GROWTH PERFORMANCE INDICES, CARCASS CHARACTERISTICS AND ORGAN WEIGHTS IN BROILER FINISHERS FED DIETS CONTAINING REPLACEMENT OF SOYABEAN MEAL WITH *MORINGA OLEIFERA* LEAF MEAL

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ABSTRACT

The escalating prices of conventional plant protein sources like soyabean and groundnut cake in Nigeria have prompted exploration into alternative feed ingredients for poultry nutrition. Moringa oleifera leaf meal (MOLM) presents a promising substitute due to its nutrient-rich composition and cost-effective cultivation. This study investigated the effects of substituting soyabean meal (SBM) with MOLM on growth performance indices, carcass characteristics, and organ weights in broiler finishers on an equal-protein basis. Five diets were formulated, wherein SBM protein was replaced with that of MOLM at 0, 25, 50, 75, and 100% levels. 200 four-week-old broiler chickens were randomly assigned to these diets in a completely randomized design, with each treatment having four replicates. Analysis of MOLM's proximate composition suggested its suitability as a substitute for SBM. Up to 50% inclusion of MOLM resulted in weight gain and feed conversion ratio similar to the control (p>0.05). However, higher inclusion levels led to decreased feed intake, weight gain, and poorer feed conversion efficiency, likely due to increased fibre content. Carcass traits were not significantly (p>0.05) affected by MOLM inclusion up to 50% level. Organ weights were largely unaffected except for the liver, spleen, and bursa, which showed variations with different levels of MOLM inclusion. Substituting SBM with MOLM at up to 50% did not negatively impact broiler growth performance or carcass characteristics. However, further research is needed to optimize MOLM inclusion levels and address the effects of high fibre content in poultry diets.

Keywords: Equal-protein, Isocaloric, Isonitrogenous, *Moringa oleifera*, Growth performance, Carcass characteristics, Organ weight, Sustainable protein source

INTRODUCTION

Prices of conventional protein sources such as soyabean and groundnut cake have skyrocketed in recent years in Nigeria. Therefore, in the quest for sustainable and economically viable alternatives to conventional feed ingredients in poultry nutrition, it is crucial to broaden the raw material base for livestock feed formulation to incorporate other non-conventional feed resources (Mosaku, 2023). *Moringa oleifera* Lam. (Brassicales: Moringaceae) leaf meal (MOLM) has emerged as a promising substitute in this regard. Broiler production, a cornerstone of the global poultry industry, heavily depends on optimized nutrition to achieve desirable growth performance indices during the finisher phase. Traditionally, soyabean meal (SBM) has been a staple protein source in broiler diets due to its balanced amino acid profile and high digestibility. However, concerns about its sustainability, availability, and price volatility have led to exploration into alternative protein sources (Papanikou, 2024).

MOLM is derived from the leaves of the *M. oleifera* plant and boasts an impressive array of nutrients, including protein, essential amino acids, vitamins, minerals, and bioactive compounds (Islam *et al.*, 2021). Moreover, its cultivation is relatively inexpensive and environmentally friendly, making it an attractive option for livestock feed formulation. *M. oleifera* possesses a more abundant supply of minerals, such as calcium and phosphorus, and larger amounts of vitamins. Commonly referred to as the horseradish or drumstick tree, *M. oleifera* has attracted interest as a protein source for livestock, as demonstrated in several studies conducted by researchers (Makker and Becker, 1996; Sarwatt *et al.,* 2002; Banjo, 2012; Sule *et al.,* 2016; Cui *et al.,* 2018). *Moringa* leaves possess quality attributes that make them a potential replacement for SBM in non-ruminant diets. Sutherland *et al.* (1999), Oluduro (2012) and Sodamade *et al.* (2013) reported that *M. oleifera* leaves have appreciable crude protein (CP) levels, while Makker and Becker (1996) reported that *Moringa* leaves and green fresh pods are rich in carotene and ascorbic acid with a good profile of amino acids. Given the significance of optimized nutrition in broiler production, this study focuses on evaluating the growth performance of finisher broilers fed diets where SBM was replaced with MOLM on an equal-protein basis. Parameters such as body weight gain, feed intake, feed conversion ratio (FCR), carcass characteristics, and organ weights were assessed to determine the efficacy of MOLM as a substitute for SBM in broiler finishers' diets.

