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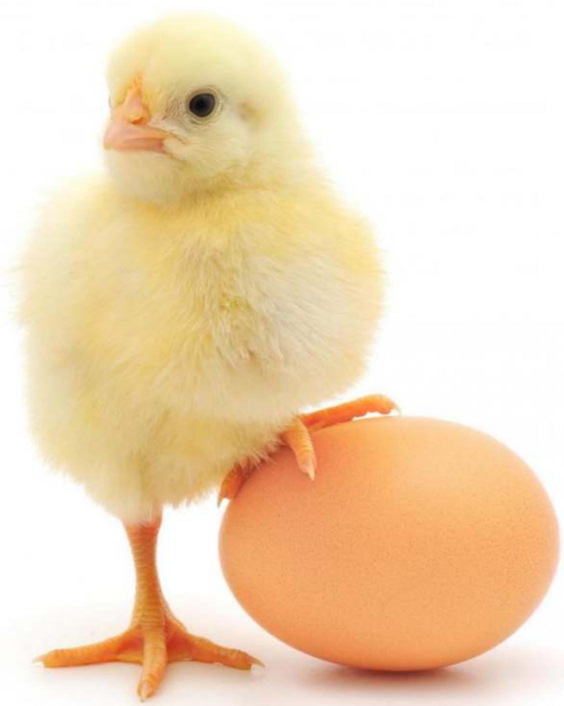

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Moringa olifera Leaf Meal as an Alternative Protein Feed Ingredient in Broiler Ration

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Abstract: A total of 300 Hubbard Classic day-old broiler chicks were randomly distributed into 15 pens equally, representing 5 feeding treatments to evaluate the performance of chicks fed varying dietary levels of *Moringa Olifera* Leaf Meal (MOLM) replacing soybean meal (SBM) up to the age of 56 days. Treatments were inclusion of MOLM at 0 (T_1), 5 (T_2), 10 (T_3), 15 (T_4) and 20% (T_5). Four birds 2 from each sex were randomly selected from each replication for carcass evaluation at the end of the study. From the same birds used for carcass evaluation, blood was taken for serum Total Cholesterol (TC) and Total Protein (TP) determination. The crude protein content of MOLM was 28%. Daily Dry Matter (DM) intake during the entire experimental period ranged 54 to 75 g/bird and was greater ($P<0.05$) for T_1 than T_3 and T_5. Daily body weight gain for the entire experimental period were 29, 25, 22, 22 and 17g (SEM = 1.0) for T_1, T_2, T_3, T_4 and T_5, respectively and values were greater for T_1 as compared to T_3, T_4 and T_5 but similar ($P>0.05$) with T_2. Replacement of MOLM for SBM lowered ($P<0.05$) yield of most parameters such as dressed weight, eviscerated weight, breast weight, thigh weight, drumstick weight and giblet weight. Sex differences were significant in drumstick weight and drumstick and thigh percentages with greater values for males than females. Conversely, eviscerated percentage was greater ($P<0.05$) for females than males. Levels of TC and TP were greater for T_3 than T_1, T_4 and T_5 ($P<0.05$). However, differences in TC and TP levels due to sex were not significant ($P>0.05$). Depending on the production parameters measured, MOLM can be substituted to SBM in broilers diet up to a level of 5% inclusion in the total ration without negative effect on biological performance. Levels of MOLM substitution to SBM of 10-20% appeared to reduce growth rate but did not have an adverse effect on the health of birds, indicating the potential of the plant as an alternative feed ingredient in poultry feeding.

Key words: Broiler, carcass, leaf meal, *Moringa olifera*

INTRODUCTION

In commercial broiler production system, profit can be maximized by minimizing feed cost which accounts the major cost of broiler production. The bulk of the feed cost arises from protein concentrates such as Soybean Meal (SBM), groundnut cake and fish meal. Prices of these conventional protein sources have soared so high in recent times that it is becoming uneconomical to use them in poultry feeds. There is a need therefore, to look for locally available and cheap sources of feed ingredients. One possible source of cheap protein is the leaf meal of tropical legumes. Many studies have been conducted using various sources of leaf meal proteins for broilers (Iheukwumere *et al*., 2008; Wude and Berhan, 2009; Onyimonyi *et al*., 2009). Leaf meals do not only serve as source of protein but also provides some necessary vitamins, minerals and oxycarotenoids (D'Mello *et al*., 1987; Opara, 1996). One plant that can serve as source of leaf meal in the diet of poultry is *Moringa olifera* tree (Kakengi *et al*., 2007; Olugbemi *et al*., 2010b).

