International Journal of Research in Agriculture and Forestry
Volume 5, Issue 11, 2018, PP 1-9
ISSN 2394-5907 (Print) & ISSN 2394-5915 (Online)

Response of Broiler Chickens to Different Levels *Moringa stenopetala* Leaf Meal as a Substitute for Noug Seed (Guizotia abyssinica) Cake on Growth Performance and Carcass Components

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Abstract

A study was conducted to investigate the effect of feeding Moringa stenopetala leaf meal (MSLM) as replacement of noug seed (Guizotia abyssinica) cake on the growth performance and carcass characteristics of broiler chickens. Two hundred unsexed chicks with equal mean weight were randomly allotted to five treatment diets with four replicates in a completely randomized design. The treatments were the control diet (T1) and diets containing MSLM at 5% (T2), 10% (T3), 15% (T4) and 20 % (T5) by completely replacing the noug seed cake. Feed offered and refused was determined on daily basis while body weight was collected on weekly basis. At the end of the experiment, one male and one female chicken per replicate were slaughtered to evaluate the carcass components. The results indicated that the crude protein and metabolizable energy contents of MSLM was higher than that of the noug seed cake, while crude fiber content was exceptionally higher in noug seed cake than MSLM. Chickens fed with T2, T2, T4 and T5 diets showed higher ($p<0.05$) body weight and gain along with lower FCR as compared to those fed with the control diet. The dressed carcass, dressing percentage and most of the dressed carcass components were ($p<0.05$) higher for chickens fed with T5, T4 and T3 diets as compared to those fed with T1 and T2. The effect of sex on all carcass components was significant indicating that males are heavier than females suggesting male birds are more beneficial for meat production than females. In conclusion, MSLM could be used as alternative source of protein in broiler nutrition by replacing noug seed cake upto 20% of the total ration in areas where noug seed cake is inaccessible or unaffordable by smallholder farmers.

Keywords: *Cobb 500 broiler chicks; Moringa stenopetala leaf; growth performance; feed intake; carcass characteristics*

Introduction

The livestock sector plays a significant economic role in most developing countries, and is essential for the food security of the rapidly growing populations. Ethiopia is believed to have the largest livestock population in Africa. This livestock sector has been contributing considerable portion to the economy of the country (CSA, 2016). It is eminent that livestock products and by-products in the form of meat, milk, honey, eggs, cheese, and butter supply the needed animal protein and related nutrients that contributes to the improvement of the nutritional status of the people. Livestock also plays an important role in providing export commodities, such as live animals, hides and skins to earn foreign exchanges to the country (CSA, 2016).

Poultry production, as one segment of livestock production, has a peculiar privilege to contribute to the sector to the national GDP. This is mainly due to their fast reproduction, short production cycle and high feed efficiency (Melesse, 2014). Poultry production especially broiler chicken production is an integral part to achieve sustainable and rapid production of high quality protein to meet up the increasing demand of the developing countries (Raji et al., 2014).

The growth and expansion of poultry in Ethiopia has been affected by many constraints, among which availability, quality, and cost of feed ingredients are the major ones. Prices of most conventional protein sources have considerably increased in recent times that it is becoming unaffordable to use them in poultry feeds. Hence, any attempt to improve commercial poultry production and increase its efficiency needs to focus on better utilization of the available unconventional feed resources. To this effect, investigation into the potential of some feed resources that are cheaper, locally available with better comparative nutritional value as the conventional protein and/or energy sources would be justifiable.

