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Effects of Feeding Different Dietary Levels of *Moringa oleifera* Leaf Meal on Egg Production, Fertility and Hatchability of Dual Purpose Koekoek Hens

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Abstract: A study was conducted to evaluate effects of Moringa oleifera leaf meal (MOLM) substitution to soybean meal in layers ration on egg laying performance, fertility and hatchability of dual purpose Koekoek hens. For the study, ninety six hens, aging 41 weeks and 12 cocks were used and equally divided into four dietary treatments with three replications. Treatment rations contained MOLM [i.e., T_1 (0% MOLM), T_2 (5% MOLM), T_3 (10% MOLM) and T_4 (15% MOLM)]. Hens were weighed at the start and end of the experiment and body weight (BW) change was calculated. Data on feed intake, hen-day egg production, hen-housed egg production and egg weight were recorded daily. Fertility and hatchability of eggs, chick quality as well as mortality of birds and embryonic mortality of fertile eggs during the incubation period were also recorded. All the above mentioned parameters were improved by the experimental diet except late embryonic mortality which was high for T_2. Body weight change was 0.32kg in T_1, 0.43kg in T_2, 0.48kg in T_3 and 0.37kg in T_4. Feed conversion ratio was 1.73 in T_1, 2.10 in T_2, 1.52 in T_3 and 1.59 in T_4. Average egg weight was 48.66gm in T_1, 54.51gm in T_2, 49.94gm in T_3 and 50.31gm in T_4. Percentage of hen-day egg production was 50.69% in T_1, 64.60% in T_2, 45.23% in T_3 and 47.65% in T_4. Fertility percentage was 80.00% in T_1, 93.33% in T_2, 91.11% in T_3 and 84.44% in T_4. Hatchability percentage was 66.66% in T_1, 78.57% in T_2, 68.22% in T_3 and 70.33% in T_4. Higher feed intake and body weight change were recorded for T_3 (10% MOLM).

Key words: Body weight change · Chick quality · Feed intake · Egg production · Fertility and hatchability

INTRODUCTION

Protein supplementation is often important to improve poultry performance and this needs to be done with respect to their requirements in addition to the balance of other nutrients available. The expansion of poultry industry depends largely on the availability of good quality feed in sufficient quantities and at prices affordable to both producers and consumers (Odunsi, 2003)[1]. This is very important especially for layers which are very sensitive to nutrition such that inadequacies in nutrient supply often lead to fall in egg production and even cessation of lay (Adenjimi *et al.,* 2011)[2]. With the present trend of rising prices of feed ingredients, there has been a search for non-conventional feedstuffs with potentials of improving poultry performance. Of such non-conventional feed sources, leaf protein sources have been reported (Farinu *et al.,* 2008)[3].

One possible source of cheap protein feed is the leaf meal of some tropical legume browse plants. Leaf meals do not only provide protein source but also some essential vitamins such as vitamins A, C, E (Sanchez-Machado *et al.*, 2006; Moyo *et al.*, 2011) [4]and iron and the two amino acids generally deficient in other feeds, i.e., methionine and cystine (Makkar and Becker, 1996[4]; Moyo *et al.,* 2011)[5] minerals and oxycarotenoids (Bhatt and Sharma, 2001[6]; Muriu *et al*., 2002)[7]. It is also claimed that leaf meals increase poultry productivity as nutritional, therapeutic and prophylactic properties. Among the leaf meals *M. oleifera* leaf meal is the one which has the above mentioned nutritional and medicinal values (Fahey, 2005)[8].

The high pepsin soluble nitrogen (82-91%) and the low acid detergent insoluble protein (1-2%) values for the moringa leaf meal suggest that most of the protein in the meal is available to most animals (Makkar and

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Becker, 1997). *M. oleifera* leaves have a negligible content of tannins and have no trypsin and amylase inhibitors or cyanogenic glucosides (Makkar and Becker, 1996; Makkar and Becker, 1997). Recently, there has been interest in the utilization of moringa (*M. oleifera*) as a protein source for poultry. Moringa leaves have quality attributes that make it a potential replacement for soybean meal or fish meal in non-ruminant diets. Moringa can easily be established in the field, has good coppicing ability, as well as good potential for forage production.