MATERIALS AND METHODS

Experimental Site: The experiment was carried out at the Poultry Demonstration Unit of the Livestock Farm of Federal College of Agriculture, Akure, Ondo State, Nigeria.

Preparation of *Moringa oleifera* Leaf Meal (MOLM), Feed Preparation and Experimental Treatments: Fresh *M. oleifera* leaves harvested from a paddock at the Horticulture Section of Federal College of Agriculture, Akure, Nigeria spread out on a flat wooden platform and allowed to dry for four days under shady and aerated conditions. The dried leaves were milled to produce the leaf meal. Five isonitrogenous and isocaloric diets were formulated and fed *ad-libitum* in conical troughs for four weeks. Clean drinking water was provided *ad libitum*. The control diet (Diet 1) contained groundnut cake and SBM as plant protein sources. The protein supplied by SBM in the control diet was replaced at 25, 50, 75 and 100% with MOLM in diets 2, 3, 4, and 5 respectively. 250-day-old chicks were subjected to a pre-experimental brooding period of 4 weeks during which a commercial broiler starter diet (Hybrid Broiler Starter containing 22% CP and 2900 kcal/kg ME) was fed *ad-libitum.* After the brooding period, 200 started broilers were randomly selected, weighed and allotted 10 birds per replicate and four replicates per each of the five dietary treatments in a completely randomized experimental design. All dietary ingredients and the formulated diets were proximately assayed (AOAC, 2000). The gross composition of the broiler finisher diets is shown in Table 1.

Data Collection: Weekly feed intake and weight gain were taken by subtracting the weight of leftover feeds and final weight gain from the weight of the original feed given and the initial weight of birds respectively.

The FCR of the birds was calculated using the formula: FCR = Feed intake/Weight gain. At the end of the experimental period, four birds were randomly selected from each treatment replicate and slaughtered to assess the carcass characteristics and organ weight. Each slaughtered chicken was de-feathered after scalding in boiling water for five seconds and dressed, eviscerated and dissected into parts as described for turkey by Hahn and Spindler (2002). The following weights were taken; live, dressed, eviscerated, thigh, drumstick, neck, head, shank, wing, chest, back, liver, heart, gizzard, lungs, spleen, and pancreas. The dressed and eviscerated weights were expressed as percentages of the live weight, while others were expressed as grams per kilogram live weight.

Table 1: Gross composition of the experimental diets containing replacement of soyabean meal with *Moringa oleifera* leaf meal fed to broiler finishers

Ingredients (kg/100kg)	MOLM	Diet 1 (0% MOLM)	Diet 2 (25% MOLM)	Diet 3 (50% MOLM)	Diet 4 (75% MOLM)	Diet 5 (100% MOLM)
Maize	-	53.50	52.75	52.20	51.50	51.00
Groundnut cake (44% CP)	-	12.00	12.00	12.00	12.00	12.00
Soyabean meal (42% CP)	-	14.00	10.50	7.00	3.50	-
MOLM (29.7% CP)	-	-	4.95	9.90	14.85	19.80
Wheat Offal	-	9.50	9.00	8.77	8.35	7.70
Brewer dry grain	-	5.73	5.75	5.30	5.20	5.10
Bone Meal	-	2.30	2.40	2.50	2.50	2.50
Oyster Shell	-	1.70	1.20	0.75	0.35	-
Salt	-	0.50	0.50	0.50	0.50	0.50
Lysine	-	0.20	0.35	0.48	0.60	0.75
Methionine	-	0.32	0.35	0.35	0.40	0.40
Vitamin/Mineral Premix*	-	0.25	0.25	0.25	0.25	0.25
Total	-	100.00	100.00	100.00	100.00	100.00
Calculated analysis	-					
Metabolizable energy (kcal/kg)	-	2823	2787	2753	2718	2685
Crude protein (%)	-	19.65	19.42	19.17	18.94	18.68
Calcium	-	1.52	1.52	1.53	1.52	1.52
Phosphorus	-	0.54	0.54	0.55	0.54	0.53
Ether Extract	-	4.03	4.07	4.11	4.16	4.20
Crude Fibre	-	4.53	5.37	6.13	6.95	7.75
Methionine	-	0.60	0.61	0.59	0.61	0.59
Lysine	-	1.01	1.02	1.02	1.01	1.02
ME: CP	-	143.7	143.5	143.6	143.5	143.7
Proximate Composition						
MC%	11.50	12.25	13.20	13.50	13.20	12.10
CP%	28.44	18.56	18.64	19.58	20.48	20.24
ASH%	8.00	11.20	11.70	11.90	9.92	11.22
CF%	8.25	5.99	6.24	6.23	6.27	7.01
EE %	3.00	4.37	5.55	6.41	4.89	6.15
NFE%	41.19	47.63	44.67	42.38	45.24	43.28