Moringa oleifera tree has probably been one of the most underutilized tropical plants. *Moringa Olifera* Leaf Meal (MOLM) is a natural source of protein with great potential. Studies revealed that MOLM has relatively high content of crude protein of up to 28% (Olugbemi *et al*., 2010a) and low anti-nutritional factors (Makkar and Becker, 1997). Kakengi *et al*. (2003) evaluated and compared nutritive value of different morphological components of *Moringa oleifera* in Tanzania and noted that the leaf to have a high pepsin and total soluble protein than other parts of the plant. The study of Kakengi *et al*. (2007) suggested that MOLM could replace sunflower seed meal and can be added up to 20% in layers ration. The study by Olugbemi *et al*. (2010a) indicated that MOLM possesses hypocholesterolemic properties and its inclusion in layers diets could facilitate reductions in egg cholesterol content. Knowledge on the feeding value of MOLM for broilers would thus play tremendous role in the future formulation of economical ration and in bridging the gap of protein feed supply to such animal species. The

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present study was thus conducted to investigate the performance of broilers fed varying dietary levels of MOLM replacing SBM.

MATERIALS AND METHODS

Experimental rations and treatments: The experiment was conducted at Debre Zeit Agricultural Research Center (DZARC), located at an altitude of 1900 meters above sea level and at 08044' N latitude and 380, 38'E longitude. The average annual rainfall and average maximum and minimum temperature for the area are 1100 mm and 28.3°C and 8.9°C, respectively (DZARC (Debre Zeit Agricultural Research Center), 2003). The feed ingredients used in the formulation of the different experimental rations for the study were corn grain, wheat middling, noug seed cake, SBM, MOLM, vitamin premix, salt, limestone and dicalcium phosphate. Leaf was harvested from young *Moringa olifera* tree of about two years of age from an orchard. The cut branches from the tree were spread out on concrete floor and allowed to dry for a period of 3 days under shade and aerated conditions. The leaves were then separated from the twigs before milling in a hammer mill sieve size of 5 mm to produce the leaf meal. All the ingredients except SBM, wheat middling, vitamin premix and dicalcium phosphate were also milled in sieve size of 5 mm and stored until required for the formulation of experimental rations. Chemical composition of the major feed ingredients (Table 1) was determined from representative samples of corn grain, noug seed cake, wheat middling, SBM and MOLM. Based on the chemical analysis result, five treatment rations containing MOLM at levels of 0 (T_1), 5 (T_2), 10 (T_3), 15 (T_4) and 20% (T_5) of the total ration at the expense of SBM were formulated. The rations were formulated to be nearly isocaloric and isonitrogenous (Table 2) with Metabolizable Energy (ME) content of 3000 kcal/kg DM and CP content of 22% for the starter phase (1 to 28 days of age) and ME content of 3200 kcal/kg DM and CP content of 20% for the finisher phase (29 to 56 days of age).

Management of experimental birds: Three hundred unsexed day old Hubbard Classic broiler chicks with initial body weight of 42.32±1.53 g (mean±SD) were randomly divided into five dietary treatments and three replications per treatment in a completely randomized design experiment, thus having 20 chicks per replicate or pen. The birds were vaccinated against Newcastle (HB1 at day 7 and Lasota a booster dose at day 21) and Infectious Bursal Disease (Gumboro) at the age of 10 days, all given through an eye drop. Other health precautions and sanitary measures were also taken throughout the study period. Before the commencement of the actual experiment, the experimental pens, watering and feeding troughs were thoroughly cleaned, disinfected and sprayed against external parasites. The chicks were brooded using 250 watt infrared electric bulbs with gradual height adjustment as sources of heat and light in a deep litter house covered with *Teff* straw mixed with sawdust litter material. Feed was offered *ad libitum* and clean tap water was available all the time throughout the experiment.

Measurements: The experimental period lasted 56 days. The amount of feed offered and refused per pen was recorded daily. The amount of feed consumed was determined as the difference between the feed offered and refused. Feed offered and refused were sampled daily per pen and pooled per treatment for the entire experimental period for chemical analysis. Birds were weighed weekly in a group per pen and pen average was calculated. Body Weight (BW) change was calculated as the difference between the final and initial BW. Average daily BW gain (ADG) was calculated as BW change divided by the number of experimental days. Dry matter conversion efficiency was computed as the ratio of ADG per daily DM consumption. Mortality was registered as it occurred and general health status was monitored throughout the experiment.