The advantages of using moringa as a protein resource are numerous and include the fact that it is a perennial plant that can be harvested several times in one growing season and also has the potential to reduce feed cost (Sarwatt*et al*., 2004)[9]. *M. oleifera* leaf meal (MOLM) could replace sunflower seed meal and can be added up to 20% in layers ration (Kakengi*et al*., 2007) [10].

Despite the high nutritional content of *M. oleifera*, there is little information regarding its utilization in poultry feeding as a protein source in the layer ration. As a result, information on effects of feeding *M. oleifera* leaf meal (MOLM) on laying performance or, egg production, fertility and hatchability in chicken is scanty. Such information is needed in designing feeding strategies to improve performances of chicken in resource limited farmers. This is even more crucial for small-scale farmers undertaking farm-based feed formulation, who constantly find it hard to produce with commercial feeds.

Therefore, the objective of this study was to determine:

- Effects of feeding varied dietary levels of *M. oleifera* leaf meal (MOLM) on feed intake, body weight change and feed conversion ratio,
- Effects of feeding MOLM on production, fertility and hatchability of eggs and chick quality; and,
- To evaluate the economic feasibility of substituting SBM by MOLM at different levels in dual purpose Koekoek hens' performance.

MATERIALS AND METHODS

Animals, Experimental Design and Treatments: The experiment was conducted at Debre Zeit Agricultural Research Center (DZARC), located at an altitude of 1900 meters above sea level (8°44'N, 38°38'E) (DZARC, 2003). For this study, a total of ninety-six, 41 weeks old, hens and 12 cocks Koekoek dual purpose breed were equally divided into four dietary treatments with three replications. Birds were sourced from DZARC poultry farm. Twenty four hens and 3 cocks were used in each dietary treatment, which were further divided into three groups of eight hens and one cock. Nine birds were randomly assigned to one of the 12 pens. Feed ingredients used in the formulation of the experimental rations for the study were corn grain, wheat middling, nougseed cake, SBM, MOLM, vitamin-mineral premix, salt, limestone, lysine and methionine (Table 3).

Leaf was harvested from young *M. oleifera* trees of about five years of age from an orchard found in DZARC poultry farm. The harvested leaves from the tree were spread out on a concrete floor and allowed to dry for a period of four days under shade and aerated conditions then run through a hammer mill sieve with a size of 5 mm to produce the leaf meal. All the ingredients, except wheat middling, SBM, vitamin-mineral premix, lysine and methionine were also milled in sieve size of 5 mm and stored until required for the formulation of experimental rations. Based on the chemical analysis result (Table 1), 4 treatment rations (i.e., T_1= diet containing 0% MOLM; T_2= diet containing 5% MOLM; T_3 = diet containing 10% MOLM; and T_4= diet containing 15% MOLM) was formulated to which MOLM substitutes SBM. Treatment rations were formulated to be nearly isocaloric and isonitrogenous (Table 2), to meet the minimum ME of 2750 kcal/kg of DM and 16.5% of CP.

Management of Experimental Birds: A wire mesh partitioned deep litter floor house covered with disinfected *Teff* straw litter material was used. Before the commencement of the actual experiment, the experimental pens, watering and feeding troughs and laying nests were thoroughly cleaned, disinfected and sprayed against external parasites. Hens were vaccinated against Newcastle, Gumboro (Infectious Bursal Disease), fowl typhoid and fowl pox diseases. Birds were offered the experimental ration at 130 g/bird per day in a round feeder and clean water was available at all times in a plastic fountain. Fluorescent lamp was placed for the lighting and birds were adapted to respective treatment diets for a week before the commencement of the actual data collection.