*ME = Metabolizable energy; CP = Crude protein; MOLM = Moringa oleifera leaf meal; SBM = Soyabean meal, *Each 2.5 kg of grower vitamins and mineral premix contains 800,000 IU of Vitamin A, 1600,000 IU of Vitamin D3; 5,000 IU of Vitamin E; 2000 mg of Vitamin K; 1500 mg of B1; 4000 mg of B2; 80g of manganese, 50 g of Zinc; 20 g of Iron; 5 g of Copper, 15000 mg of Niacin; 10 mg of B12; 5000 mg of Pantothenic acid, 5000 mg of Folic acid, 20 mg of Biotin, 125 mg of Antioxidant; 200 g of Selenium; 200 mg of Cobalt and 200 mg of Choline*

Statistical Analysis: All data generated were subjected to one-way ANOVA using SAS (2005). Significant means were separated using the Duncan Multiple Range Test of the same statistical package.

RESULTS AND DISCUSSION

Proximate Composition of *Moringa oleifera* Leaf Meal and Experimental Diets: The proximate composition of MOLM and the five experimental diets are presented in Table 1. The CP content (28.44%) of MOLM obtained in this study compared favourably well with the values of 29.6, 27.5 and 28.2% reported by Marker and Becker (1996), Oduro *et al.* (2008) and Melesse *et al.* (2009) respectively. It was however lower than the values of 32.1 and 36.0% reported by Soliva *et al.* (2005) and Negesse *et al.* (2009) respectively. The similarities in the chemical composition of MOLM in the present study when compared with other studies indicated that environmental factors such as season and geographical location play a minor role in determining the nutritive value of MOLM. The CP contents of the experimental diets varied between 18.56 to 20.48%. These CP levels were within the recommended levels for broiler chicken finishers as reported by Van Eekeren *et al.* (2004) and Scanes *et al.* (2004). The nutrient composition of the experimental diets showed an increase in crude fibre with higher levels of MOLM in the diet. This can be ascribed to the fibrous nature of MOLM and agreed with the reports of similar studies (Gadzirayi *et al*., 2012; Oludoyi and Toye, 2012; Oghenebrorhie and Oghenesuvwe, 2016).

Table 2 shows the growth performance of finisher broilers fed diets containing the replacement of soyabean meal with MOLM. The results obtained in this study regarding feed intake demonstrated that the total feed intake of the birds fed MOLM-based diets was significantly different ($p<0.05$) from the control group. Numerically, birds on Diet 1 with 0% MOLM had higher feed intake, even though the reduction in feed intake among birds fed the other diets was not drastic. Alabi *et al.* (2017) reported similar results when aqueous extracts of *M. oleifera* leaf were incorporated into the diets of Hubbard broiler chicken. Gakuya *et al.* (2014) and Rajesh *et al.* (2022) also reported that the control groups had higher feed intake compared to the treatment groups when MOLM-based diets were fed to laying hens. The decrease in feed intake in birds fed MOLM-based diets in this study is in agreement with the finding of Portugaliza and Fernandez (2012) who reported that *M. oleifera* aqueous leaf extracts in drinking water significantly decreased the feed intake of broilers as the concentration increased. Divya *et al.* (2014) also reported that the addition of *M. oleifera* leaf powder at any level slightly decreased feed intake as compared to control, although the decrease was not significant ($p>0.05$).