At the end of the experiment, 4 randomly selected birds 2 male and 2 female from each replication were starved for 12 hours, weighed immediately before slaughter and exsanguinated by severing the neck. After slaughtering, the birds were dry de-feathered by hand plucking. Birds were eviscerated and carcass cuts and non-edible offal components were determined according to the

Table 1: Chemical composition of feed ingredients used to formulate the experimental rations

Nutrients	Corn grain	Noug seed cake	Wheat middling	SBM	MOLM
DM (%)	92.1	92.9	92.9	94.0	90.9
CP (% DM)	8.4	34.6	19.2	42.2	28.2
CF (% DM)	2.3	17.2	8.4	6.5	6.5
EE (% DM)	4.4	7.1	5.4	6.8	6.6
Ash (% DM)	3.3	10.4	4.0	6.0	11.9
ME (kcal/kg DM)	3849	2389	3336	3496	3247
Calcium (% DM)	0.04	0.26	0.11	0.30	0.76
Phosphorus (% DM)	0.30	0.65	1.15	0.65	0.30
Beta-carotene (mg/100 g)	-	-	-	-	15.25

CP: Crude protein; CF: Crude fiber; DM: Dry matter; EE: Ether extract; ME: Metabolizable energy; MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal.

Table 2: Proportion of ingredients used in formulating broiler starter and finisher rations and chemical composition of treatment rations

	Treatment									
	T_1		T_2		T_3		T_4		T_5	
Ingredients (%)	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher
Corn grain	44.0	49.8	43.8	50.0	44.0	51.0	37.0	47.0	31.8	48.0
Wheat middling	7.0	10.0	6.0	7.8	3.8	4.8	10.8	9.0	16.0	4.8
Noug seed cake	17.0	13.0	19.0	15.0	21.0	17.0	21.0	16.8	21.0	20.0
SBM	28.0	24.0	23.0	19.0	18.0	14.0	13.0	9.0	8.0	4.0
MOLM	0.0	0.0	5.0	5.0	10.0	10.0	15.0	15.0	20.0	20.0
Vitamin premix*	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Limestone	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100	100	100	100
Nutrient Contents										
DM (%)	92.4	91.8	92.4	92.9	91.2	93.5	91.1	93.5	91.9	93.4
CP (% DM)	22.5	21.0	22.4	20.9	22.7	20.7	22.2	20.4	21.8	20.2
CF (% DM)	6.8	6.3	7.2	6.7	7.8	7.0	7.9	7.2	8.1	7.6
EE (% DM)	4.8	4.7	4.8	4.8	5.0	4.8	5.0	4.9	5.1	4.9
Ash (% DM)	12.0	13.9	10.7	10.6	9.9	10.9	10.9	12.5	10.7	13.0
ME (kcal/kg DM)	3039	3292	3005	3290	3000	3280	3026	3246	3040	3208
Ca (% DM)	1.10	1.00	1.13	1.02	1.16	1.04	1.18	1.07	1.21	1.10
P (% DM)	0.55	0.57	0.56	0.56	0.53	0.53	0.53	0.55	0.53	0.51

MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal. T_1 = Ration containing 0% MOLM. T_2 = Ration containing 5% MOLM. T_3 = Ration containing 10% MOLM. T_4 = Ration containing 15% MOLM. T_5 = Ration containing 20% MOLM. *Vitamin premix = 50 kg contains, Vit A 1000000 IU, Vit D_3 200000 IU, Vit E 10000 mg, Vit K_3 225 mg, Vit B_1 125 mg, Vit B_2 500 mg, Vit B_3 1375 mg, Vit B_6 125 mg, Vit B_{12} 1 mg, Vit pp (Niacin) 4000000 mg, Folic acid, 100 mg, Choline chloride 37500 mg, Anti-oxidant (BTHT) 0.05%, Manganese 0.60%, Zinc 0.70%, Iron 0.45%, Copper 0.05%, Sodium 0.01%, Selenium, 0.004%, Calcium 2.7%; DM: Dry matter; CP: Crude protein; CF: Crude fiber; EE: Ether extract; ME: Metabolizable energy; Ca: Calcium; P: Phosphorous.

procedure described by Kubena *et al.* (1974). Dressed carcass weight was measured after the removal of blood and feather and the dressing percentage calculated as the proportion of dressed carcass weight to slaughter weight multiplied by 100. Eviscerated carcass weight was determined after removing blood, feather, lower leg (shank), head, kidney, lungs, pancreas, crop, proventriculus, small intestine, large intestine, caeca and urogenital tracts from dressed carcass. The eviscerated percentage was then determined as the proportion of the eviscerated weight to slaughter weight multiplied by 100. From eviscerated carcass weight drumstick, thigh and breast meat were separated and weighed, then their weight were divided by slaughter weight and multiplied by 100 to determine percentage weights of each component. Fat around the proventriculus and gizzard and against the abdominal wall and the cloacae were collected and weighed and fat percentage was calculated as the proportion of slaughter weight. The edible offal which includes the heart, gizzard and liver, were weighed and expressed in relation to slaughter weight.

