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Research Article

Effect of Season and Dietary *Moringa oleifera* Leaf Meal on Growth Performance of the Pearl Guinea Fowl

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Abstract

Objective: A study was carried out to determine the effect of graded levels of *Moringa oleifera* leaf meal (MOLM) and season on growth performance of the Pearl Guinea fowl in Ghana. **Materials and Methods:** One hundred and sixty (160) local Guinea fowls (one-day-old) were used for the study. The birds were brooded from day-old to four weeks under the same housing and management practices. Four dietary treatments contained 0, 9, 12 and 15% MOLM in the diet were formulated. Each treatment had forty (40) birds with ten (10) birds per replicate and reared in three seasons (Dry season: December-March, Major rainy season: April-July and Minor rainy season: August-November). A 3×4 factorial arrangement was used for the experiment. Data collected were analyzed using General Linear Model (GLM) procedure of Statistical Analysis System and means were separated by the probability of difference (PDIFF) procedure. **Results:** Results showed that daily feed intake decreased ($p<0.05$) with increasing level of dietary MOLM. Body weight and body weight gain increased ($p<0.05$) with increasing level of dietary MOLM. Birds fed the control (0% MOLM) diet showed higher ($p<0.05$) FCR values (3.69, 3.42) at 0-4 and 5-8 weeks respectively while birds fed 15% MOLM had the lower FCR values (2.97 and 2.49) at 0-4 and 5-8 weeks, respectively. Daily feed intake, body weight and weight gain across the seasons were significantly ($p<0.05$) higher in the major rainy season followed by minor rainy season and least in the dry season. However, feed conversion ratio was better ($p<0.05$) in the major rainy season. **Conclusion:** Feeding of MOLM to guinea fowls promotes better feed utilization and enhances rapid growth. A 15% inclusion level for MOLM is recommended by this study for farmers and breeders.

Key words: Body weight, feed conversion ratio, feed intake, guinea fowl, moringa leaf meal

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The poultry industry is one of the largest industries in Ghana and offers employment opportunities to many people especially the youth. People in Northern Ghana use Guinea fowls for a wide variety of purposes ranging from socio-cultural to economic and religious[1]. The birds are the most common among the numerous poultry species in Northern Ghana (Upper East, Upper West and Northern Region) where they have been estimated to be about 4 million[2] and the extensive system is used to rear these birds.

In Guinea fowl production, the higher productivity depends on the age of breeding stock, the health status of the flock and nutrition provided during the breeding season[3]. Possible causal factors affecting Guinea fowl production include poor nutrition, low body weight at first maturity, time of joining (out of season breeding), seasonal changes and age of hen and cock. At certain times of the year, hens may not lay due to seasonal changes. Egg laying is affected by short day length because it affects hormone production and reproduction[2]. Poor nutrition can lead to inadequate protein intake, which can affect sperm production, fertility and hatchability. In non-ruminant diets, moringa leaves have quality attributes that make them an excellent alternative to soybean meal or fish meal. In addition to being easily established in the field, moringa has good coppicing ability and good forage potential[4]. Furthermore, moringa can produce large amounts of high quality forage without expensive inputs due to favourable soil and climatic conditions for its growth. Odetola *et al.*[5] and Ogbe and Affiku[6] reported that, moringa leaves are inexpensive and potential source of protein for livestock feeding. Recently, there has been interest in the utilization of moringa (*Moringa oleifera*) commonly called horseradish tree or drumstick tree, as a protein source for livestock[4].

Despite the nutritive and medicinal value of *Moringa oleifera*, there are few publications regarding its effect on the growth performance of Guinea fowls. It is known that guinea fowls are seasonal breeders and their growth is influenced by season[3]. The study was carried out to determine the effect of dietary moringa leaf meal (MOLM) and season on growth performance of the Pearl Guinea fowl in Ghana.

MATERIALS AND METHODS

The study was conducted at the Poultry Unit of the Department of Animal Science Education, University of Education, Winneba, Mampong-Ashanti. Mampong-Ashanti lies in the transitional zone between the Guinea savanna zone of the north and the tropical rain forest of the south of Ghana. The climatic, vegetation and demographic characteristics of Mampong-Ashanti have been described by Ghana Districts[7]. Mampong-Ashanti lies between latitude 07° 04' degree north and longitude 01° 24' degrees west with an altitude of 457 m above sea level. Maximum and minimum annual temperatures recorded during the study period were 30.6 and 21.2°C, respectively[8,9]. Rainfall pattern in the district is bimodal, occurring from April to July (major rainy season) and again from August to November (minor rainy season), with about 1224 mm per annum. The dry season occurs from December to March[9,10].

A total of 160 pearl Guinea fowl pullets (32 males and 128 females) were selected from the initial stock obtained from Akate Farms Co. Limited in Kumasi after brooding and used for the study. A 3×4 factorial arrangement was used in this study. The factors that were considered in the experiment were; Factor I: 3 seasons, dry season (December-March), major rainy season (April-July) and minor rainy season (August-November). Factor II: 4 levels of MOLM (0% MOLM, 9% MOLM, 12% MOLM and 15% MOLM). All treatment combination (Season and different levels of MOLM combination: 0% MOLM: Dry season, Major rainy season and Minor rainy season, 9% MOLM: Dry season, Major rainy season and Minor rainy season, 12% MOLM: Dry season, Major rainy season and Minor rainy season, 15 % MOLM: Dry season, Major rainy season and Minor rainy season) were used. Each treatment was replicated four times and had ten birds per replicate. The birds in each replicate were housed in one pen. At the age of four months, a male was paired with four Guinea hens.