One possible source of cheap protein is the leaf meal of tropical legumes (Etalem et al., 2013). Due to their availability and relatively low cost, the incorporation of protein from leaf sources in diets of broilers has been becoming a common production practice (Onyimonyi and Onu, 2009; Melesse et al., 2011; 2013). Moringa tree is a multipurpose tree that is cultivated for both human food and animal feed in Southern Ethiopia. The studies conducted by Melesse et al. (2009; 2012) and Negesse et al., (2009) have indicated that the leaves are rich in protein in which the amino acid profiles are comparable to that of soybean meal. Both noug seed (*Guizotia abyssinica*) cake and Moringa stenopetala leaves contain comparable values of crude protein (noug seed cake 28-30% and stenopetala leaves 28-36%) on dry matter basis (Melesse et al., 2012, 2017; Negesse et al., 2009). However, they differ considerably in their crude fiber content being highest in noug seed cake (24.5%) compared to that of M. stenopetala leaves (9.6%; Melesse et al., 2017). Moreover, the *M. stenopetala* leaves are very rich in calcium (1.6-1.8% on DM basis) compared to that of noug seed cake (0.5%).

Noug seed cake is considered in Ethiopia as one of the most common protein sources in poultry nutrition (personal observation). However, the cost of noug cake has been consistently rising over the last decades making it inaccessible to smallholder poultry producers.

Moreover, due to its high crude fiber content, feeding high levels of the noug seed cake poses serious problems on the feed consumption and subsequently on the performance of chickens. Consequently, substituting the noug seed cake with other suitable cheap protein and calcium sources becomes justifiable in monogastric nutrition such as poultry.

The current study was thus designed to evaluate the nutritional potential of leaf meal prepared from M. stenopetala as alternative protein and mineral sources on growth performance and carcass components of commercial broilers by substituting the noug seed cake.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at Agarfa Agricultural and Technical, Vocational and Educational Training (ATVET) College Poultry Farm, which is situated between 70 17' N Latitude and 390 49' E Longitude. The lowest and highest altitude of the study site is 1000 and 3000 m above sea level, respectively. The minimum and maximum temperature is 10 ^{o}C and 25 ^{o}C, respectively. The average annual rainfall of the area based on 21-year meteorological data is 829 mm.

Moringa Stenopetala Leaf Meal Preparation

The Moringa stenopetala leaf was collected from the local farmers that grow the plant. The leaves were removed from the stem and then dried under the shade. During the drying process, regular turning of leaves was undertaken to prevent the possible growth of moulds The dried leaves were then ground using a commercial grinding mill to produce which is referred hereafter as *Moringa stenopetala* leaf meal (MSLM). The MSLM was then mixed with others processed feed ingredients by substituting noug seed cake at different levels.

Ingredients of the Experimental Diets

The dietary ingredients were composed of noug seed cake (*Guizotia abyssinica*), maize (white), wheat bran, soya bean meal (Glysine max), limestone, mature Moringa leaves, dicalcium phosphate (DCP), common salt, vitamin premix, lysine and methionine (Table1).

All ingredients were purchased from the local market. Except, nitamin premix and limiting amino acids, al other feed ingredients were milled with 5 mm sieve size. All ingredients were then mixed according to the formulated experimental diets. Moreover, representative samples from each treatment diets were taken for the determination chemical and mineral compositions.

Experimental Design

The experiment was arranged in a Completely Randomized Design (CRD) with five dietary treatments replicated four times each with 10 birds. After having results on chemical and mineral analysis of each feed ingredients, five experimental diets were formulated to contain MSLM at0% (treatment 1 = T1), 5% (treatment 2 = T2), 10% (treatment3 = T3), 15% (treatment 4 = T4) and 20% (treatment 5 = T5) by substituting noug seed cake of the control diet.

Table1. *Proportion of feed ingredients used to formulate the ration (%, DM)*

Feed ingredients%	T1	T2	T3	T4	T5
Maize	37	37	37	37	37
Noug seed cake	20	15	10	5.0	0.0
Wheat bran	14.2	14.2	14.2	14.2	14.2
Soya bean meal	24.5	24.5	24.5	24.5	24.5
Moringa stenopetala leaf meal	0.0	5.0	10	15	20
Limestone	2.0	2.0	2.0	2.0	2.0
Salt	0.5	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5	0.5
Lysine	0.8	0.8	0.8	0.8	0.8
Methionine	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