From the same birds used for carcass evaluation, blood was taken for serum Total Cholesterol (TC) and Total Protein (TP) determination. Blood samples were collected by inserting a sterile needle into the wing vein of the birds and extracting about 1 ml of blood. The samples were then placed inside plain vacutainers and centrifuged at 4000 rpm for 2 minutes in order to separate the serum. The collected sera were stored at -20°C pending analysis.

Laboratory analysis: Feed ingredients and samples of feed offered and refusal of the formulated diets from the respective treatments were analyzed for Dry Matter (DM), Crude Fiber (CF), Total Ash (TA), Ether Extract (EE) and Kjeldahl Nitrogen (N) (AOAC (Association of Official Analytical Chemists), 1998). The CP was then determined by multiplying N by 6.25. Calcium and total phosphorus content were determined by atomic absorption and vanado-molybdate method, respectively (AOAC (Association of Official Analytical Chemists), 1998) and beta-carotene by spectrophotometer (AOAC (Association of Official Analytical Chemists), 1998). Metabolizable Energy (ME) content of the experimental diets was determined according to Wiseman (1987) as:

$$\text{ME (kcal/kg DM)} = 3951+54.4\text{EE}-88.7\text{CF}-40.80\text{Ash}$$

The chemical composition analysis of breast and thigh muscles without skin was carried out. The fresh samples of breast and thigh muscles were separately minced, dried and homogenized and analyzed for DM, CP, fat, ash, Ca and P (AOAC (Association of Official Analytical Chemists), 1998). Serum total cholesterol and total protein assay were done using cholesterol and protein liquor commercial kit manufactured by Human Diagnostics Worldwide based on CHOD-PAP method (Liebermann, 1985).

Statistical analysis: Data were analyzed using the general linear model procedures of Statistical Analysis Systems software (SAS, 2002), with the model

Table 3: Dry matter intake, body weight change, feed conversion efficiency and mortality rate of broilers fed ration containing different levels of *Moringa olifera* leaf meal

	Treatment					
Parameters	T_1	T_2	T_3	T_4	T_5	SEM
DMI (g/bird)						
Starter	40.1^a	34.0^{ab}	33.2^b	32.4^b	28.2^b	1.49
Finisher	109.7^a	92.3^{ab}	85.2^{ab}	88.3^{ab}	79.8^b	5.28
Entire experiment	74.9^a	63.1^{ab}	59.2^b	60.3^{ab}	54.0^b	3.12
IBW (g/bird)	42.3	42.3	42.3	42.1	42.6	0.46
FBW (g/bird)						
Starter	490^a	432^b	401.7^{bc}	368^c	305^d	7.42
Finisher	1624^a	1384^{ab}	1223^{bc}	1203^{bc}	968^c	55.65
BW change (g/bird)						
Starter	448^a	390^b	359^{bc}	325^c	263^d	7.45
Finisher	1133^a	952^{ab}	822^{bc}	836^{bc}	663^c	53.11
Entire experiment	1581^a	1342^{ab}	1181^{bc}	1161^{bc}	925^c	55.70
ADG (g/day)						
Starter	16.3^a	13.9^b	12.8^{bc}	11.6^c	9.4^d	0.30
Finisher	40.5^a	34.0^{ab}	29.3^{bc}	29.9^{bc}	23.7^c	1.90
Entire experiment	29.0^a	24.7^{ab}	21.9^b	21.5^{bc}	17.1^c	1.01
DMCE (g ADG/g DMI)						
Starter	0.41^a	0.41^a	0.39^{ab}	0.36^{ab}	0.33^b	0.01
Finisher	0.37	0.37	0.35	0.35	0.30	0.03
Entire experiment	0.38	0.40	0.37	0.36	0.32	0.02
Mortality rate	0.11	0.16	0.29	0.30	0.48	0.11

[a-d]Means within a row with different superscripts differ significantly ($P<0.05$); SEM: Standard error of the mean; ADG: Average daily body weight gain; BW: Body weight; IBW: Initial BW; FBW: Final BW; DMCE: Dry matter conversion efficiency; DMI: Dry matter intake; MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal. T_1 = Ration containing 0% MOLM. T_2 = Ration containing 5% MOLM. T_3 = Ration containing 10% MOLM. T_4 = Ration containing 15% MOLM. T_5 = Ration containing 20% MOLM.