Measurements: The experimental period lasted for 12 weeks during which the amount feed offered to and refused from birds per pen was recorded daily. Hens were weighed at the start and end of the experiment and body weight (BW) change was calculated as the difference between the final and initial BW. Feed conversion ratio (FCR) was determined as a unit egg weight per unit feed consumed. Mortality was registered as it occurred.

Table 1: Chemical composition of feed ingredients used in the formulation of the experimental rations

Ingredients	Corn grain	Wheat middling	Soybean meal	Nougseed cake	MOLM[6]
[1]DM (%)	91.8	92.1	93.8	91.6	86.9
[2]CP (%DM)	8.3	19.8	39.8	33.8	28.2
[3]CF (%DM)	3.1	8.5	6.9	18.1	6.5
[4]EE (%DM)	4.3	5.0	6.8	7.3	6.6
Ash (%DM)	3.4	3.9	6.1	10.5	11.9
[5]ME (Kcal/kg DM)	3470	3130	3498	2430	3247
Calcium (%DM)	0.04	0.12	0.30	0.28	0.76
Phosphorus (%DM)	0.30	1.12	0.68	0.67	0.35
Beta carotene(mg/100g)	-	-	-	-	14.60

[1]dry matter, [2]crude proteins, [3]crude fibers, [4]ether extract, [5]metabolizable energy, [6]*Moringa oleifera* leaf meal.

Table 2: Proportion (%) of ingredients used for formulating experimental diets

	Treatment			
Ingredient (%)	T_1	T_2	T_3	T_4
Corn grain	62	61	57.8	52.8
Wheat middling	7.3	2.3	2	5
Noug seedcake	5.5	11.5	15	17
SBM	18.0	13.0	8.0	3.0
MOLM	0.0	5.0	10.0	15.0
Vitamin premix	0.5	0.5	0.5	0.5
Salt	0.3	0.3	0.3	0.3
Limestone	6	6	6	6
Methionine	0.1	0.1	0.1	0.1
Lysine	0.3	0.3	0.3	0.3
Total %	100	100	100	100
CP%	16.56	16.60	16.62	16.63
DM %	89.48	89.56	89.60	89.68
Ash (% DM)	8.93	9.20	10.90	10.97
EE (% DM)	6.55	7.14	7.26	7.34
CF (% DM)	6.14	7.05	7.20	7.26
ME (kcal/kg DM)	2759	2765	2767	2769
Calcium (% DM)	3.35	3.43	3.46	3.44
Phosphorus (% DM)	0.40	0.41	0.43	0.45

MOLM: *Moringa oleifera* leaf meal; SBM: soybean meal; T_1: No MOLM inclusion; T_2: 5%; T_3: 10%; T_4: 15% MOLM of the total ration substituting SBM; CP: Crude Protein; DM: Dry Matter, EE: ether extract, CF: crude fiber.

Eggs were collected three times a day from each pen at 0800, 1300 and 1700 hours. The sum of the three collections along with the number of birds alive on each day was recorded and summarized at the end of the period. Eggs collected daily were weighed immediately after collection for each pen and average egg weight was computed. Hen-day egg production (HDEP) and hen-housed egg production as percentage were determined following the method of Hunton (1995).

%HDEP = total number of eggs produced/total number of hens present on that day x100

%HHEP = total number of eggs produced/number of hens originally housed x100

Eggs for incubation were collected towards the end of the study (11th weeks of lay) and stored for a week at a temperature of 10-14 ºC. Average sized eggs (30 eggs for each replication) were selected and used for incubation. Fertility was checked by candling the incubated eggs on the 9th day of incubation in the dark room with egg Candler. Average percentage fertility was determined by dividing the total number of eggs found fertile at candling by total number of eggs set.

Average percentage hatchability of the fertile eggs was computed by dividing the number of chicks hatched by the number of fertile eggs. Embryonic mortality of the incubated eggs at different stages was determined by breaking of eggs at the end of the incubation that seemed to be mortal to determine early, mid and late embryonic mortalities and all unhatched eggs were broken and opened to determine the age at death.