A total of 16 experimental pens were used for rearing the birds, each measuring 1.4×1.34 m and housed 10 birds. The floor was concreted and wood shavings were used as litter for the birds. Removable wooden feeding troughs measuring 0.8×0.04×0.03 m were used for feeding the growers. A 4.5 L watering trough was used for supplying water *ad libitum* for the growers in each pen. The experimental diets (Table 1-3) were supplied to the birds *ad libitum* throughout the experimental period, vaccination and other routine poultry practices were also carried out. The weather records for the year 2017 and 2018 in Table 4 and 5.

Growth parameters measured: The following growth parameters were measured: daily feed intake (DFI), total feed intake (TFI), body weight gain (BWG), daily body weight gain (DBWG) and feed conversion ratio (FCR).

Feed intake: Daily feed was weighed before being offered to the birds using A and D Weighing EK-6000i electronic balance

Table 1: Ingredient and composition (%) of starter diet

Attributes	0% MOLM	9% MOLM	12% MOLM	15% MOLM
Moringa	0.00	9.00	12.00	15.00
Maize	57.50	54.00	52.50	52.00
Wheat bran	11.00	8.50	8.50	6.00
Soya bean meal	8.50	8.00	7.00	7.00
Tuna fish meal	8.00	6.50	6.00	6.00
Anchovy fish meal	12.00	11.00	11.00	11.00
Oyster shell	1.50	1.50	1.50	1.50
Dicalcium phosphate	0.50	0.50	0.50	0.50
Vitamin premix	0.50	0.50	0.50	0.50

Table 2: Ingredient and composition (%) of grower diet

Attributes	0% MOLM	9% MOLM	12% MOLM	15% MOLM
Moringa	0.00	9.00	12.00	15.00
Maize	63.00	60.50	56.00	58.00
Wheat bran	22.00	18.50	16.00	17.00
Soya bean meal	3.00	2.00	3.00	2.00
Tuna fish meal	4.00	3.00	4.00	2.00
Anchovy fish meal	5.00	4.00	6.00	3.00
Oyster shell	1.50	1.50	1.50	1.50
Dicalcium phosphate	0.50	0.50	0.50	0.50
Vitamin premix	0.50	0.50	0.50	0.50

Table 3: Ingredient and composition (%) of Breeder diet

Attributes	0% MOLM	9% MOLM	12% MOLM	15% MOLM
Moringa	0.00	9.00	12.00	15.00
Maize	55.00	50.00	50.00	50.00
Wheat bran	19.50	18.50	16.50	14.50
Soya bean meal	4.00	3.00	2.50	2.00
Tuna fish meal	4.50	4.50	4.00	3.00
Anchovy fish meal	8.00	6.00	6.00	6.50
Oyster shell	7.50	7.50	7.50	7.50
Dicalcium phosphate	0.50	0.50	0.50	0.50
Vitamin premix	0.50	0.50	0.50	0.50

Table 4: Weather records for the municipality for 2017

Variables	Dry season (December-March)	Major rainy season (April-July)	Minor rainy season (August-November)
Temperature (°C)	32.00	30.25	27.00
Rainfall (mm)	27.28	130.00	125.05
Humidity (%)	65.50	81.25	84.50
Cloud cover (%)	37.50	60.00	65.25
Sun hours	103.10	89.30	62.45

Table 5: Weather records for the municipality for 2018

Variables	Dry season (December-March)	Major rainy season (April-July)	Minor rainy season (August-November)
Temperature (°C)	33.0	29.11	26.30
Rainfall (mm)	28.41	123.12	117.02
Humidity (%)	68.9	82.07	80.11
Cloud cover (%)	38.80	65.21	63.15
Sun hours	106.2	67.22	85.40

(A and D Co. Ltd, USA) with a capacity of 5 kg. The difference between feed supplied to a replicate and feed left-over at the end of each day was recorded as daily feed intake. At the end of each week, these were added up to give weekly consumption values. The weekly consumption value was then divided by the number of birds to obtain the average weekly feed consumption.

$$\text{Feed intake (g)} = \text{Feed given (g)} - \text{Feed left over (g)}$$

Body weight: Birds were weighed at the start of the experiment and also at weekly intervals using A&D Weighing EK-6000i electronic balance (A and D Co. Ltd, USA) with a capacity of 5 kg. Weight measured at the end of the previous week was deducted from that of the current week to obtain the weight gained for the week. Birds were weighed in batches using a box on a top-pan balance. The weekly body weight gain was then divided by the number of birds in a replicate to obtain average weekly body weight gain per bird per replicate.