T1 = control diet without Moringa stenopetala leaf meal; T2 = treatment diet containing Moringa stenopetala leaf meal of 5%; T3 = treatment diet containing Moringa stenopetala leaf meal at a rate of 10 %; T4 = treatment diet containing Moringa stenopetala leaf meal at a rate of 15%; T5 = treatment diet containing Moringa stenopetala leaf meal at a rate of 20%

Chickens and Their Management

The experiment was initially conducted using three hundred day-old Cobb-500 broiler chicks which were purchased from Alema Poultry Farm private limited company, located at Debre Zeit City, Ethiopia. The chicks were vaccinated against Marek's disease, Newcastle disease (HB1 strain) and Infectious bursa Gumboro (IBDV). Moreover, anti-coccidiosis (20-40 g/100 l of water), Oxy tetracycline (20 g/100 l of water) and multivitamin were given with drinking water when clinical symptoms were observed. The chicks were reared in the brooder house for two weeks at the experimental site and placed on commercial starter ration along with small quantities of measured MSLM to make them adapt to the experiment feed. At the end of adaptation period, two hundred day-old Cobb-500 broiler chicks were randomly selected, weighed individually on a digital balance and transferred into the experimental pens. Then after the chicks were divided in to five treatment groups of 40 chicks each and randomly allotted to the 5 treatment diets. Each treatment group was further sub categorised in to 4 replications each with 10 chicks. Chickens in each replication were reared in a 1.0 m x 2.0 m wire mesh partitioned pens. The pens were initially cleaned and disinfected with potassium per manganeze plus 37% formalin before the arrival of chicks. Each pen was equipped with feeder and waterer. The floor was covered with wood shavings at a depth of about 5 cm. The experimental feed was offered twice a day at 8:30 am and 5:30 pm throughout the experimental period. Water was provided ad libitum. The house environment and other related things were monitored as necessary. The experiment period lasted for 40 days.

Data Collection Protocols

Feed Intake and Body Weight

Chicks were fed on replicate basis and each day a measured amount of feed was offered in the morning (between 7.00 and 8.00 am) and late afternoon (between 4.00 and 5.00 pm) and refusals were always collected and weighed in the morning of the following day before feed is offered. The amount of feed was increased keeping in mind that at the end at least 10% refusal is left. Feed intake on group basis was then computed by subtracting the feed refusal from that of feed offered. Body weight was taken at the beginning of the experiment (considered as initial weight) and then on weekly basis between 7:00 and 8:00 am before feed is offered. The body weight taken at the end of the experiment was considered as final body weight. Total body weight gain was then computed by subtracting the initial body weight from the final. Feed conversion ratio (FCR) was calculated by dividing the total feed intake by total weight gain.

Carcass Components

At the end of the experimental period, two chickens (1 male and 1 female) per replicate (in total 40 chickens) were picked and kept in a separate pen without feed. After overnight fasting, each bird was weighed (considered as pre-slaughter weight) and manually eviscerated. The dressed carcass weight was taken after defeathering and removal of feet, head and the viscera while the skin was included. The dressed carcass, breast, thighs, drumsticks and keel bone were weighed inclusive of bones. The wings were removed by a cut through the shoulder joint at the proximal end of humerus. The thigh and drumstick portions were obtained by cutting through the joint between the femur and ilium bone of the pelvic girdle. The drumstick was separated from the thigh by a cut through the joint formed by the femur, fibula and tibia. The dressing percentage was calculated from dressed carcass weight as a percentage of the slaughter weight. The carcass analysis in this study included only those edible components of the carcass as the chickens used in this experiments are the commercial broilers.