Chick quality assessment was performed by employing chick weight, chick length and yield percentage at hatch as well as by considering visual scoring. Chick length was determined by stretching the chick along a ruler and measuring the length from beak to the end of the middle toe. Chick weight was measured by weighing the chick at hatch. Yield percentage that evaluates the weight loss during incubation was calculated as the percentage of chick weight to initial eggs set weight for incubation (Molenaar, 2009)[11]. Visual scoring was determined by considering whether the chick is clean, dry, free of deformities or lesions, had bright eyes or not (Reijrink *et al*., 2010) [12].

To estimate the profitability of feeding MOLM, the partial budget was calculated as the difference between the feed costs incurred during the experimental period per bird and sale of eggs and bird in each treatment diet.

Statistical Analysis: Data were analyzed using the general linear model procedures of Statistical Analysis Systems software with the model containing treatments. Differences between treatment means were separated using Tukey Kramer test (SAS, 2009).

RESULTS

Feed Intake, Body Weight Change and Feed Conversion Ratio: The effect of replacing SBM by MOLM at different levels on feed intake, BW change and FCR of dual purpose Koekeok hens is presented in Table 3. Total feed intake was higher ($P<0.05$) for hens in T_1 and T_3 as compared to the others with the lowest intake recorded for T_2. Average initial BW was similar along treatments. Final average BW was higher ($P<0.05$) for hens in T_2 and T_3 than hens in T_4 and T_1. Hens in T_2 had higher ($P<0.05$) BW change than hens in T_3 and T_4 but not significantly differ ($P>0.05$) with T_1. Also, hens in T_1 had no significant difference ($P>0.05$) in BW change with hens in T_3. The FCR (kg egg/kg feed) was higher ($P<0.05$) for T_2 than the rest of the treatments, with no differences ($P>0.05$) between the other treatments. Mortality rate was not affected by the dietary treatment only one bird in each treatment was died.

Egg Production: Substitution of SBM with MOLM at 5% level in the hens diet in the present study resulted in higher ($P<0.05$) total egg weight (EW) and hen day-egg production (HDEP) than the rest of the treatments. Substitution of SBM by MOLM at 10% and 15% did not result in statistically significant differences ($P>0.05$) in

Table 3: Feed intake, body weight change and feed conversion ratio of dual purpose Koekoek hens fed different levels of MOLM for 12 weeks

	Treatments				
Parameters	T_1	T_2	T_3	T_4	Sig.
TFI (kg)	10.73±0.01^a	10.16±0.04^c	10.73±0.07^a	10.37±0.01^b	*
IBW (kg)	1.54± 0.02^a	1.54±0.02^a	1.54±0.01^a	1.54±0.01^a	NS
FBW (kg)	1.86±0.01^b	1.93±0.02^a	1.90±0.01^{ab}	1.77±0.01^c	*
BWC (kg)	0.32±0.02^{ab}	0.38±0.01^a	0.35±0.01^b	0.22±0.02^c	*
FCR (kg egg/kg feed)	1.73±0.04^b	2.10±0.03^a	1.52±0.01^b	1.59±0.10^b	*

*:$P<0.05$; Means followed by the same letter in rows do not differ statistically from one another by the Tukey test at 5% probability; MOLM: *Moringa oleifera* 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; NS: Non-significant; TFI: Total feed intake; IABW: Initial average body weight; FABW: Final average body weight; BWC: Body weight change; FCR: Feed conversion ratio.

Table 4: Egg production of dual purpose Koekoek hen in different dietary levels of MOLM

	Treatments				
Parameters	T_1	T_2	T_3	T_4	Sig.
Total EW (kg)	18.49±0.46^b	21.37±0.38^a	16.28±0.15^b	16.45±1.08^b	*
HDEP (%)	50.69±0.18^b	64.60±0.17^a	45.23±2.89^b	47.65±1.67^b	*
HHEP (%)	47.02±1.26^b	61.91±0.46^a	44.57±2.91^b	46.90±6.33^b	*

*: $P<0.05$; Means followed by same letter in rows do not differ statistically from one another by the Tukey test at 5% probability; MOLM: *Moringa oleifera* 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; EW: egg weight; HDEP: Hen day egg production; HHEP: Hen housed egg production.