Feed conversion ratio: Feed conversion ratio was calculated from feed consumed and weight gained for each replicate by dividing the weekly feed consumption value by the respective weight gains of the replicates for that week. Feed conversion ratio is the ratio of the total feed intake in grams (g) throughout the experimental period to the total weight gain in grams (g). It was expressed as gain to feed ratio. That is:

$$\text{Feed conversion ratio} = \frac{\text{Average feed intake}}{\text{Average body weight gain}}$$

Data analysis: Data collected were analyzed with the help of General Linear Model (GLM) procedure of Statistical Analysis System (SAS for Windows, version 7). The means were separated using the probability of difference (PDIFF) procedure of SAS[11].

RESULTS AND DISCUSSION

Proximate composition of MOLM: Moringa leaf meal (MOLM) contain higher levels of carbohydrates (26.96±1.52), crude protein (28.91±0.21), metabolizable energy (2043.50±55 kcal kg^{-1}) and appreciable levels of crude fibre (13.34±0.078), dry matter (89.64±0.45), ether extracts (5.32±0.21), moisture (10.36±0.075), nitrogen free extracts (43.85±0.11) and total ash (7.13±0.04) as shown in Table 6.

Phytochemical properties in MOLM: High level of chlorogenic acid was observed in MOLM compared to all the other parameters (Table 7). Kaempferol, quercetin and luteolin were observed to be moderate. However, apigenin was observed to be the lowest among all the parameters measured.

Proximate composition of the experimental diets: The proximate composition of the experimental diets is shown in Table 8. The levels of ash, crude protein, crude fibre and metabolizable energy in the starter, grower and breeder diets increased with increasing levels of dietary MOLM. The control treatment recorded the highest levels of moisture, ether extract and dry matter in the starter, grower and breeder diets while the 15% MOLM inclusion level recorded the lowest levels of moisture, ether extract and dry matter in the starter, grower and breeder diets. The diet met the nutrient requirement for Guinea fowls as suggested by Okyere *et al.*[12].

Table 6: Proximate composition of MOLM

Parameter	Mean (%)	Standard deviation
Carbohydrates	26.96	1.52
Crude protein	28.91	0.21
Crude fibre	13.34	0.08
Dry matter	89.64	0.45
Ether extracts	5.32	0.21
Moisture	10.36	0.05
Nitrogen free extracts	33.94	0.21
Total ash	7.13	0.04
ME (kcal kg^{-1})	2043.50	55.00

ME: Metabolizable energy

Table 7: Proximate composition of MOLM

Parameter	Dry matter (μg g^{-1})	Standard deviation
Apigenin	25.30	72.19
Chlorogenic acid	295.87	11.41
Kaempferol	51.23	1.86
Luteolin	45.36	2.02
Quercetin	48.49	1.80

Effect of dietary MOLM and season on feed intake: The effect of different levels of MOLM and season on daily feed intake is presented in Table 9. Different levels of MOLM had significant ($p<0.05$) effect on daily feed intake at 0-4, 5-8 and 17-20 weeks of age. Daily feed intake decreased with an increase in dietary MOLM. Birds fed with control diet (0% MOLM) showed the highest ($p<0.05$) daily feed intake throughout the experimental period followed by the birds fed with diet containing 12 and 9% MOLM. Birds fed with diet containing 15% MOLM showed the lowest daily feed intake.

There was a significant ($p<0.05$) effect of season on daily feed intake at 0-4, 5-8, 9-12, 17-20 and 21-24 weeks of age (Table 9). Daily feed intake at 0-4 weeks of age was the highest in the minor rainy season (August-November) and the lowest in the major rainy season (April-July).

Daily feed intake at 5-8, 9-12, 17-20 and 21-24 weeks of age was the highest in the major rainy season (April-July). However, the lowest daily feed intake was recorded in the dry season (December-March). Daily feed intake was significantly ($p<0.05$) affected by different levels of MOLM and season interaction at 0-4, 5-8 and 9-12 weeks of age (Table 9). However, daily feed intake at 13-16 and 17-24 weeks of age was not influenced ($p>0.05$) by the interaction effect. This means that the amount of feed consumed in a particular season depends on the level of MOLM in the diet. Birds raised in the minor rainy season and fed with the control diet consumed the highest feed at 0-4, 5-8 and 9-12 weeks of age and the lowest feed intake was observed among birds raised in the major rainy season and fed with diet containing 15% MOLM.

Table 8: Proximate composition and energy of experimental diets

Nutrient composition	0% MOLM	9% MOLM	12% MOLM	15% MOLM
Starter diet				
Ash (%)	15.470	15.770	15.890	15.960
Crude protein (%)	20.080	20.140	20.890	20.970
Crude fibre (%)	3.490	3.780	4.520	4.710
Moisture (%)	10.330	9.850	9.740	9.710
Ether extract (%)	3.720	3.190	2.940	2.750
DM (%)	92.900	92.240	91.170	91.450
ME (kca kg^{-1})	2841.400	2851.000	2876.000	2879.000
Grower diet				
Ash (%)	15.890	16.170	16.720	16.880
Crude protein (%)	16.040	16.070	16.440	16.480
Crude fibre (%)	3.430	3.490	3.550	3.560
Moisture (%)	10.450	10.030	10.010	9.960
Ether extract (%)	4.232	4.193	4.208	4.159
DM (%)	91.560	90.670	90.890	90.130
ME (kca kg^{-1})	2803.000	2809.000	2809.000	2819.000
Breeder diet				
Ash (%)	16.820	17.010	17.060	17.250
Crude protein (%)	14.550	14.650	14.690	14.700
Crude fibre (%)	3.840	3.890	3.920	3.980
Moisture (%)	10.160	10.080	9.890	9.830
Ether extract (%)	4.460	4.410	4.400	4.380
DM (%)	91.770	91.670	91.620	92.030
ME (kca kg^{-1})	2712.000	2710.000	2712.000	2744.000