Table 4: Carcass components of broilers fed ration containing different levels of *Moringa olifera* leaf meal

	Treatments						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Slaughter weight (g)	1541^a	1156^b	1086^b	1007^{bc}	862^c	37.1	1155	1106	23.5
Dressed weight (g)	1370^a	1044^b	984^b	910^{bc}	787^c	36.5	1049	989	23.1
Dressing percentage	88.7	90.3	90.6	90.4	91.3	0.65	90.9	89.7	0.41
Eviscerated weight (g)	1006^a	782^b	704^{bc}	662^{bc}	588^c	27.6	756	741	17.5
Eviscerated percentage	65.1	67.7	65.2	65.7	68.1	0.90	65.4^b	67.3^a	0.57
Breast weight (g)	337^a	245^b	231^{bc}	196^c	149^d	10.3	240	223	6.5
Breast percentage	21.8^a	21.2^a	21.3^a	19.5^b	17.2^c	0.37	20.4	19.9	0.24
Thigh weight (g)	154^a	113^b	104^{bc}	97^{bc}	86^c	5.5	116	106	3.50
Thigh percentage	9.9	9.7	9.6	9.6	9.9	0.18	10.0^a	9.6^b	0.11
Drumstick weight (g)	136^a	104^b	102^b	87^{bc}	78^c	4.5	108^a	95^b	2.8
Drumstick percentage	8.8	9.0	9.4	8.7	9.0	0.18	9.3^a	8.7^b	0.11
Giblet weight (g)	75^a	54^{bc}	59^b	53^{bc}	48^c	2.3	60	56	1.5
Fat percentage	2.1	1.6	1.1	1.9	1.4	0.25	1.4	1.8	0.16

[a-d]Means within a row and within treatment or sex with different superscripts differ significantly ($P<0.05$); SEM: Standard error of the mean; MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal. T_1 = Ration containing 0% MOLM. T_2 = Ration containing 5% MOLM. T_3 = Ration containing 10% MOLM. T_4 = Ration containing 15% MOLM. T_5 = Ration containing 20% MOLM.

containing treatments for data other than carcass characteristics and serum parameters that were analyzed with a model containing treatments and sex. Differences between treatment means were separated using Tukey Kramer test.

RESULTS

The CF and EE contents of MOLM are comparable to that of SBM (Table 1). The CP content of MOLM was 28% and the leaf meal has greater total ash content than the rest of the ingredients used in this study. Beta carotene content of MOLM is quite high. The five treatment rations were nearly isonitrogenous and isocaloric (Table 2).

Average DM intake, BW changes, Average Daily Gain (ADG), Dry Matter Conversion Efficiency (DMCE) and mortality rate of chicks are presented in Table 3. Replacement of MOLM for SBM resulted in a significant ($P<0.05$) depression in starter average DM intake at MOLM levels of 10-20%, while values for T_2 (5%) was similar ($P>0.05$) with that of T_1. During the finisher

Table 5: Weight and length of gut parts of broilers fed ration containing different levels of *Moringa olifera* leaf meal

	Treatment						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Esophagus weight (g)	2.05^{ab}	2.27^{a}	1.95^{ab}	2.23^{a}	1.50^{b}	0.14	2.01	1.99	0.09
Crop weight (g)	9.30^{ab}	7.02^{ab}	10.37^{a}	7.23^{ab}	5.72^{b}	0.91	8.52	7.33	0.58
Proventriculus weight (g)	8.15^{a}	5.47^{b}	5.80^{b}	5.37^{b}	4.90^{b}	0.26	5.80	6.07	0.16
Small intestine weight (g)	65.9^{a}	50.3^{b}	47.7^{b}	49.5^{b}	33.1^{c}	2.67	53.9^{a}	44.7^{b}	1.69
Large intestine weight (g)	15.7^{a}	13.9^{ab}	10.3^{cd}	12.2^{bc}	8.6^{d}	0.71	12.1	12.2	0.45
Caeca weight (g)	11.7	10.6	8.8	9.1	8.2	0.82	10.1	9.3	0.52
Esophagus length (cm)	6.72^{a}	5.42^{b}	4.50^{bc}	5.42^{b}	4.27^{c}	0.22	5.31	5.22	0.14
Crop length (cm)	9.42^{a}	7.33^{c}	7.02^{c}	8.28^{b}	6.92^{c}	0.17	7.81	7.77	0.11
Proventriculus length (cm)	3.58^{a}	3.57^{a}	3.75^{a}	3.50^{ab}	3.23^{b}	0.07	3.66^{a}	3.39^{b}	0.04
Small intestine length (cm)	182^{a}	167^{ab}	150^{bc}	171^{a}	144^{c}	3.93	166	160	2.49
Large intestine length (cm)	25.8^{a}	20.1^{b}	22.7^{ab}	22.2^{ab}	19.3^{b}	1.14	22.2	21.9	0.72
Caeca length (cm)	13.3^{ab}	13.4^{ab}	10.6^{b}	16.3^{a}	12.8^{b}	0.79	14.5	12.1	0.50
Leg length (cm)	7.75^{a}	6.57^{b}	8.05^{a}	6.83^{b}	6.30^{b}	0.20	7.21	6.99	0.13

$^{a-d}$Means within a row and within treatment or sex with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal. T_1 = Ration containing 0% MOLM. T_2 = Ration containing 5% MOLM. T_3 = Ration containing 10% MOLM. T_4 = Ration containing 15% MOLM. T_5 = Ration containing 20% MOLM.