Chemical Analysis

Representative samples of the feed ingredients, the treatment rations, and refusal feed were dried in an oven at 60 oC for 48 hours and ground to pass through 1 mm mesh screen and stored in air tight bags until used for laboratory chemical analysis. Analyses of proximate nutrients were performed as outlined by AOAC (1995). Prepared samples were then analyzed for dry matter (DM, method 950.46), ether extract (EE, method 920.39), crude fibre (CF, method 962.09) and ash (method 942.05). The crude protein (CP) was assessed using Kjeldahl procedure (AOAC, 1995, method 954.01) and the nitrogen content was multiplied by 6.25 to obtain the CP. The metabolizable energy (ME) of diets was estimated by indirect method according to Wiseman (1987) using the following formula: ME (kcal/kg DM) = 3951 + (54.4 * EE) – (88.7*CF) – (40.8*Ash). All the samples were analyzed in duplicates at Animal Nutrition Laboratory of Hawassa University.

Statistical Analysis

Data from feed intake, body weight, weight gain, and feed conversion ratio were subjected to one-way ANOVA by fitting treatment diet effect as independent variable. Data on carcass components were subjected to two-way ANOVA by fitting the effects of treatment diets and sex as fixed factors. All data were analyzed using the General Linear Model (GLM) Procedures of SAS ver. 9.4 (SAS, 2012). Means were then separated using Duncan's multiple range tests. Treatment differences were considered significant at the $P<0.05$ level unless noted otherwise. The following statistical models were used to analyze the data:

ANOVA Model 1 (Feed Intake, Body Weight, Weight Gain and FCR)

$Y_{ij} = \mu + T_i + e_{ij}$, where:
Y_{ij} = the observed j variable in the ith treatment
μ = overall mean of the response variable
T_i = the effect due to the ith M. stenopetala leaf meal level (i = 1, 2, 3, 4, 5)
e_{ij} = random residual error

Anova Model 2 (Carcass Components)

$Y_{ijk} = \mu + T_i + S_j + T_i{*}S_j + e_{ijk}$, where:
Y_{ijk} = the observed k variable in the ith treatment and jth sex
μ = overall mean of the observed variable
T_i = effect due to ith treatment levels (i = 1, 2, 3, 4, 5)
S_j = effect due to jth sex of chickens (j = male and female)
$T_i{*}S_j$ = effect due to the interaction between ith treatment and jth sex
e_{ijk} = random residual error

Results And Discussion

Chemical Compositions of Moringa Stenopetala

Nutrients composition of feed ingredients and treatment diets are presented in Table 2. The CP and ME contents of MSLM was comparatively higher than noug seed cake. The CF content of noug seed cake was, however, exceptionally higher than MSLM, which consequently has resulted in high level of fiber in the control diet. The supplied level of CF in broilers ration should not be higher than 5% for optimum feed consumption and growth performances. The relative low CF content of MSLM used in the current study might be due to stage of harvest in which case leaves were collected at the early stage of the plant.The CP and estimated ME contents of MSLM in this study can be considered as good sources of broiler feed. The calculated ME values appeared to be higher than required by the broiler chickens. This could be explained by the fact that the adopted equation from Wiseman (1987) might have overestimated the ME values. Other scholars in the previous studies have also noted similar overestimations (Emshaw et al., 2012). The CP and ME concentrations in MSLM are comparable to those reported by Melesse et al. (2011) (30.6% and 2992 kcal/kg respectively). However, the

CP content of MSLM in the present study is higher than reported by Moyo et al. (2011) and Melesse et al. (2012) for Moringa oleifera. Negesse et al. (2009) reported 36.1% CP for Moringa stenopetala leaf, which was exceptionally higher than observed in the current study. The ash content of MSLM (11.3%) in the present study was comparable to that of Alem (2014), who reported 12.2% on DM basis. However, Melesse et al. (2011) reported higher value of 14.8% ash in the leaves of Moringa stenopetala. The observed differences in nutrient compositions might be due to difference in plant's growing environment, species difference, sample harvesting stage and processing.