DM: Dry matter and ME: Metabolizable energy

Table 9: Effect of dietary MOLM and season on daily feed intake (g bird^{-1} day^{-1})

Variables	0-4 weeks	5-8 weeks	9-12 weeks	13-16 weeks	17-20 weeks	21-24 weeks
***Moringa oleifera* leaf meal**						
0% MOLM	12.4700^{a}	29.3100^{a}	44.9400	50.4200	67.6700^{a}	95.630
9% MOLM	11.8000^{b}	26.3300^{c}	43.9100	50.5300	67.5900^{a}	95.120
12% MOLM	12.1000^{ab}	27.5700^{b}	44.2200	50.6800	65.4000^{b}	95.570
15% MOLM	11.1400^{c}	24.0100^{d}	43.5000	49.6900	65.2900^{b}	96.140
SEM	0.2030	0.2040	0.4240	0.3070	0.4170	1.060
p-value	0.0050	0.0010	0.1260	0.1260	0.0010	0.820
Season						
Major rainy season	11.2500^{c}	28.6900^{a}	45.7500^{a}	50.1800	67.2200^{ab}	96.660^{a}
Minor rainy season	12.4000^{ab}	26.3100^{b}	44.3400^{b}	50.1000	65.5400^{c}	95.860^{b}
Dry season	11.9800^{b}	25.4100^{c}	42.3400^{c}	50.7100	66.6900^{b}	94.320^{c}
SEM	0.1760	0.1770	0.3670	0.2660	0.3610	0.918
p-value	0.0020	0.0010	0.0010	0.2260	0.0080	0.046
Interaction						
Maj.R.S.*0% MOLM	12.6700^{a}	31.1900^{a}	46.7500^{a}	49.9700	69.0100	96.110
Maj.R.S.*9% MOLM	11.2200^{b}	29.9000^{b}	45.6200^{b}	50.1600	68.3900	96.020
Maj.R.S.*12% MOLM	11.0900^{b}	28.4300^{c}	45.2900^{b}	50.7400	65.9500	96.070
Maj.R.S.*15% MOLM	10.0400^{c}	23.5400^{g}	40.3300^{f}	49.8400	65.5500	96.940
Min.R.S.*0% MOLM	12.9700^{a}	28.6400^{c}	45.6700^{b}	50.6000	65.6400	95.430
Min.R.S.*9% MOLM	12.8100^{a}	24.9200^{f}	44.1300^{c}	50.0700	66.7100	95.620
Min.R.S.*12% MOLM	12.6100^{a}	28.1400^{c}	44.1400^{c}	50.7000	64.8000	95.270
Min.R.S.*15% MOLM	11.2200^{b}	25.2500^{e}	43.4100^{d}	49.0400	65.0300	95.340
Dry S.*0% MOLM	11.7900^{b}	28.1000^{c}	43.8100^{d}	50.6900	68.3400	95.630
Dry S. *9% MOLM	11.3800^{b}	24.1600^{f}	41.9900^{e}	51.3500	67.6700	95.120
Dry S. *12% MOLM	12.5900^{a}	26.1500^{d}	43.2400^{d}	50.6100	65.4400	95.170
Dry S. *15% MOLM	12.1800^{ab}	23.2500^{g}	46.7500^{f}	50.1900	65.2900	95.240
SEM	0.3520	0.3540	0.7350	0.5330	0.7230	1.201
p-value	0.0018	<.0001	0.0456	0.6712	0.5347	0.710

[abc]Means bearing different superscripts in the same column are significantly different (p<0.05), *Significant, ns: Not significant, %: Percentage, MOLM: Moringa leaf meal, S.E.M: Standard error of means, P: Probability of main effects, Dry S: Dry season, Maj. R. S.: Major rainy season and Min. R. S.: Minor rainy season

Table 10: Effect of dietary MOLM and season on body weight (g bird^{-1} day^{-1})

Variables	Day-old	4 weeks	8 weeks	12 weeks	16 weeks	20 weeks	24 weeks
***Moringa oleifera* leaf meal**							
0% MOLM	24.410	120.250	362.410^c	750.410	1084.080	1181.500	1576.580
9% MOLM	24.750	125.330	376.000^b	752.500	1106.080	1197.800	1590.500
12% MOLM	25.180	131.660	399.910^a	763.080	1118.750	1194.300	1608.910
15% MOLM	25.580	131.910	403.000^a	790.080	1134.500	1206.100	1605.500
SEM	0.431	3.343	9.655	11.496	14.533	13.240	13.029
p-value	0.280	0.055	0.015	0.075	0.113	0.326	0.290
Season							
Major rainy season	26.120^a	136.120^a	411.680^a	791.430^a	1145.310^a	1217.510^a	1639.750^a
Minor rainy season	24.930^b	128.310^a	391.750^a	751.000^b	1098.180^b	1185.110^b	1580.430^b
Dry season	23.810^c	117.430^b	352.560^b	749.620^b	1089.060^b	1182.210^b	1565.930^b
SEM	0.373	2.895	8.362	9.955	12.586	11.460	11.284
p-value	0.005	0.003	0.001	0.008	0.007	0.006	0.001

