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INFLUENCE OF DIETARY INCORPORATION OF MORINGA (*MORINGA OLEIFERA*) LEAF MEAL IN DIETS OF BROILER CHICKENS ON GROWTH PERFORMANCE AND ECONOMIC BENEFITS

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ABSTRACT

Consuming enough high-quality protein is essential for a long and healthy life. Because of their high-quality protein content, broiler chickens are a valuable food source that can support optimum growth and development and assist in address dietary deficiencies in Nigeria. The experiment was carried out at Adamawa State University Teaching and Research Farm, Mubi to evaluate the effects of diets containing varying levels of moringa (*Moringa oleifera*) leaf meal (MoLM) on growth performance and cost benefits fed to broiler chickens. The broiler chicks were purchased and maintained on a deep-litter system throughout the study. Fresh *Moringa oleifera* leaves were shed-dried and pulverised into fine particles. The powder was incorporated into the diets at 0, 0.5, 1, 1.5 and 2 g/kg denoted as control, 0.5MoLM, 1MoLM, 1.5MoLM and 2MoLM, respectively. The birds were randomly allotted to the different diets in a completely randomised design. Data collected during the study were: weight gain, feed intake, feed conversion ratio and the cost benefits of feeding MoLM-based diets. Significant ($p<0.05$) results were observed for most growth performance parameters. Weight gain and feed intake were high in the control followed by 2MoLM (1023.00 and 2825.80 g, respectively). The FCR was least for 1.5MoLM (2.37) compared to the control diet. The 1.5MoLM ensured a higher cost saving amongst the other diets. Mortality was reduced with increased levels of MoLM. It can therefore be agreed from this study that the inclusion of 1.5 g/kg MoLM in broiler chicken diets promoted better feed efficiency and more cost saving.

Keywords: Broiler, Chicken, Moringa leaf meal, Growth performance, Cost-saving

INTRODUCTION

Poultry production accounts for 80% of the overall livestock sector, vital to Nigeria's sustainable economic advancement (Chiekezie *et al*., 2022). It is the most commercialised of all agricultural sub-sectors in Nigeria with 180 million birds producing up to 300 metric tons of meat and 650 metric tons of eggs per year (Agriculture and Food, 2024). The FAO report from 2019 indicates that Nigeria's poultry sector accounts for 30% of the agricultural GDP, positioning it as the foremost poultry producer and the fourth largest meat producer on the African continent (FAO, 2019). This informs the assertion by the World Bank in 2017, that the income as well as food safety of households in rural communities depend significantly on the poultry sub-sector, which accounts for approximately 37% of their total intake (Wong *et al.*, 2017).

Protein is an essential component for the growth, maintenance, and repair of all body cells, and a shortage in the system of Nigerians has multiple adverse health challenges including wasting and shrinkage of muscle tissues, immune system wasting, marasmus, impaired mental health, shrinkage of muscle tissues, oedema, kwashiorkor, and organ failure (Khan *et al*., 2017). Adequate intake of protein of high quality is essential for efficient and healthful living (Obayelu *et al.*, 2022). To meet the demands of a healthy population, regardless of age, the recommended dietary allowance for protein is 133 milligrams of nitrogen per kilogramme of body weight per day or 0.83 g of protein per kilogramme of body weight per day. This amounts to 10-35% of daily calories (Hruby and Jacques, 2021). Nigeria is a large and diverse country with an elevated incidence of nutritional insufficiency that varies greatly throughout its boundaries due to the high cost and insufficient supply of animal protein (Adekunmi *et al*., 2017; SPRING, 2018). In 2019, Nigeria's per capita daily protein intake (45.4 g) was less than both the Food and Agriculture Organization (FAO) recommended minimum per capita daily protein intake (53.8 g) and the global daily intake (64 g), suggesting that the country is facing with protein deficit (FAO, 2019). Malnutrition based on protein-energy nutrients is currently widespread in Nigeria as a result of the fall in protein consumption due to shortage and the prohibitive price of protein food sources of animal origin (De Vries-ten Have *et al*., 2020).