Table 6: Chemical composition of breast muscle of broilers fed ration containing different levels of *Moringa olifera* leaf meal

	Treatment						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Moisture (%)	74.6	75.6	78.2	76.9	77.8	0.89	76.2	77.0	0.56
Ash (%)	3.57	3.11	3.14	3.60	3.12	0.17	3.20	3.42	0.11
CP (%)	23.8	23.0	20.3	21.2	20.5	0.90	22.0	21.6	0.57
EE (%)	3.08	3.30	3.03	3.75	3.10	0.67	3.64	2.86	0.42
Ca (ppm)	69.8	49.4	47.1	58.7	36.3	10.24	41.6^{b}	62.9^{a}	6.48
P (ppm)	122	112	122	136	116	7.1	120	123	4.5

$^{a-b}$Means within a row and within sex with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; Ca: Calcium; CP: Crude protein; DM: Dry matter; EE: Ether extract; P: Phosphorus; MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal. T_1 = Ration containing 0% MOLM. T_2 = Ration containing 5% MOLM. T_3 = Ration containing 10% MOLM. T_4 = Ration containing 15% MOLM. T_5 = Ration containing 20% MOLM.

Table 7: Chemical composition of thigh muscle of broilers fed ration containing different levels of *Moringa olifera* leaf meal

	Treatment						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Moisture (%)	70.3	74.4	73.7	70.2	72.2	1.44	73.0	71.3	0.91
Ash (%)	3.02	2.86	2.76	2.89	2.74	0.13	2.86	2.84	0.08
CP (%)	22.0^{ab}	20.0^{b}	20.9^{ab}	23.8^{a}	20.0^{b}	0.79	21.4	21.3	0.50
EE (%)	10.01	7.04	5.77	6.66	9.12	1.27	6.93	8.51	0.81
Ca (ppm)	72.7	85.1	52.1	62.8	61.2	12.46	54.8^{b}	78.7^{a}	7.88
P (ppm)	112	104	114	103	107	6.6	106	110	4.2

$^{a-b}$Means within a row and within treatment or sex with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; Ca: Calcium; CP: Crude protein; DM: Dry matter; EE: Ether extract; P: Phosphorus; MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal. T_1 = Ration containing 0% MOLM. T_2 = Ration containing 5% MOLM. T_3 = Ration containing 10% MOLM. T_4 = Ration containing 15% MOLM. T_5 = Ration containing 20% MOLM.

phase, DM intake was lower for T_5 than T_1, while other means were similar (P>0.05) among each other. Average DM intake for the entire experimental period was greater (P<0.05) for T_1 than T_3 and T_5.

Final BW, BW change and ADG during the starter phase was in the order of $T_1>T_2>T_4>T_5$, while values for T_3 was similar with T_2 and T_4 but less than T_1 and greater than T_5. Final BW during the finisher phase and BW change and ADG during the finisher phase and the entire experimental period had a similar trend and were greater for T_1 and T_2 as compared to T_5, while values for T_3, T_4 and T_5 were similar (P>0.05). Dry matter conversion efficiency (DMCE) was affected only in the starter phase (P<0.05) and value for T_1 and T_2 was greater than that of T_5, while other means were similar to each other. Mortality rate ranged from 0.11-0.48 and was not significantly variable (P>0.05) among treatments.

Moringa olifera leaf meal replacement for SBM in broilers ration resulted in a lower carcass yield characteristics in most parameters considered (Table 4). The slaughter weight, dressed weight, eviscerated weight, breast weight, thigh weight, drumstick weight

Table 8: Serum total cholesterol and serum total protein levels of broilers fed ration containing different levels of *Moringa olifera* leaf meal

	Treatment						Sex		
Parameters	T_1	T_2	T_3	T_4	T_5	SEM	Male	Female	SEM
Cholesterol level (mg/dl)	282^c	382^{ab}	443^a	296^{bc}	256^c	20.6	348	316	13.0
Protein level (g/dl)	6.00^c	9.50^{ab}	11.00^a	7.33^{bc}	5.83^c	0.61	8.20	7.67	0.38

$^{a-c}$Means within a row and within treatment with different superscripts differ significantly (P<0.05); SEM: Standard error of the mean; MOLM: *Moringa olifera* leaf meal; SBM: Soybean meal. T_1 = Ration containing 0% MOLM. T_2 = Ration containing 5% MOLM. T_3 = Ration containing 10% MOLM. T_4 = Ration containing 15% MOLM. T_5 = Ration containing 20% MOLM.