Table 2. *Chemical composition of M. stenopetala leaves, feed ingredients,starter and treatment diets(%DM basis)*

Feed ingredients	Ash	CP	CF	EE	ME(kcal/kg DM)
Maize	2.13	10.7	2.70	5.53	3925
Noug seed cake	12.2	28.3	23.5	1.46	1448
Soybean meal	6.22	37.9	5.50	8.04	3647
Wheat bran	3.85	17.4	7.93	2.69	3237
MSLM	11.3	31.6	6.75	5.43	3187
Starter ration	5.54	22. 0	6.64	5.92	3458
T1	9.06	19.6	8.03	4.85	3136
T2	8.91	20.0	7.54	5.07	3194
T3	8.22	20.4	6.72	5.62	3325
T4	8.51	21.0	5.86	6.25	3424
T5	8.93	21.5	5.25	6.81	3491

CP = crude protein; EE = ether extract; CF = crude fiber; ME = metabolizable energy; MSLM = Moringa stenopetala leaf meal

Table 3. *Feed intake, growth performances (g/bird) and feed conversion ratio (g feed / g body weight gain) of Cobb-500 broiler chicks fed with M. stenopetala leaf meal by substituting noug seed cake*

Parameters	T1	T2	T3	T4	T5	SEM	P-value
Initial body weight	319	318	319	319	318	1.02	0.950
Final body weight	2203^{d}	2313^{c}	2420^{b}	2508^{b}	2600^{a}	18.2	<.0001
Total weight gain	1884^{d}	1995^{c}	2101^{b}	2189^{a}	2282^{a}	18.9	<.0001
Daily weight gain	47.1^{d}	49.9^{c}	52.5^{b}	54.7^{b}	57.1^{a}	3.24	<.0001
Average daily feed intake	115^{c}	119^{b}	122^{b}	119^{b}	119^{b}	1.40	0.001
Feed conversion ratio	2.44^{a}	2.38^{ab}	2.31^{b}	2.17^{c}	2.08^{c}	0.05	0.004

$^{a-d}$ Means within the same row bearing different superscript letters are significant at $p<0.05$; SEM = standard error of the mean

Feed Consumption, Body Weight and Weight Gain

Feed intake of broiler chickens fed different levels of MSLM during the experimental period is presented in Table 3. Replacement of noug seed cake by MSLM at inclusion levels of 5%, 10%,15% and 20% appeared to have positively affected the feed intake of broilers. As a result, there was ($p<0.05$) difference in feed intake among treatment diets. Chickens reared in treatment diets showed ($p<0.05$) higher feed intake as compared to those of T1.

The highest feed consumption in treatment diets could be attributed to the palatability of the feed due to MSLM, which has lower crude fiber content than noug seed cake. These findings are consistent with those of Gakuya et al. (2014), Who reported that increased levels of Moringa oleifera leaf meal did not affect the feed intake of chickens. On the other hand, Ayssiwede et al. (2011) reported that at higher levels of Moringa oleifera leaf meal inclusion (16% and 24%) reduced the feed intake of Tanzanian local chickens. It has been further speculated that the presence of anti-nutritional factors and phytochemical compounds present in Moringa oleifrea leaf meal might have been responsible for decreased feed intake of chickens (Onunkwo and George, 2015). Nevertheless, recent studies conducted by Melesse et al. (2017) indicated that Moringa stenopetala leaf to contain negligible anti-nutritional factors. They reported (g/kg DM) 30.5, 22.5 and 3.0 total phenols, non-tannin phenols and soluble condensed tannins, respectively. As presented in Table 4, the concentration of almost all essential amino acids in MSLM was comparatively higher than those found in noug seed cake. The protein of MSLM is notably rich in tryptophan, methionine and threonnine compared to soybean meal. The highest concentration of lysine as a limiting amino acid as well as other essential amino acids in MSLM might have contributed to the observed improved body weight, weight gain and FCR of broilers compared to those on the control diet.

Moreover, there is a major difference in ME content of MSLM and noug seed cake. The ME content of MSLM is exceptionally higher (2818 kcal/ kg DM; Melesse et al., 2017) than found in noug seed cake (1767 kcal/kg DM, Melesse et al., unpublished data). This has been reflected in the ME content of the formulated treatment diets in which the energy content has increased linearly with increasing substitution levels of noug seed cake with MSLM.