Educating rural and urban populations about the importance of increasing protein supply through broiler chicken production is essential for promoting better nutrition, combating malnutrition, and improving overall health and well-being (Vlaicu *et al.*, 2024). Broiler chicken meat is rich in high-quality protein, vitamins, and minerals, making them a valuable food source that can help address dietary deficiency and support optimal growth and development, particularly in resource-constrained environments (Chatterjee *et al.*, 2022). By raising awareness about the nutritional benefits of broiler products, we can encourage dietary diversification, enhance food security, and impact the general health and productivity of communities (Weiler *et al.*, 2023). Bibyan and Kour (2024) in one of their studies stated: "Only a smaller number of raw materials are used in poultry feed formulation due to a lack of reliable data on their nutritive quality, feeding value and safe or efficient levels of inclusion in various types of poultry feed". Therefore, to certify the use of any alternative feedstuff, it is important to identify its potential in terms of feeding attributes, safe levels of inclusion, and nutritional value. Over time, a lot of researchers have gone into the exploration of the potential of different parts of the moringa tree. *Moringa oleifera* is a highly nutritious and beneficial plant that has been increasingly used as an additive in poultry diets due to its numerous health benefits for chickens (Sule *et al.*, 2024). Moringa is rich in essential nutrients such as amino acids, minerals, and vitamins, making it a valuable dietary supplement for poultry (Islam *et al.*, 2024). When included in the diet of poultry, Moringa can contribute to improved growth, egg production, and overall health (Amad and Zentek, 2022). They added that moringa foliage is predominantly rich in amino acids, vitamins A and C, calcium, and antioxidants, all of which are essential for the optimal development and immune function of poultry birds. Moringa leaf meal (MoLM) can be used as a partial replacement for the traditional protein sources in poultry diets, with promising results regarding growth performance and feed efficiency (Mseleku *et al.*, 2023).

The use of some parts of the tree, such as the leaves as a natural-rich feed resource for promoting growth and immune boosting capabilities at a lowered cost in this part of the country (Mubi, Adamawa State) has received less attention from researchers. Therefore, this study was designed to evaluate the effect of feeding broiler chickens with diets containing varying levels of MoLM on their growth performance and economic benefits.

MATERIALS AND METHODS

Location of the study area

The study was carried out at Adamawa State University's Teaching and Research Farm in the Mubi Local Government Area. The area is geo-located in northern Nigeria's Guinea savannah zone. It is positioned 560 meters above sea level, between latitude 10°16.6'6.9" north of the equator and longitude 13°16'1.2" east of the Greenwich meridian. The dry season in the area starts in November and ends in March, whereas the wet season starts in April and finishes in late October. The average yearly rainfall is approximately 1050 mm. The relative humidity is quite low (20-30%) during January and March but reaches a high of roughly 80% in August and September. The highest temperature can exceed 40°C, especially in April, while the minimum temperature is approximately 12°C between December and January (Metrological Enclosure, 2023).

Ethical consideration

The Institutional Animal Care and Ethics Committee at Adamawa State University approved the research procedures and animal use under approval number ADSUIACEC/2024/015. It attests to the processes' compliance with global guidelines for the use and care of animals.

Source and processing of moringa

Fresh moringa leaves were harvested 120 days after planting and were used for the experiment. It was obtained from a local Moringa farmer in Michika LGA, Adamawa State. The Moringa leaves were separated from their branches and shade-dried for one week. It was milled using a local roller mill grinder into powder (Singh, 2020). After milling, the MoLM was stored in an airtight plastic bag until required for the experiment.

Preparation of experimental diets

The ingredients used for the study diets were acquired from the Mubi grain market and Mubi main market, Mubi North LGA, Adamawa State. The study evaluated the following rations: control (no MoLM); 0.5 g/kg MoLM inclusion (0.5MoLM); 1 g/kg MoLM inclusion (1MoLM); 1.5 g/kg MoLM inclusion (1.5MoLM); 2 g/kg MoLM inclusion (2MoLM). The diets were formulated using the least-cost ration formulation method. The diets formulated were designed to fulfil the requirements of the birds (Table 1). While some of the course ingredients were pulverized using an industrial hammer mill into fine particles, the diets were compounded using the floor mixing method. The diets were fed in their mesh form.

Table 1: Gross composition of experimental diets for broiler chickens

Ingredients (kg)	Control	0.5MoLM	1MoLM	1.5MoLM	2MoLM
Maize	28.90	28.76	28.62	28.50	28.37
Maize bran	14.43	14.38	14.31	14.25	14.18
Wheat bran	14.43	14.38	14.31	14.25	14.18
Soybean meal	24.23	24.06	23.91	23.74	23.58
Groundnut meal	12.11	12.03	11.95	11.87	11.79
Moringa leaf meal	0.00	0.50	1.00	1.50	2.00
Bone meal	5.00	5.00	5.00	5.00	5.00
Salt	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.20	0.20	0.20	0.20	0.20
Analysed Composition (%)					
Energy (ME kcal/kg)	3403.56	3326.73	3273.30	3276.46	3402.54
Dry matter	96.73	95.89	92.59	92.79	92.58
Crude protein	25.07	24.52	24.90	24.96	24.08
Crude fibre	5.40	4.89	5.92	4.96	5.41
Fat	4.35	4.65	3.89	4.01	4.40
Ash	5.50	8.50	8.00	8.03	5.50
Nitrogen free extract	59.68	57.44	57.29	57.04	60.61