and giblet weight were lower (P<0.05) in birds that received dietary MOLM than those in T_1. Slaughter weight, dressed weight and drumstick weight was greater (P<0.05) for T_2 and T_3 than T_5 among birds that received dietary MOLM, while values for T_4 was similar with T_2, T_3 and T_5. Eviscerated and thigh weights were greater (P<0.05) for T_2 than T_5, with values for T_3 and T_4 being similar with T_2 and T_5. Breast weight was in the order of T_2>T_4>T_5 with values for T_3 being similar with T_2 and T_4 but less than T_1. Dressed and eviscerated, thigh and drumstick percentages were unaffected by treatment (P>0.05). Breast percentage was in the order of $T_1 = T_2 = T_3 > T_4 > T_5$ (P<0.05). Differences between sexes were not significant in most carcass parameters measured in this study. Sex differences were significant in drumstick weight and drumstick and thigh percentages with greater values for males than females. Conversely, eviscerated percentage was greater (P<0.05) for females than males.

Weight and length of gastro intestinal tract parts are shown in Table 5. With the exception of caecal weight, all other parameters were significantly affected (P<0.05) by MOLM substitution to SBM. Generally, trends of change in the weight and length of the different gut parts was not consistent in all of the parameters measured. But in most parameters values for T_1 was greater than those for T_5. The esophagus and the crop length in birds that received dietary MOLM appeared to be relatively not well developed. Weight of the small intestine and length of proventriculus was greater (P<0.05) for males than females, while other parameters were similar (P>0.05) between the two sexes.

The contents of moisture, ash, CP, EE, Ca and P in the breast muscle was unaffected (P>0.05) by MOLM inclusion in the diet (Table 6). Sex effect was significant only for the level of Ca in breast muscle which was greater for females than the males. The CP content of thigh muscle was greater for T_4 than T_2 and T_5, while other means were similar to each other (Table 7). The contents of moisture, ash, EE, Ca and P for the thigh muscle were similar among the different diets (P>0.05). Similar to the breast muscle, Ca content for the thigh muscle were also greater (P<0.05) for females than the males. Sex effect was not significant in other parameters for the thigh muscle.

There was a significant (P<0.05) difference among treatments in serum total cholesterol and total protein level (Table 8) due to replacing SBM with MOLM. Levels of serum cholesterol and total proteins were greater for T_3 than T_1, T_4 and T_5 (P<0.05). However, differences in serum cholesterol and protein levels due to sex were not significant (P>0.05).

DISCUSSION

The CF content of MOLM in the present study was low as compared to the 9-19% CF reported for *Moringa stenopetala* leaf (Abera *et al*., 2009; Yisehak *et al*., 2011). The relatively low CF content of MOLM used in this study might be due to the young age at which the leaf was harvested. The CP level of MOLM in this study was similar to the 27.5% reported by Oduro *et al*. (2008). This makes the leaf to be a rich source of protein, containing a good profile of amino acids (Makkar and Becker, 1997; Sarwatt *et al*., 2002). The high mineral level in MOLM of this study appeared to be consistent with that noted for different accession of *Moringa stenopetala* species (Dechasa *et al*., 2006). Makkar and Becker (1996) reported that the leaf of moringa to be rich in carotene and ascorbic acid. As such beta carotene content of MOLM in the present study was quite high, much higher than most green vegetables (Amin and Cheah, 2003). Generally the five treatment rations used in this study were nearly isonitrogenous and isocaloric and the nutrient contents including Ca and P were within the recommended values for starter and finisher broiler diets (Leeson and Summers, 2005).

Replacement of MOLM for SBM at levels above 5% appeared to depress feed intake in broilers in this study. This might be presumably due to greater content of CF and Ca with increasing dietary levels of MOLM. In the current study, MOLM inclusion appeared to have relatively increased the CF and Ca contents in both the starter and finisher diets. Increased CF, EE and Ca in poultry ration is known to hinder protein and energy digestibility and depress feed intake as well as enzymatic activity that assist in carbohydrate, protein and fat digestion (McDonald *et al*., 2002; Mirnawati *et al*., 2011). This suggests that replacing SBM with MOLM at higher proportions in the diet should be accompanied with low CF, Ca and fat containing dietary ingredients for better feed utilization. According to some authors (Ash and Petaia, 1992; Omekam, 1994), chickens do not eat voluntarily fresh or dried legume leaves and could often show a decline in their performance due to the lack of appetite when fed diet containing high level of leaves and for such dietary ingredients pelleting the feed may increase intake. However, in other studies increased dietary intake with MOLM substitution to sunflower seed meal (Kakengi *et al.*, 2007) or to cassava based diets (Olugbemi *et al.*, 2010b) have been noted.