^{abc}Means bearing different superscripts in the same column are significantly different (p<0.05)

Effect of dietary MOLM and season on body weight: The effect of different levels of MOLM and season on body weight is shown in Table 10. Different inclusion levels of MOLM in the diet had significant (p<0.05) effect on body weight at 8 weeks of age. Body weight increased with an increase in dietary MOLM. Birds fed with diet containing 12 and 15% MOLM showed the highest similar (p>0.05) body weight followed by 9% MOLM inclusion level while, birds fed with the control diet showed the lowest body weight. Season had significant effect (p<0.05) on body weight throughout the period of study (Table 10). The highest (p<0.05) body weight at day-old, 4, 8, 12, 16, 20 and 24 weeks of age was observed in the major rainy season (April-July). This was followed by minor rainy season (August-November). However, the lowest body weight gain was recorded in the dry season (December- March). There was no significant (p>0.05) effect of season×different levels of MOLM interaction on body weight. Hence, figures were not presented.

Effect of dietary molm and season on body weight gain: Different inclusion levels of MOLM in the diet influenced (p<0.05) body weight gain at 5-8 weeks of age. Birds fed with diets containing 15% and 12% MOLM gained more weight than the others. Birds fed with diets containing 9 and 0% MOLM had similar (p>0.05) body weight gains (Table 11). There was significant (p<0.05) effect of season on body weight gain from day-old to 8 weeks of age (Table 11). Body weight gain at 1-4 and 5-8 weeks of age was the highest in the major rainy season (April-July), followed by the minor rainy season (August-November). However, the lowest body weight gain was recorded in the dry season (December-March). Interaction effects of all fixed factors on body weight gain were similar (p>0.05) (Table 11).

Effect of dietary MOLM and season on feed conversion ratio: The effect of different levels of MOLM and season on feed conversion ratio is presented in Table 12. Different inclusion levels of MOLM in the diet influenced (p<0.05) feed conversion ratio at 0-4 and 5-8 weeks of age. Birds fed with the control diet had the poorest feed conversion ability while the MOLM-based treatment groups had better feed conversion ability.

Seasonal variation had influence (p<0.05) on feed conversion ratio at 0–4 and 9–12 weeks of age (Table 12). From 0-4 weeks, the poorest (p<0.05) feed conversion ratio was observed in the dry season (December- March) and was followed by minor rainy season (August-November). The best feed conversion ratio at 0-4 weeks of age was recorded in the major rainy season (April-July). However, the reverse occurred from 9-12 weeks. There was no significant (p>0.05) effect of season×different levels of MOLM interaction on feed conversion ratio (Table 12).

Proximate composition of MOLM: Table 6 shows that moringa leaf meal had higher values for protein (28.91%) than those reported by Ogbe and Affiku[6] (17.01%) and Olugbemi *et al.*[13] (23%). However, similar results were reported by Ogbe and Affiku[6] (27.44%) and Kwafo *et al.*[4] (28.50%) but lower (30.65%) than those reported by Mutayoba *et al.*[14]. The obtained results confirmed that MOLM is a good source of protein in the diets of birds. The crude fibre value (13.34%) obtained in this study was lower (16.11%) than those reported by Kwafo *et al.*[4] but higher (13.05 and 10.59%) than those obtained by Abbas *et al.*[15]. According to the results of the present study the value for dry matter (89.64%) was lower (90.21) than those obtained by Kwafo *et al.*[4] but higher (86%) than those reported by Applegate *et al.*[16]. The values obtained for ether extracts (5.23%), moisture (10.36%), nitrogen free

Table 11: Effect of dietary MOLM and season on body weight gain (g bird^{-1} day^{-1})