MoLM: Moringa leaf meal, ME: metabolizable energy,

**Composition of vitamin-mineral premix (BIO-ADDMIX®) supplying the following per tonne of feed: vitamin A 1000000 IU, vitamin D_3 200000 IU, vitamin E 10000 IU, vitamin K 2500 mg, vitamin B_1 2000 mg, vitamin B_2 70000 mg, vitamin B_6 2000 mg, vitamin B_{12} 15 mg, Niacin 50000 mg, Pantothenic 5000 mg, Folic acid 750 mg, Choline chloride 400 g, BHT 125 g, Manganese 10 g, Zinc 100 g, Iron 30 g, Copper 10 g, Iodine 1.5 g, Selenium 200 mg, Cobalt 200 mg, Lysine 15 g, Methionine 20 g, Biotin 100 mg.*

Experimental animals and management

A total of 150-day-old unsexed OLAM Cobb 500 broiler chicks were purchased from Olam Feeds and Hatchery in Kaduna, Kaduna State, Nigeria. The birds were raised in a well-ventilated and illuminated poultry house on deep litter. Before their arrival, the pen was washed with disinfectant. The floor was covered with wood shavings which served as the litter material (about 3 cm deep). The chicks were brooded and managed according to standard chicken management techniques (NRC, 1994 as cited by Akure *et al*., 2021). Fresh feed and clean drinking water were supplied daily at 7:00 and 14:00 hours to the birds using *ad libitum* feeding regime throughout brooding and that of the study. Commercial starter feed was supplied during the brooding phase.

Animal housing, design and feeding

The experimental pen housing the birds was partitioned into 15 units that accommodated 10 birds per unit, which served as the replicates. The birds were allotted randomly into the five dietary groups in a completely randomized design. The starter and finisher phases were designed for four-week periods each, during which the birds received their corresponding starter and finisher rations, respectively.

Data collection

The collection of data on growth performance began after the brooding period. The broiler chickens were weighed using an electronic kitchen scale (WH-B05) at the start of the trial and weekly afterwards. The weight gained was harmonized at the end of the experiment. The amount of feed consumed was recorded daily while the feed-to-gain ratio was calculated at the termination of the trail. The profitability of feeding the broiler chickens with the experimental diets was assessed using a cost-benefit analysis. Inputs and product costs were calculated based on the cost of goods at current market prices in 2024 (April–June) to arrive at the cost/kg feed. The value of gain was determined to examine the returns of broiler chickens fed with MoLM-based rations. The total cost of feed was obtained as cost/kg feed multiplied by total feed intake. The feed cost/kg gain was acquired as the total cost of feed divided by total weight gain, while cost saving was calculated as the feed cost/kg gain of treated groups subtracted from that of the control.

Nutrient composition determination

The feed samples collected were taken to the Animal Nutrition Laboratory, Department of Animal Production, Adamawa State University, Mubi, to determined their proximate compositions using the procedures described by AOAC (2005). Metabolizable energy was calculated using the methods documented by Pauzenga (1985).

Statistical analysis

All data collected were analyzed according to PROC GLM procedures of IBM SPSS Statistics (2015). Treatment means were assessed at a 95% probability level ($p<0.05$) and Dunnetts' Test was used to compare significant effects. The statistical model for this study was

$$Y_j = \mu + T_j + e_{jk}$$

Where μ = population mean

T_j = effect of the j^th^ treatments

e_{jk} = all error terms are assumed to be random, normally distributed and independent with expectations equal to zero

RESULTS AND DISCUSSION

Effects on Growth Performance

Table 2 shows the growth performance of broiler chickens fed diets with varied doses of moringa leaf meal (MoLM). Most of the data measured were observed to have significant ($p<0.05$) effects except for initial weight which showed a non-significant ($p>0.05$) effect. Higher ($p<0.05$) values were observed for total weight gain (TWG), average daily gain (ADG), total feed intake (TFI), and average daily intake (ADI) in the control group followed by the group of birds receiving 2MoLM (1023.00, 20.88, 2825.80, and 65.33 g, respectively).

Table 2: Growth performance by broiler chickens fed diets containing varying levels of moringa leaf meal

Parameters	Control	0.5MoLM	1MoLM	1.5MoLM	2MoLM	SEM
Initial weight (g)	370.00	370.00	368.33	370.00	370.00	5.08^{NS}
Final weight (g)	1444.06^a	1329.09^a	1096.90^b	1213.25^b	1393.00^a	66.83
Total weight gain (g)	1074.06^a	959.09^c	728.57^e	843.25^d	1023.00^b	15.68
ADG (g)	21.92^a	19.57^c	14.87^e	17.21^d	20.88^b	0.32
Total feed intake (g)	2963.20^a	2408.60^c	1788.30^e	2005.60^d	2825.80^b	44.48
ADI (g)	67.22^a	60.19^c	53.06^d	59.43^c	65.33^b	0.86
FCR	2.77^c	2.52^b	2.47^b	2.37^a	2.76^c	0.05
Mortality	2.67^b	1.00^a	0.67^a	0.67^a	0.33^a	0.18