Table 4. *Concentration of essential amino acids in soybean meal and noug seed (Guizotia abyssinica) cake (g/16g N) compared to Moringa stenopetala leaves*

Amino acids	Soybean meal[a]	*M. stenopetala* leaves[b]	Noug seed cake[c]
Methionine	1.22	1.71	1.75
Cysteine	1.70	2.04	2.01
Valine	4.59	5.34	4.18
Leucine	7.72	8.50	6.29
Phenylalanine	4.84	5.27	4.36
Threonnine	3.76	4.45	3.25
Tryptophan	1.24	1.54	-
Isolucine	4.62	4.47	3.39
Lysine	6.08	5.68	3.44
Arginine	7.13	6.40	8.54

Source: [a]Hossain and Becker (2001); [b]Melesse et al. (2009); [c]Melesse et al. (unpublished data)

The observed decrease in weight gain of birds fed T1 diet as compared to other treatments diet may be due to higher crude fiber content due to noug seed cake, which may impair nutrient digestion and absorption protein content of the diet. Feeds containing high level of crude fiber are nutritionally poor in compounding poultry ration.In agreement with our observations, Okafor, et al. (2014) reported that 20 % inclusion level of Moringa olfeifera leaf in broiler diets improved the performance of the chicks. The findings of Juniar et al. (2008) and Onunkwo and George (2015 revealed that the inclusion of Moringa oleifera leaf meal up to 10% did not produce significant effects on feed consumption, body weight, feed conversion ratio, carcass weight and production efficiency.

Carcass Components

The evaluation of carcass quality of broiler chickens is a very important segment in production and marketing of poultry products. Carcass characteristics are the main tool to evaluate the quality of carcass (Nikolova and Bogosavljević-Bošković, 2011). Consumers prefer chickens with high yield of noble parts, such as breast muscle, drumsticks, and thighs (Faria et al., 2010).

The effect of feeding various levels of MSLM on main carcass parameters has been shown in Table 5. Dressing percentage and most dressed carcasses were ($p<0.05$) higher for chickens fed with T5, T4 and T3 diets as compared to those fed with T1. In agreement with the current findings, Ayssiwede et al. (2011) reported no adverse effect on carcass characteristics up to 24% inclusion of Moring oleifera leaf meal in the diet of growing indigenous Senegal chickens. These findings are further in good agreement with that of Safa (2012), who reported that inclusion of Moringa oleifera leaf meal in broiler diets significantly improved dressed carcass weight, dressing percentage, breast meat, and drumsticks. Replacing of 20% MSLM for noug seed cake in broiler ration considerably increased yield of most carcass characteristics in the current study, which might be because of increased levels of CP and ME in T5. In contrast, Onunkwo and George (2015) reported that utilization of Moringa oleifera leaf meal in broiler diet had no influence on the organ proportion of poultry. Etalem et al. (2013) reported that Moringa oleifera leaf meal substitutions for soybean meal in broilers ration reduced yield of most carcass characteristics. Such variations in the literature might be attributed to the type of chicken breed used, method of ration formulation and the environment in which birds were tested. The result of the current study implies that inclusion of MSLM up to 20% did not produce any significant effect to the normal function of liver in broiler chickens. This finding is similar with the reports of Debersac et al. (2001) who indicated that a plant extract from rosemary enhanced hepatic metabolism and hence, increased relative liver weights in rats. The similarity in gizzard weight across the treatment diets suggests that birds have received adequate energy level from all the dietary treatments. According to Rodgers et al. (2012), birds given first access to fiber-rich diets take time to adapt to the feed. However, this changes once the gizzard has developed properly, allowing birds to take full advantage of coarse feeds, thereby increasing their energy utilization efficiency. This phenomenon has been reflected in those chickens fed with the control diet, which had relatively higher crude fiber content due to noug seed cake. As presented in Table 5, except back bone and heart, the effect of sex on all carcass components was significant indicating that male birds were heavier than females, which suggests using male birds could be more beneficial than rearing females. These findings are consistent with the findings of Melesse et al. (2013) for Koekeok chickens fed with different levels of Moringa stenopetala leaf meals by replacing roasted soybean. Similarly, Lidetewold et al. (2016) reported that slaughter weight, drumsticks, thighs, breast muscle, commercial carcass, and total edible weight of male chickens were significantly heavier than the female counter parts of Cobb-500 broilers.