Variables	0-4 weeks	5-8 weeks	9-12 weeks	13-16 weeks	17-20 weeks	21-24 weeks
***Moringa oleifera* leaf meal**						
0% MOLM	3.420	8.640^{b}	13.850	11.910	8.790	7.620
9% MOLM	3.590	8.950^{b}	13.440	12.620	8.650	6.870
12% MOLM	3.800	9.57^{0a}	12.970	12.700	8.750	7.380
15% MOLM	3.790	9.680^{a}	13.820	12.300	8.410	7.290
SEM	0.111	0.233	0.528	0.491	0.128	0.490
p-value	0.060	0.009	0.613	0.663	0.166	0.510
Season						
Major rainy season	3.92^{a}	9.840^{a}	13.560	12.630	8.830	7.080
Minor rainy season	3.69^{a}	9.400^{a}	12.830	12.390	8.610	6.890
Dry season	3.34^{b}	8.390^{b}	14.180	12.120	8.510	7.890
SEM	0.096	0.202	0.457	0.425	0.110	0.430
p-value	0.006	0.001	0.128	0.695	0.138	0.059
Interaction						
Maj.R.S.*0% MOLM	3.510	8.870	14.030	12.270	8.830	7.230
Maj.R.S.*9% MOLM	3.850	9.570	13.110	12.850	8.820	7.420
Maj.R.S.*12% MOLM	4.170	10.450	12.800	12.750	9.160	7.460
Maj.R.S.*15% MOLM	4.160	10.560	14.390	12.670	8.490	7.980
Min.R.S.*0% MOLM	3.650	9.230	12.870	11.810	8.850	7.250
Min.R.S.*9% MOLM	3.730	9.230	12.800	12.400	8.680	7.380
Min.R.S.*12% MOLM	3.690	9.440	12.860	12.730	8.500	7.600
Min.R.S.*15% MOLM	3.690	9.720	12.770	12.640	8.400	7.400
Dry S.*0% MOLM	3.090	7.840	14.660	11.660	8.690	7.690
Dry S.*9% MOLM	3.180	8.050	14.420	12.620	8.430	7.430
Dry S.*12% MOLM	3.550	8.830	13.240	12.620	8.590	7.190
Dry S.*15% MOLM	3.530	8.850	14.400	11.580	8.330	7.730
SEM	0.192	0.405	0.915	0.850	0.220	0.420
p-value	0.651	0.762	0.958	0.992	0.782	0.962

[abc]Means bearing different superscripts in the same column are significantly different ($p<0.05$), *Significant, ns: Not significant, %: Percentage, MOLM: Moringa leaf meal, S.E.M: Standard error of means, P: Probability of main effects, Dry S: Dry season, Maj. R. S.: Major rainy season and Min. R. S.: Minor rainy season

Table 12: Effect of dietary MOLM and season on feed conversion ratio

Variables	0-4 weeks	5-8 weeks	9-12 weeks	13-16 weeks	17-20 weeks	21-24 weeks
***Moringa oleifera* leaf meal**						
0% MOLM	3.6900^{a}	3.4200^{a}	3.2900	4.2900	2.070	2.030
9% MOLM	3.3300^{b}	2.9600^{b}	3.3000	4.0900	2.060	2.040
12% MOLM	3.2000^{c}	2.8900^{b}	3.4800	4.0700	2.060	2.030
15% MOLM	2.9700^{b}	2.4900^{c}	3.1900	4.1100	2.060	2.030
SEM	0.0800	0.0800	0.1200	0.1500	0.020	0.010
p-value	0.0010	0.0010	0.4370	0.7530	0.487	0.697
Season						
Major rainy season	2.9300^{c}	2.9700	3.4500^{a}	4.0400	2.020	2.020
Minor rainy season	3.3800^{b}	2.8100	3.4800^{a}	4.1200	2.070	2.030
Dry season	3.5900^{a}	3.0500	3.0100^{b}	4.2600	2.080	2.040
SEM	0.0700	0.0600	0.1100	0.1300	0.090	0.010
p-value	0.0010	0.0600	0.0080	0.5100	0.101	0.279
Interaction						
Maj.R.S.*0% MOLM	3.6500	3.5700	3.2900	4.1200	2.120	2.050
Maj.R.S.*9% MOLM	2.9900	3.1800	3.5100	3.9900	2.130	2.050
Maj.R.S.*12% MOLM	2.6600	2.7200	3.7100	4.0500	2.120	2.040
Maj.R.S.*15% MOLM	2.4100	2.4100	3.2800	4.0100	2.140	2.060
Min.R.S.*0% MOLM	3.6100	3.1200	3.5500	4.3400	2.150	2.010
Min.R.S.*9% MOLM	3.4300	2.7000	3.4500	4.1200	2.160	2.030
Min.R.S.*12% MOLM	3.4200	2.9900	3.4600	4.0700	2.120	2.040
Min.R.S.*15% MOLM	3.0500	2.4300	3.4800	3.9600	2.140	2.060
Dry S.*0% MOLM	3.8100	3.5900	3.0300	4.4100	2.160	2.030
Dry S.*9% MOLM	3.5700	3.0200	2.9400	4.1600	2.150	2.060
Dry S.*12% MOLM	3.5400	2.9600	3.2800	4.1000	2.170	2.020
Dry S.*15% MOLM	3.4400	2.6300	2.8000	4.3800	2.140	2.030
SEM	0.1400	0.1300	0.2200	0.2700	0.280	0.130
p-value	0.0565	0.1195	0.8798	0.9850	0.211	0.111

[abc]Means bearing different superscripts in the same column are significantly different ($p<0.05$), *Significant, ns: Not significant, %: Percentage, MOLM: Moringa leaf meal, S.E.M: Standard error of means, P: Probability of main effects, Dry S: Dry season, Maj. R. S.: Major rainy season and Min. R. S.: Minor rainy season

extracts (43.85%) and total ash (7.13%) were similar to values obtained in previous study[5]. The metabolizable energy value (2043.5 kcal kg^{-1}) obtained in this study was lower (2086.5 kcal kg^{-1}) than those reported by Ogbe and Affiku[6] and Olugbemi *et al.*[13] but higher (2024.43 MJ kg^{-1}) than those obtained by Kwafo *et al.*[4]. In this study, the proximate composition of the MOLM differed from that observed by other researchers could be due to age of plant, soil fertility and the season of harvest. The proximate compositions of MOLM observed in this study indicate that it could be used as feed ingredient[15].