Table 5: Fertility and hatchability of hens fed different dietary levels of MOLM

Parameters	Treatments T_1	T_2	T_3	T_4	Sig.
Fertility (%)	80.00±0.57^c	93.33±0.57^a	91.11±0.57^a	84.44±0.57^b	*
Hatchability (%)	66.66±0.88^c	78.57±0.57^a	68.22±0.57^{bc}	70.33±0.33^b	*
Embryonic mortality (%)					
Early	5.00±0.57^b	4.00±0.57^c	6.66±0.66^a	7.00±0.57^a	*
Mid	1.33±0.57^a	0.66±0.57^{ab}	0.33±0.57^{ab}	0.00±0.00^b	*
Late	0.33±0.03^a	1.33±0.33^a	1.33±0.33^a	0.33±0.03^a	NS

*: P<0.05; Means followed by same letter in rows do not differ statistically from one another by the Tukey test at 5% probability; MOLM: *Moringa oleifera* leaf meal; SBM: Soybean meal; NS: non-significant; T_1: Ration containing 0% MOLM; T_2: Ration containing 5% MOLM; T_3: Ration containing 10%MOLM; T_4: Ration containing 15% MOLM.

Table 6: Effects of substituting SBM by MOLM on chick quality of dual purpose Koekoek hens

Parameters	Treatments T_1	T_2	T_3	T_4	Sig.
ACW (g)	32.63±0.27^b	35.03±0.34^a	32.29±0.38^b	32.95±0.26^b	*
ACL (cm)	15.83±0.12^b	17.12±0.17^a	16.69±0.13^a	16.60±0.12^a	*
YP (%)	61.48±0.11^{ab}	60.62±0.44^{ab}	61.96±0.61^a	60.18±0.04^b	*
VS (%)	2.33±0.33^a	0.00±0.00^b	0.00±0.00^b	0.33±0.03^b	*

*: P<0.05; Means followed by the same letter in rows do not differ statistically from one another by the Tukey test at 5% probability; MOLM: *Moringa oleifera* 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; ACW: Average Chick Weight; ACL: Average Chick Length; YP: Yield Percentage; VS: Visual Scoring.

total EW and HDEP% than the control. Hen housed egg production (HHEP %) was higher (P<0.05) for hens in T_2 than the rests, but, there was no statistical differences (P>0.05) between T_1, T_3 and T_4 in their HHEP (Table 4).

Fertility, Hatchability and Embryonic Mortality: Table 5 shows the effect of feeding different dietary levels of MOLM on fertility, hatchability and embryonic mortality of dual purpose Koekoek hens. The result revealed that, eggs from those hens fed on T_2 (5% MOLM) had higher fertility percentage (P<0.05) but it did not statistically different (P>0.05) with T_3. Hens in T_1 had lower value (P<0.05) than the others. Hatchability percentage was higher (P<0.05) in T_2 than the others. Hens in T_1 had lower percent (P<0.05) than the others but it was not significantly differ (P>0.05) with T_3. There was no also significant difference (P>0.05) between T_3 and T_4.

High (P<0.05) early embryonic mortality was observed in T_4 but it was not statistically different (P>0.05) with T_3. Hens in T_2 had lower early embryonic mortality (P<0.05) than the others. Mid embryonic mortality was higher (P<0.05) in T_1 but it was not significantly different (P>0.05) between T_2 and T_3. There was no mid embryonic mortality observed in T_4. There was significant difference (P<0.05) between T_1 and T_4. Late embryonic mortality was not affected by the experimental diet.