Table 5. *Effect of treatment, sex and their interactions on carcass components of Cobb-500 broiler chicks fed with Moringa stenopetala leaf meal by replacing noug seed cake (g)*

Carcass components	T1	T2	T3	T4	T5	SEM	Sources of variations		
							Treatment(Trt)	Sex	Trt*Sx
Slaughter weight	2113^{b}	2208^{b}	2323^{ab}	2430^{a}	2435^{a}	54.1	0.045	0.0024	0.9203
Dressed carcass	1398^{c}	1508^{bc}	1554^{b}	1746^{a}	1714^{a}	46.3	<.0001	<.0001	0.1044
Dressing percentage	66.2	68.3	66.9	71.9	70.4	2.65	0.073	0.0333	0.4304
Breast meat	329^{b}	423^{a}	357^{b}	435^{a}	355^{b}	20.8	0.003	0.0002	0.6929
Thigh	197^{b}	245^{a}	239^{a}	251^{a}	220^{b}	11.1	0.015	0.0034	0.0794
Drumstick	155^{c}	211^{ab}	186^{b}	193^{ab}	227^{a}	9.53	0.0001	<0.0001	0.0589
Keel bone meat	169^{c}	193^{ab}	175^{bc}	192^{ab}	202^{a}	6.72	0.008	<0.0001	0.0009
Neck	67.5	74.7	71.5	70.8	68.9	4.06	0.743	<.0001	0.0483
Back bone	137^{b}	143^{b}	165^{a}	158^{a}	168^{a}	5.74	0.0061	0.3939	0.0113
Wing	71.1	76.4	78.9	75.3	70.8	2.65	0.150	<.0001	0.7332
Liver	44.9^{b}	42.1^{b}	43.0^{b}	50.8^{a}	51.1^{a}	1.83	0.002	<.0001	0.2734
Gizzard	43.8	46.8	44.3	42.5	43.3	1.84	0.544	<.0001	0.0007
Heart	12.0	14.6	13.6	11.4	12. 8	1.05	0.208	0.1026	0.3292

$^{a-d}$ Row means within the same category with different superscripts letters are significant at $p<0.05$; SEM= standard error of the mean

This sex difference might be attributed to the presence of sex hormone (androgen) in males that enhanced muscle development than the sex hormone (estrogen) in females, which is mostly responsible for fat deposition rather than muscle tissue development. Moreover, the difference between male and females in carcass traits might be due to increased feed intake of males than those of females, which enable them to grow faster than females as suggested by Donald and William (2002).

The interaction of treatment by sex was only significant for keel bone meat, neck, back bone and gizzard, which suggest the existence of association between these traits in both sexes to express them.

CONCLUSION

Chickens fed with increasing levels of MSLM diets appeared to have better performances in body weight, average feed intake, and gain as compared to those of other treatment diets. The feed conversion ratio and most common carcass parameters were better in those chickens fed with MSLM than those of the control diet. It is thus recommended to replace noug seed cake with MSLM as suitable option for improved productivity of broiler chickens in areas where noug seed is not available or unaffordable due to high prices.

ACKNOWLEDGEMENTS

This research project was fully supported by the research fund granted by Agarfa Agricultural and Technical, Vocational and Educational Training College and Niche Project for which the authors are highly grateful.

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Citation: *Cheru Tesfaye, Aberra Melesse , Aster Abebe.“ Response of Broiler Chickens to Different Levels Moringa Stenopetala Leaf Meal as a Substitute for Noug Seed (Guizotia Abyssinica) Cake on Growth Performance and Carcass Components” International Journal of Research in Agriculture and Forestry, 5(11),pp 1-9.*