of MOLM-based diets and the control. Although birds on treatments diets T2, T3 and T4 showed similar average daily feed intake and weight gains, a progressive decline in weight gain was observed as the inclusion level of MOLM increased. A similar decline in broiler performance at higher inclusion levels of leaf meals was reported by Nkukwana *et al*. (2014), who observed that body weight gain significantly decreased with increased incorporation of *Moringa oleifera* leaf meal in the diet. This result also aligned with earlier findings by Ash and Petaia (1992), Olugbemi *et al*. (2010), and Animashahun *et al*. (2022), who reported that higher inclusion levels of leaf meals in broiler diets negatively affected growth performance.

The reduced growth may be attributed to the increased dietary fibre, which can hinder nutrient digestibility and absorption (Ige *et al*., 2006; Onu, 2010). The effect observed above could also be attributed to imbalance

nutrient value and improper metabolism associated with the *Moringa oleifera* leaf meal as reported by Ihezuo *et al*. (2013). Additionally, the higher crude protein content and palatability of the control diet likely enhanced its acceptability and utilization by the birds. The presence of anti-nutritional factors and phytochemicals in MOLM, such as tannins (1–23 g/kg as reported by Kakengi, 2003), may also have contributed to the reduced performance. Leaf meals are often bitter, and the inclusion of MOLM likely decreased feed palatability, leading to reduced intake. Omekam (1994) noted that the unpalatable nature of feed ingredients can deter chicks from consuming adequate quantities.

Interestingly, birds fed MOLM-based diets showed a significantly lower feed conversion ratio compared to the control group, suggesting improved nutrient utilization. This may be due to increased dietary bulkiness with higher MOLM levels, enhancing nutrient use efficiency.

The generally higher values of haematological indices observed in MOLM chickens are indicative of better utilization, absorption and assimilation of the nutrients into the circulatory system of the chickens (Onu, 2010). The above observation is similar to that of Basit *et al*. (2020). All the values obtained for MCV and MCHC were statistically similar irrespective of the inclusion level of the MOLM in the diets. The values for all the haematological and erythrocyte indices obtained in this study are within the acceptable levels for healthy chickens as reported by Bounous and Stedman (2000) and Okeudo *et al*. (2003). Previous workers have attributed the variations in avian haematological blood values to the physiological condition of the birds (Islam *et al*., 2004; Attia *et al*., 2015).

The reduction in the protein and its fraction could be a result of the anti- nutrients in the test ingredient (Odetola *et al*., 2012). The total protein and serum albumin, on the other hand, were within normal levels for hens (Meluzzi *et al*., 1992). The non-significant ($p>0.05$) difference in serum urea between the control and the treated groups agree with the results of Esonu *et al*., (2001); Iyayi and Taiwo (2003); Egu (2019) who reported that total protein and serum urea contents depend on the quality and quantity of the protein provided in the diet. The increase in albumin and total protein with the inclusion of MOLM in the diets of the birds underscores the nutritional acceptability of treated MOLM in satisfying the protein requirement of the chickens. ALP, AST and ALT decreased with the inclusion of graded level of MOLM in the diets of the birds.

Conclusion and Recommendation

From this study, MOLM can be included in the diets of broiler chickens up to 10% for improved growth performance, feed conversion ratio without hampering the haematological and serum biochemistry of the chicks. It is recommended that further studies be carried out on processing methods to remove the effect of anti-nutritional factors inherent in moringa leaf.

Conflict of Interest

The authors declare no conflict of interest.

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