^abcde^: Means with different superscripts within the same raw are statistically different at $p<0.05$, MoLM: moringa leaf meal, ADG: average daily gain, ADI: average daily intake, FCR: feed conversion ratio, SEM: standard error of means

The high TWG observed in 2MoLM was lower and differed from the findings of 2065.87 g recorded when 1% *Moringa oleifera* leaf meal was fed to broiler chickens (Meel and Sharma, 2021). The observed increase in weight of birds fed moringa-supplemented feed may be linked to the availability of vitamin C in moringa foliage, which can have a crucial function in minimizing heat stress and enhancing the growth of broiler chickens (Amad and Zentek, 2022; Kairalla *et al.*, 2023; Islam *et al.*, 2024). However, the control diet had higher protein and therefore higher weight. High feed intake in this study differed from the findings of Meel and Sharma (2021) who observed that feed intake decreased when the level of MoLM included in the diets of broilers increased. The observed increase in this study might be linked to the high palatability of the diet which might have resulted from higher soluble carbohydrates from the diet (Table 1).

The birds consuming 1.5MoLM (2.37) had a higher ($p<0.05$) feed conversion ratio (FCR) than the control diet. This improvement in FCR may be attributable to the rich amount of nutrients in MoLM and the antibacterial characteristics of Moringa, which could have promoted better diet efficiency in the gut (Meel and Sharma, 2021). The result coincided with the findings of the authors who recorded the least FCR in the group of broilers receiving 1.5% MoLM inclusion. Mortality values were similar ($p>0.05$) across diets containing varying levels of MoLM as compared to the control diet. It also decreases as the level of MoLM increases. This implies that the survivability of broiler chickens increased with a rise in the level of MoLM.

Effects on Economic Benefits

The cost benefits of feeding broilers chicken with diets containing varying levels of MoLM are shown in Table 3. Lower values for cost/kg feed and total cost of feed were observed in the group of birds receiving 0.5MoLM (1294.36 ₦/kg) and 1MoLM (2352.01 ₦/kg), respectively. Lower cost/kg feed might be linked to the lesser proportion of MoLM in the diet. Onibi *et al.* (2020) also documented a lower cost of feed/kg at the lower addition of leaf meals. Lower results for the total cost of feed might be attributable to the lesser feed consumed by the birds in the treatment group and relatively lower feed cost/kg. The result for total cost of feed was similar to the findings of Akhouri *et al.* (2013) who indicated a low cost of total feed consumed in treatment where less feed was consumed by the birds. The lowest feed cost/kg gain and higher cost savings were observed in the group of birds receiving 1.5MoLM (₦3191.93 and ₦556.75, respectively) compared to the control group. The lowest feed cost/kg gain might be due to the relatively lower cost of feed consumed. Zanu *et al.* (2020) made a similar observation, exhibiting reduced feed cost per kg gain and lower cost of feed consumed. Higher cost savings could be attributed to lower feed cost/kg gain. Abdulsalam *et al*. (2015) also reported higher cost savings due to decreased feed cost/kg gain.

Table 3: Cost benefits of diets containing varying levels of moringa leaf meal fed to broiler chickens

Parameters	Control	0.5MoLM	1MoLM	1.5MoLM	2MoLM
Cost/kg feed (₦)	1354.77	1294.36	1313.97	1333.56	1353.15
Total feed intake (kg)	2.96	2.41	1.79	2.01	2.83
Total cost of feed (₦)	4010.12	3119.41	2352.01	2680.46	3829.41
Total weight gain (kg)	1.07	0.96	0.73	0.84	1.02
Feed cost/kg gain (₦)	3747.78	3249.39	3221.93	3191.02	3754.32
Cost saving (₦)	–	498.39	525.84	556.75	-6.55

MoLM: moringa leaf meal

CONCLUSION

The results of the present study revealed that the average daily gain increased in 2MoLM by 6.01 g amongst the treated diets and the average daily intake increased in 2MoLM by 12.27 g amongst the treated diets. Also the feed conversion ratio improved in 1.5MoLM by 0.4 compared to the control diet, while mortality decreased in 2MoLM by 12.36% compared to the control diet, and feed cost/kg gain was cheaper in 1.5MoLM (₦3191.02) which led to a cost saving of ₦556.75 compared to the control diet.

Therefore, it could be agreed from this study that feeding MoLM at 1.5 g/kg in the diets of broiler chickens could improve feed efficiency resulting in a reduced feed cost and is therefore recommended.

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