Chick Quality: Table 6 presents chick quality of dual purpose Koekoek hens under different dietary levels of MOLM. Hens in T_2 had higher mean value for average chick weight (P<0.05) than the others. There was no significant difference (P>0.05) between T_1, T_3 and T_4. Average chick length was also higher (P<0.05) in T_2 than T_1 but there was no difference (P>0.05) between T_3 and T_4. Hens in T_1 had lower value (P<0.05) of chick length than the rest of treatments. Yield percentage was higher (P<0.05) in T_3 than T_4 but it did not statistically differ (P>0.05) with T_1 and T_2. Hens in T_4 also had no significant difference (P>0.05) with T_1 and T_2. Percentage of visual scoring was higher (P<0.05) in T_1 than others but there was no significant difference (P>0.05) between the rest of treatments.

Economic Consideration: The partial budget analysis is presented in Table 12. It indicated that, there was a significant difference regarding those parameters which used to determine the profitability of substituting MOLM

Table 7: Effects of inclusion of different proportion of MOLM in dual purpose Koekoek hens ration on net income and marginal rate of return

	Treatments				
Parameters	T_1	T_2	T_3	T_4	Sig.
Cost/100Kg diet	676.67±1.00^d	1387.57±1.00^c	2097.32±1.5^b	2801.74±1.0^a	*
TFI(Kg)/bird	10.66±0.01^a	10.16±0.04^c	10.73±0.07^a	10.37±0.019^b	*
TEP	380.00±1.15^b	392.00±1.00^a	326.00±1.52^c	327.00±1.52^c	*
Egg sell	1330.00±1.5^b	1372.00±1.00^a	1141.00±1.5^c	1144.50±1.0^c	*
Hen sell	840±1.00	840±2.00	840±1.00	840±1.15	NS
Total return	2170.00±2.5^b	2212.00±3.00^a	1981.00±2.5^c	1984.50±1.5^c	*
TFC /bird	72.13±1.52^d	140.97±1.73^c	225.04±2.51^b	290.54±1.52^a	*
Net return	2097.86±1.7^a	2071.02±3.4^b	1755.95±2.0^c	1693.96±1.0^d	*
CNR	-	-26.84±1.73^b	341.91±3.60^c	-403.91±2.64^d	*
CTC	-	68.84±1.15^c	152.91±1.73^b	218.41±1.00^a	*
CTR	-	42.00±0.57^a	189.00±2.00^c	-185.50±1.73^c	*
MRR	-	-0.39±0.01^b	-2.24±0.01^d	-1.85±0.004^c	*

*: P<0.05; Means followed by the same letter in rows do not differ statistically from one another by the Tukey test at 5% probability. MOLM: *Moringa oleifera* leaf meal; SBM: Soybean meal; TFI: total feed intake; TFC: Total feed cost; TEP: total egg produced; CNR: Change in net return; CTC: change in total cost; CTR: Change in total return; MRR: marginal rate of return; T_1: Ration containing 0% MOLM; T_2: Ration containing 5% MOLM; T_3: Ration containing 10%MOLM; T_4: Ration containing 15% MOLM.

instead of SBM in the present study. Higher feed cost was calculated for T_4 while, lower one was for T_1. There was significant difference (P<0.05) among all treatments in feed cost. Higher number of eggs was recorded hens in T_2 and lower value for T_3. Hens in T_1 and T_2 significantly differed (P<0.05) with each other and also with T_3 and T_4. But there was no difference (P>0.05) between T_3 and T_4 in their number of eggs which was laid.

Returns obtained from egg sale was higher (P<0.05) for T_2 but it was lower for T_3 There was no significant difference (P>0.05) between T_3 and T_4. Revenue obtained from sale of birds was similar along with all treatments with the same mean value. As a result, there was no statistical difference (P>0.05) among treatments. Total return was higher for T_2 while it was lower for T_3.