Consistent with the DM intake of broilers, final body weight and daily body weight gain of broilers was generally depressed at levels above 5% MOLM substitution to SBM. This agreed with the general observations made by Olugbemi *et al.* (2010b) that noted reduced growth performance at inclusion level of *Moringa olifera* leaf meal above 5-10% in broiler diets. Similarly, Iheukwumere *et al.* (2008) suggested up to 5% level of cassava leaf meal dietary inclusion without any adverse effect on broiler performance. The depression in growth with increased MOLM inclusion level agree with the general similar observations noted before with leaf meal inclusion in the diet of poultry (Ash and Akoh, 1992; Opara, 1996), even when maize oil was used to compensate for the low metabolizable energy value of the leaf meal (Opara, 1996). However, up to 24% inclusion level of MOLM in the diet of growing indigenous Senegal chicken with no negative impact on body weight, average daily weight gain and feed conversion ratio was reported (Ayssiwede *et al.*, 2011).

Moringa olifera leaf meal substitutions for SBM in broilers ration reduced yield of most carcass characteristics in the current study which appeared to be a consequence of reduced feed intake and growth rate of the birds (Iheukwumere *et al.*, 2007). The current result is however, in contrast to the findings of Ayssiwede *et al.* (2011) who reported no adverse effect on carcass cuts due to inclusion of MOLM up to 24% in the diet of growing indigenous Senegal chicken. Sex effect was significant in eviscerated percentage, thigh percentage, drumstick percentage and drumstick weight out of the major carcass parameters measured in this study. Previous studies noted females to have greater proportion of breast than males (Rondelli *et al.*, 2003) which was not the case in this study. However, similar breast proportion between sexes in line with the findings of this study was also reported (Horniakova and Abas, 2009). Greater thigh percentage, drumstick weight and percentage for males than females in this study is consistent with similar other reports (Bogosavljevic *et al.*, 2006, Ojedapo *et al.*, 2008).

Ghasi *et al.* (2000) and Olugbemi *et al.* (2010a) reported a reduction in serum cholesterol level with increasing level of MOLM inclusion in the diet of rats and layers, respectively. Similarly, Olugbemi *et al.* (2010a) noted that *Moringa oleifera* possesses hypocholesterolemic properties and its inclusion in the diet of layers is thought to reduce egg cholesterol content. But, this study failed to note the hypocholesterolemic properties of MOLM in the serum of broilers and differences in serum cholesterol levels observed among treatments in the current study lack an apparent trend. According to Rondelli *et al.* (2003) female birds had fatter skin but less cholesterol than males but serum cholesterol levels in this study was similar for the two sexes. Total serum protein has been reported as an indication of the protein retained in the animal body (Akinola and Abiola, 1991; Esonu *et al.*, 2001). The relatively greater total serum protein content of broilers receiving dietary MOLM might be an indication of the good protein content and/or quality of the leaf meal.

Though *Moringa oleifera* has been claimed to boost immune systems (Fuglier, 1999), such property of the plant most likely might be contained and restricted to the pods which possesses lectin, a substance that modulates the body defense system (Jayavardhanan *et al.*, 1994). Kakengi *et al.* (2007) reported a non adverse effect on mortality rate of birds receiving dietary MOLM similar to the present results. The general non-significance difference of the mortality across treatments might be indicative that the experimental diets were proportionately sufficient in supplying comparable amounts of nutrients that might have prevented health problems and might be also an indication for the lack of anti-nutrients in MOLM at levels that may induce health problems.

Generally, there was a pronounced intense yellowish coloration of the beak, legs, carcass cuts, abdominal fat and feathers of broilers that received dietary MOLM than birds that got no MOLM. This presumably may be due to the high content of beta-carotene in MOLM. The yellow color in the body and products of broilers observed in this study is an indication of the efficient absorption and utilization of the pigment xanthophyll present in MOLM. Similarly, Ayssiwede *et al.* (2011) observed that dietary MOLM inclusion to have produced yellow coloration of the skin and abdominal fat of growing indigenous chickens. The higher beta-carotene content of MOLM can play role in layers ration to produce yellow egg yolk that are demanded by consumers, although this call for further research.

Conclusions: Depending on the production parameters measured in this study, MOLM can be substituted to SBM in broilers diet up to a level of 5% inclusion in the total ration without negative effect on biological performance of birds. Levels of MOLM substitution to SBM of 10-20% appeared to reduce growth rate of broilers but did not have an adverse effect on the health of birds, indicating the potential of the plant as alternative feed ingredient in poultry feeding.

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