Contrarily, Tesfaye *et al*. (2013) who experimented on MOLM as a protein feed ingredient in broiler rations, reported a significant increase ($p<0.05$) in feed intake for the supplemented groups as compared to the control group. In the same vein, Van Krimpen *et al.* (2009) with layers and Rezaei and Hajati (2010) with broilers, indicated that diets with diluted energy as a result of high fibre content promoted higher feed intake, were not confirmed in the present study.

Body weight gain in this study showed no significant difference ($p>0.05$) from the control group up to 50% MOLM inclusion. Numerically, a progressive decrease in weight gain was noticed with increasing levels of MOLM diets fed to birds thus, birds fed Diet 1 (0% MOLM) had the highest weight, while those on Diet 5 (100% MOLM) had the lowest weight. Similar trends have been reported in the studies of Olorode *et al.* (2007), Atuahene *et al.* (2008), Olugbemi *et al.* (2010), Gadzirayi *et al.* (2012), and Zanu *et al.* (2012), who recorded reductions in the weights of broiler chickens when placed on diets containing increasing levels of MOLM. The decrease in weight gain with increasing levels of MOLM inclusion may be attributed to the high fibre levels in the MOLM-based diets; this is also consistent with the finding of Ash and Petaia (1992) that inclusion of leaf meal in broiler diets at the levels of 5 – 10% led to depressed performance.

It is noteworthy that the FCR was lowest in birds placed on Diet 2 (25% MOLM) and highest in birds placed on Diet 5 (100% MOLM). This may be a direct effect of the fibre content of the diets which had earlier led to a decrease in feed intake and weight gain in birds fed MOLM-based diets. Similar results were obtained by Gadzirayi *et al.* (2012), who recorded the lowest FCR at a 25% level of inclusion when MOLM was substituted for SBM in broiler finishers' diets, while Kakengi *et al.* (2005) recorded the lowest FCR at a 20% level of inclusion when MOLM was substituted for sunflower seed meal in the diet of laying birds. Xiao *et al.* (2012) reported that the utilization of forage plants in non-ruminant animal diets has historically been limited due to their negative impact on animal performance; their characteristic high fibre content has been noted to be responsible for poor feed conversion rates, with many containing anti-nutritional factors. However, some evidence suggests that incorporating small amounts of forage species may enhance animal performance due to their growth-promoting properties (Banjo, 2012; Nkukwana *et al*., 2014; 2015; Cui *et al*., 2018).

Carcass Characteristics and Organ Weight: Table 3 shows the carcass characteristics of broiler finisher chickens fed MOLM-based diets. Most of the important carcass traits (dressed, eviscerated, thigh, chest and back weights) showed no significant difference ($p>0.05$) with the control group up to 50% MOLM inclusion level.

Table 2: Growth performance of finisher broilers fed diets containing replacement of soyabean meal with *Moringa oleifera* leaf meal

Parameters	Diet 1 (0% MOLM)	Diet 2 (25% MOLM)	Diet 3 (50% MOLM)	Diet 4 (75% MOLM)	Diet 5 (100% MOLM)
IW(g/bird)	838.90 ± 7.20	855.60 ± 7.94	856.89 ± 8.27	832.56 ± 7.98	821.44 ± 7.76
FW(g/bird)	2315.10 ± 9.92^{c}	2285.00 ± 9.88^{c}	2238.90 ± 9.96^{c}	1975.70 ± 9.98^{b}	1743.20 ± 9.46^{a}
TWG(g/bir)	1476.20 ± 8.22^{c}	1429.40 ± 8.20^{c}	1382.01 ± 8.57^{c}	1143.14 ± 8.29^{b}	921.76 ± 8.27^{a}
TFI(g/bird)	5434.30 ± 60.20^{c}	4834.40 ± 65.27^{a}	5068.70 ± 65.29^{b}	4778.80 ± 67.11^{a}	5156.80 ± 57.98^{b}
AFI(g/b/d)	194.08 ± 2.25^{c}	172.66 ± 2.30^{a}	181.03 ± 2.41^{b}	170.67 ± 2.11^{a}	184.17 ± 2.23^{b}
AWG(g/b/d)	52.72 ± 3.55^{c}	51.05 ± 4.12^{c}	49.36 ± 3.82^{c}	40.83 ± 3.11^{b}	32.92 ± 4.60^{a}
FCR	3.68 ± 0.24^{a}	3.38 ± 0.11^{a}	3.67 ± 0.34^{a}	4.18 ± 0.12^{b}	5.59 ± 0.24^{c}