Feed cost per bird was higher for T_4 whereas T_1 had lower value. There was a significant difference (P<0.05) along with all the treatments. Higher net return was calculated for T_1 while lower one was for T_4. Change in net return was determined on the base of the control group (T_1). For this, higher value was obtained for T_2 but lower value observed for T_4 with intermediate value for T_3. The indication of negative signs was the amount of loss in relation to the control group. As a result, T_2 had a chance of losing 26.84 Birr when comparing with T_1. Similarly, T_3 and T_4 lost 341.91 and 403.91 Birr than the control group. There was a statistical difference (P<0.05) among all the treatments.

In addition, change in total return was also determined by using T_1 as reference point. Higher value was deliberated from T_2 whereas lower one was for T_3. These values could give an understanding by how many Birr was the treatments were greater or lesser when compared with T_1 on the base of their total return. According to this, T_2 obtained additional income of 42 Birr when compared to T_1. Conversely, T_3 and T_4 lost 189 and 185 Birr than T_1, respectively; T_2 had a significant difference with T_3 and T_4 but there was no significant difference between T_3 and T_4.

Change in total cost was also higher for T_4 and lower for T_2 followed by T_3 when compared with T_1. This showed that by how many Birr do these treatments used up extra cost than T_1. On the base of this, T_2 had an additional cost of 68.84 Birr than T_1. Likewise, T_3 used up further 152.95 Birr than T_1, T_4 also spend more 218.41 Birr than T_1.

The marginal rate of return measures the increase in net income associated with each additional unit of expenditure. It is also determined relating to T_1 (control group). Negative sign indicated that, the decreasing of net income as increasing of unit of cost when compared with T_1. Thus, T_2 decreased its net income by 0.39 Birr every additional unit of cost than T_1. As well, T_3 and T_4 decreased their net income by 2.24 and 1.85 Birr, respectively than T_1.

DISCUSSION

In the current study, CF shows an increasing trend as increasing of inclusion level of MOLM. This was parallel with the finding of Tesfaye *et al*. (2012) [13] and Gadzirayi *et al*. (2012) [14]. Conversely, Kakengi *et al*.

(2007)[15] reported a decreasing trend of CF with increasing of MOLM. Crude protein and ash contents obtained in the present study were increased as increasing of MOLM inclusion level which is consistent with the finding of Gadzirayi *et al*. (2012)[14]. But, Tesfaye *et al*. (2012)[13] reported that the CP content of the control diet was higher than levels in the 5% MOLM diet and the ash content decreased as the level of MOLM increased in the diet.

Substitution of SBM by MOLM at different levels (5%, 10% and 15%) in dual purpose Koekoek hens showed a significant effect on their feed intake, BW change and FCR in the current study. This was similar with the finding of Olugbemi *et al.* (2010a)[16] who noted that addition of 10% and 20% MOLM to the laying hen diet increases these parameters. Similarly, Kakengi *et al*. (2007)[15] reported that substitute for sunflower seed meal in ISA brown breed significantly increased feed intake and FCR. The result of the current study was also consistent with those reported for broilers, were supplementation with 5% MOLM showed significantly better FCR as compared to the 0%, 3% and 7% MOLM containing experimental diets (Safa and Tazi, 2014)[17].

According to Melesse *et al*. (2011)[18] the use of *M. stenopetala* leaf meal in the diet of Rhode Island Red chicks produced significant increase in feed and FCR when compared to a control diet. In the same way, Gadzirayi *et al.* (2012) observed that significant differences in FCR as evidenced by the variation in weight change in 0%, 25%, 50%, 75% and 100% MOLM. But the present study did not agree with the finding of Etalem *et al*. (2014) who noted that addition of MOLM on Dominant CZ layers up to 10% had no effect on average feed intake and final BW, FCR of hens. Olugbemi *et al*. (2010b) also found that addition of 5% MOLM to broilers' diet had no significant effect on FCR and final BW when compared to a diet free of MOLM.