Phytochemical properties of MOLM: In the current study, results of the phytochemical analysis are consistent with those reported by Valdez-Solana *et al.*[17] who observed high levels of chlorogenic acid (286.13$\pm$15.09 g g^{-1}), kaempferol (46.43$\pm$2.14 g g^{-1}), quercetin (46.18$\pm$0.6 g g^{-1}) and luteolin (44.56$\pm$2.03 g g^{-1}). The levels of phytochemicals observed in this study indicate that the levels of lipids in the liver and plasma were low and hence, will have little or no negative effect on the health status of the birds. Previous investigations have identified quercetin and kaempferol phytochemicals in MOLM[18]. Moringa leaves obtained from Ghana, Senegal and Zambia contain quercetin and kaempferol, traceable amounts of chlorogenic acid and derivatives[18]. Chlorogenic acid and its isomers are esters of quinic and caffeic acids that have abilities to inhibit oxidation, acute lung injury and also reduce plasma and liver lipids and obesity[17]. Abou Sekken[19] reported that the levels of phytochemical in moringa leaves influence the production of hormones.

Proximate composition of the experimental diets: The levels of crude protein in the formulated diets (Table 8) for the starter, grower and breeder were within the recommended levels for Guinea fowls[12,16]. These values fell within 21-23% for starters, 17-20% growers and 14-16% for pullets[12]. This implies that inclusion of MOLM in the diets of Guinea fowl increased the protein level in the diets. It was reflected in the study because the crude protein content of the experimental diet increased slightly as the inclusion of MOLM increased (Table 8).

Ether extract in the starter, grower and breeder diets showed a decreasing trend with increasing dietary MOLM. This is in agreement with the findings of Valdez-Solana *et al.*[17]. The decrease in ether extract levels could be attributed to a decrease in the inclusion levels of soya bean in the diets as soya bean is known to have a high fat content[4].

Crude fibre levels in the starter, grower and breeder diets showed an increasing trend in the test diets which was in contrast with the findings of Valdez-Solana *et al.*[17] but agrees with the report of Kwafo *et al.*[4]. The crude fibre value*s* in this study were below the recommended maximum levels at 5% for Okyere *et al.*[12] and thus, the feed had better crude fibre levels, because the higher the crude fibre content, the poorer the diet for Guinea fowls. The high level of crude fibre in the test diets was due to high fibre content of MOLM. Moisture and dry matter levels in the starter, grower and breeder diets showed a decreasing trend with increasing dietary MOLM which was in contrast with Mutayoba *et al.*[14] but corroborates with the reports of Kwafo *et al.*[4].

The energy value of the control diet in Table 8 was slightly lower than that of the test diets. The energy content of MOLM (Table 6) was observed to be high, which increased as MOLM levels were increased in the starter, grower and breeder diets[4]. In this study, with the control diet, birds showed the lowest fat, protein and carbohydrate levels resulting in the lowest energy level for growth. Feeding guinea fowls the control diet caused stunted growth and low production.

Effect of dietary MOLM and season on feed intake: From growth phase to sexual maturity, moringa leaf meal variation in the diet influenced daily feed intake. Increasing levels of MOLM in the diet decreased daily feed intake across the period. The significant variation observed in this study could be attributed to the high level of tannin in the test diets while the higher feed intake among birds fed with the control diets could be attributed to the absence of tannin[20]. Again, the reduction in feed intake with increasing levels of MOLM in the diet can be explained that, phytochemical properties such as apigenin, chlorogenic acid and quercetin inhibits the production of leptin which is known as the satiety hormone. Hence, leading to a reduction in feed intake.

There is a possibility that the higher feed intake in birds fed the control diet is due to the relatively low energy value of the starter diet, as reflected in the metabolizable energy value due to the absence of MOLM. Generally, birds consume more low-energy feed to satisfy their physiological requirement[21]. Among the test treatment groups, the reduction in daily feed intake could be due to better accessibility and efficient protein utilization[22]. The reduction in daily feed intake among the test treatment groups could be due to the higher levels of crude fibre with increasing levels of MOLM. This result is in agreement with the findings of Zanu *et al.*[23] who conducted an experiment to assess the possibilities of using moringa (*Moringa oleifera*) leaf meal as a partial substitute for fishmeal in broiler chicken diet. The authors observed that, mean daily feed intake reduced significantly ($p<0.05$) with increasing levels of MOLM at 5, 10, 15 and 20%, respectively. This result is supported by Juniar *et al.*[24] who reported similar effect of MOLM on broilers.

The highest feed intake was observed in the minor and major rainy season and the lowest in the dry season which indicate that more feed is required during the minor and major rainy seasons to generate heat in birds to maintain body temperature. In minor and major rainy seasons, when ambient temperature is low, the body demands a high amount of oxygen, low partial pressure of oxygen in the blood (hypoxemia) and higher metabolic rate (favours high feed intake). This finding is supported by Kingori[25] who reported that the environmental effect of high ambient temperature is a potential factor to reduce feed intake of chicken by 20%. The author further reported that, in the major rainy season the temperature is ranging from 15-27°C which is tolerable for layers to achieve maximum egg production.