^{abc} = Means along the same row with different superscripts are significantly different (p<0.05), Average feed intake, AWG – Average weight gain, FCR – Feed conversion ratio

Table 3: Relative carcass characteristics of broiler chicken finishers fed diets containing replacement of soyabean meal with *Moringa oleifera* leaf meal

Parameters	Diet 1 (0% MOLM)	Diet 2 (25% MOLM)	Diet 3 (50% MOLM)	Diet 4 (75% MOLM)	Diet 5 (100% MOLM)
Live weight (kg)	2.34 ± 0.07	2.25 ± 0.04	2.23 ± 0.05	2.22 ± 0.06	2.20 ± 0.03
Dressing weight (%)	90.90 ± 1.39^{b}	90.80 ± 1.49^{b}	88.20 ± 1.45^{ab}	87.80 ± 1.36^{ab}	84.70 ± 1.56^{a}
Eviscerated Wt (%)	87.40 ± 1.34^{b}	83.90 ± 1.39^{ab}	83.60 ± 1.42^{ab}	80.10 ± 1.37^{a}	80.00 ± 1.38^{a}
Thigh (g/kg LW)	113.60 ± 2.79^{b}	102.60 ± 2.98^{ab}	108.10 ± 2.97^{ab}	105.6 ± 2.91^{ab}	96.60 ± 2.70^{a}
Drumstick (g/kg LW)	99.40 ± 2.43	93.30 ± 2.58	98.30 ± 2.21	86.90 ± 2.46	97.60 ± 2.57
Shank (g/kg LW)	33.30 ± 0.92	36.30 ± 0.98	36.60 ± 0.89	32.20 ± 0.99	35.80 ± 0.92
Wing (g/kg LW)	75.40 ± 1.35	77.00 ± 1.17	75.70 ± 1.32	77.20 ± 1.14	73.50 ± 1.37
Chest (g/kg LW)	210.70 ± 13.77^{b}	208.80 ± 14.22^{ab}	207.40 ± 12.98^{ab}	193.90 ± 14.02^{a}	183.50 ± 14.61^{a}
Back (g/kg LW)	148.60 ± 3.65^{b}	148.50 ± 3.76^{b}	140.60 ± 3.56^{b}	129.20 ± 3.20^{a}	127.00 ± 3.23^{a}
Neck (g/kg LW)	73.50 ± 1.58^{b}	74.90 ± 1.45^{b}	45.10 ± 1.65^{a}	41.20 ± 1.45^{a}	39.20 ± 1.77^{a}
Fat (g/kg LW)	32.75 ± 1.32^{c}	32.68 ± 1.20^{c}	31.56 ± 1.46^{c}	27.55 ± 1.27^{b}	18.73 ± 1.45^{a}

^{abc} = Means along the same row with different superscripts are significantly different (p<0.05), LW = Live weight, MOLM = Moringa oleifera leaf meal

However, numerical values of carcass parameters measured decreased as the level of inclusion of MOLM increased in the diets. This may be attributed to the slight decrease in the metabolizable energy of the diets as the level of MOLM increased in the diets. Iyayi and Yahaya (1999) reported that a reduction in the metabolizable energy content of feed reduces the weight of carcasses. There was a drastic reduction in the quantity of abdominal fat along with the dietary treatment levels. This was a result of the restriction of nutrient intake through dietary dilution as reported by March and Hansen (1977). Olugbemi *et al*. (2010) and Kumar *et al*. (2018) also reported that abdominal fat was lower in broiler chickens fed MOLM-based diets. Sule *et al*. (2016) reported a decreasing trend in serum cholesterol concentration with increasing levels of MOLM in the diets of broiler finishers, and according to Tewe and Bokanga (2001), a high level of cholesterol content is an indication of a high level of fat deposition in the carcass. The fact that there was a reduction in the amount of fat content with increasing MOLM levels in the present study affirmed the hypocholesterolemic potential of *M. oleifera*. Reduction in fat content of the carcass by MOLM-based diets may have been achieved through the lowering of plasma concentrations of low-density lipoprotein cholesterol by β-sitosterol, the bioactive phyto-constituent isolated from *M. oleifera* leaves (Saluja *et al*., 1978; Kane and Malloy, 1982; Ghasi *et al*., 2000).

Organ weights were largely unaffected by treatment effects except for the liver, spleen, and bursa, which showed some variations with different levels of MOLM inclusion in the diets (Table 4). Relative weights of the liver were significantly higher (p<0.05) in the control group than in the treatment groups. There was a gradual decrease in the weight of the liver with increasing levels of MOLM in the diets. This was consistent with the findings of Kumar *et al*. (2018) who also reported a reduction in the

Table 4: Relative organ weight of broiler chicken finishers fed diets containing replacement of soyabean meal with *Moringa oleifera* leaf meal

Parameters	Diet 1 (0% MOLM)	Diet 2 (25% MOLM)	Diet 3 (50% MOLM)	Diet 4 (75% MOLM)	Diet 5 (100% MOLM)
Heart	4.30 ± 0.12	4.51 ± 0.17	4.92 ± 0.19	4.51 ± 0.14	4.44 ± 0.13
Lung	5.76 ± 0.22	4.40 ± 0.34	5.91 ± 0.33	6.07 ± 0.39	4.31 ± 0.27
Liver	19.20 ± 0.55^{c}	17.24 ± 0.45^{b}	17.00 ± 0.62^{b}	16.40 ± 0.65^{b}	14.20 ± 0.63^{a}
Spleen	3.15 ± 0.45^{a}	4.40 ± 0.39^{b}	3.95 ± 0.68^{ab}	3.82 ± 0.47^{ab}	3.80 ± 0.51^{ab}
Pancreas	1.44 ± 0.09	1.64 ± 0.10	1.57 ± 0.12	1.53 ± 0.09	1.97 ± 0.10
Kidney	4.79 ± 0.20	5.63 ± 0.15	5.73 ± 0.27	6.38 ± 0.24	5.55 ± 0.29
Head	26.40 ± 0.55	26.80 ± 0.71	27.10 ± 0.49	24.50 ± 0.69	24.50 ± 0.76
Gizzard	21.10 ± 0.69	18.60 ± 0.66	20.49 ± 0.85	20.73 ± 0.82	21.07 ± 0.68
Proventriculus	4.43 ± 0.15	4.50 ± 0.19	4.32 ± 0.18	4.23 ± 0.17	4.23 ± 0.16
Bursa	0.60 ± 0.10^{a}	1.26 ± 0.12^{b}	0.72 ± 0.14^{a}	1.14 ± 0.14^{b}	1.43 ± 0.10^{b}

abc = Means along the same row with different superscripts are significantly different (p<0.05), LW = Live weight, MOLM = Moringa oleifera leaf meal

weight of the liver when MOLM-based diets were fed to Vanaraja chicken in India. Apart from liver, birds fed the control diet had higher weights of gizzard than those on the treatment groups. Relative weights of the lung, heart, spleen, pancreas, and kidney appear to be higher in birds placed on MOLM diets than those on the control. As reported by Iyayi and Fayoyin (2004), the relative weights of the kidneys increase with high-fibre diets.

Conclusion: This study demonstrates that substituting SBM with *M. oleifera* leaf meal in broiler finisher diets up to 50% replacement level did not adversely affect growth performance or carcass characteristics. However, higher levels of MOLM inclusion led to decreased feed intake, weight gain, and feed conversion efficiency, likely due to increased fibre content. Organ weights were largely unaffected except for the liver, spleen, and bursa, which showed some variations with different MOLM inclusion levels. *M. oleifera* leaf meal shows promise as a sustainable alternative protein source for broiler finisher diets, but further research is needed to optimize inclusion levels and mitigate potential negative effects.

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