Similarly, results of this study (feed intake) are supported by Talukder *et al.*[26] who observed that high temperature (above 27°C) affected feed consumption and egg weight while relative humidity has less impact on egg production and feed consumption. This result is in line with the observation made by Alves *et al.*[27] who reported higher feed intake in the minor rainy season.

Effect of dietary MOLM and season on body weight and body weight gain: The result of this study showed that body weight and body weight gain increased with increasing level of dietary MOLM up to 15%. This can be explained that MOLM contains high levels of crude protein, valine and phenylalanine (Table 10 and 11) which enhance rapid growth and development of muscles with small feed intake. The significant differences observed could also be explained that histidine, methionine and lysine in all the test treatment diets increased with increasing levels of MOLM up to 15% which are all essential for rapid growth of Guinea fowls.

The significant improvement in body weight gain observed in this study can be attributed to the high levels of arginine and valine in the moringa based diets. Arginine and valine act as antimicrobial agents that facilitate the establishment of beneficial bacteria in the gastrointestinal tract, as well as reinforce the competitive exclusion principle by inhibiting the colonization of pathogenic bacteria. In addition, arginine reduces water loss in the epithelial cells of the intestines and enhances the intestinal function in the absorption of water and nutrients thereby, promote rapid growth with higher body weight gain in Guinea fowls. In addition, alkaloids and phytic acids compounds modulate the metabolism process in relation to the absorption of nutrients through signal transduction pathways to promote body weight and body weight gain. Nutrient's augmentation in portal vein (specifically, glutamic acid, histidine and tryptophan) derived from the small intestine are adequate to stimulate tissue protein synthesis in birds, which promote rapid growth and development. This result is in agreement with the findings of Olugbemi *et al.*[13] who reported that body weight gain of broilers increased with increasing levels of MOLM in the diet. Results of the present study are also supported by Poku Jr. *et al.*[28] and Ashong and Brown[29] who used MOLM in the diet of broilers and reported a significant increase in body weight with increasing level of dietary MOLM up to 10%. Kakengi[17] reported a higher body weight of birds fed diet containing 10% MOLM, followed by 7.5 and 5%, respectively, while, the control treatment recorded the lowest body weight.

Body weight and body weight gain were influenced by season (April-July) where temperatures were relatively lower due to seasonal variation. Mean values for body weight and weight gain observed in this study is similar to those reported by Duodu *et al.*[1]. Alves *et al.*[27] reported that in relatively high temperature, birds lose considerable energy and trying to maintain their body temperature which physiologically affects growth as well as body weight and body weight gain. However, under moderate temperatures birds are able to utilize feed efficiently to attain higher body weight. Hot humid environment has significant effect on the body of birds and change the physiological activities including feed intake and body weight. Kyere *et al.*[2] reported that the body weight decreases as the temperature increases due to a reduction in tissue metabolism through adaptive physiological and biochemical mechanisms.

Effect of dietary MOLM and season on feed conversion ratio: Birds in the control group had the poorest feed conversion ability while the birds in the treatment groups had better feed conversion ability which is an indication that birds fed diet supplemented with MOLM converted feed mass into increased body mass more efficiently. As compared to the control diet, the diets supplemented with MOLM might have been more effective in terms of growth rates and weight gain because of their superior feed conversion ratio. Another reason is that there were high levels of valine, phenylalanine, lysine and methionine in the test diets due to the inclusion of MOLM, which were sufficient to meet the minimum nutrient requirements for Guinea fowl growth[19].

Roth[30] reported that, arginine regulates the serotonin synthesis by employing tryptophan and finally improved the feed conversion ratio. MOLM contained phytic acids and alkaloids which increased the serum amino acids such as arginine, phenylalanine and methionine in birds which promote feed conversion ratio. Alkaloids in MOLM strengthen the capacity to assimilate and absorb ingested protein and amino acids leading to better feed conversion ability. This result is supported by Kakengi *et al.*[18] who reported that birds fed diet supplemented with MOLM had better feed conversion ability as compared with the control treatment. Similar results were reported by other researchers[4,31] who reported that birds fed diet supplemented with MOLM had superior feed conversion ratio as compared to birds on the control treatment.

In the current study, the poorest feed conversion ability was recorded in the dry season (December- March) while the best feed conversion ability was recorded in the major rainy season (April-July). This indicated that heat stress reduced feed intake and utilization as nutrients were used for maintaining internal body temperature and physiological adjustment to heat stress (Table 12). A previous study showed that hot and cold periods exert detrimental effect on feed efficiency[32]. This result agrees with Kyere *et al.*[2] who reported that feed conversion ratio decreases with increasing temperature.

CONCLUSION AND RECOMMENDATION

This study concludes that feeding Guinea fowls with moringa leaf meal promotes better feed utilization and enhances rapid growth. Due to their higher feed conversion ability, guinea fowls raised in rainy seasons grow faster than their counterparts in the dry season. For rapid growth, early maturity and higher body weight of local Guinea fowls, 15% inclusion level for MOLM is recommended for farmers and breeders.

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