Similar to this finding and conversely to the current study, Juniar *et al.* (2008)[19] observed that inclusion of MOLM at amounts up to10% did not produce significant effects on feed consumption, BW and FCR. Nuhu (2010) and Gakuya *et al.* (2014) also reported non-significant effect of MOLM addition in poultry diets. The reduction of feed intake in birds fed 5% MOLM may be due to reduced palatability of the diet (Kakengi *et al.,* 2003). The improvement in BW and FCR in the present study may be attributed to rich content of nutrients in MOLM (Sarwatt *et al*., 2004; Kakengi *et al*., 2003) and antimicrobial properties of moringa (Fahey *et al*., 2001). Since egg production and egg weight are higher in a special diet containing 5% MOLM, egg weight is higher; as a result FCR is improved in the current study.

Egg production parameters (total egg weight and HDEP) were significantly higher for birds fed diets containing 5% MOLM whereas HHEP was showed a lower value for birds at 10% MOLM added diets than 5% MOLM and similar with the rest treatments (0% and 15% MOLM added diets. On the contrary, Olugbemi *et al.* (2010b) showed a non-significant effect on HDEP for hens fed a diet containing MOLM at 0, 5 and 10% of the diet. In addition Etalem *et al*. (2014) observed a non-significant effect of a diet containing MOLM in layer rations at 5% on HDEP.

The current study was in line with Zanu *et al*., (2011) [20] who reported similar results on response to various levels of MOLM in diets in laying chickens. In contrast, Kwari*et al.* (2011) and Olabode and Okelola (2014)[21] noted non-significant results on egg weight and egg production when fed *M. oleifera* leaf and twig meals at different levels ranging from 0.2 to 0.8%. The significant effect of MOLM on egg weight and egg production in the present study might be due to the presence of lysine and methionine in moringa as reported by Bunchasak and Silapasort (2005)[22]. Wu *et al*. (2007) and Fakhraei *et al*. (2010)[23] also showed that increased methionine and lysine in the feed improves egg production and increases egg weight.

The higher egg production in layers fed the diet containing MOLM could be due to the improvement in balanced nutrient supply by MOLM in the diet. *M. oleifera* leaf meal contains lysine, methionine and a combination of other amino acids, which might supply the required amount of essential nutrients for better production (Sohail *et al*., 2003)[24]. In accordance with the present finding, Uma (2000)[25] reported that methionine and lysine levels in poultry diets have positive correlation with egg production and egg weight. Egg production increased significantly as dietary levels of lysine increased from 0.50 to 0.64% (Fakhraei *et al*., 2010).

Decrease in egg mass production, egg production percentage and egg weight at higher levels of MOLM was attributed to low digestibility of energy and protein (Kakengi *et al*., 2007). Jacob *et al.* (2014) [26] reported that there are positive correlation between feed conversion ratio, egg weight and egg production. So, increase of egg weight in T_2 might lead to increasing in egg production and improving FCR in the current study.

The result obtained in the current study was inconsistent with the finding of Etalem *et al.* (2014)[27] using MOLM as an alternative feed ingredient in the layer ration which showed non-significant effect of MOLM on fertility, hatchability and embryonic mortality. Park *et al*. (2004)[28]; Mahmood and Al-Daraji, (2011)[29] and Moyo *et al.* (2011) reported that *M. oleifera* leaf contains higher levels of zinc and vitamin E, which can play a beneficial role in hatchability of eggs. Similarly, Durmus *et al.* (2004)[30] noted increased hatchability with increasing zinc concentration in the diets of Brown parent stock layers.

Brown and Pentland (2007) showed that zinc helps in protecting the structure of the genetic material or the DNA chromatin in the sperm nucleus, a structure important for successful fertilization. Moringa contains significant amount of iron, phosphorus, calcium and is relatively rich in vitamin C (Agbaje *et al*., 2007)[31]. The current study is also in line with Adesola *et al.* (2012)[32] who reported improved hatchability as a result of ascorbic acid supplementation to diets of indigenous Venda hens. However, the relatively poor hatchability and higher embryonic mortality observed in the control group of the present study might be due to a deficiency in critical nutrients, such as zinc, vitamin E and so on, which are important for better hatchability as reported (Park *et al.,* 2004; Mahmood and Al-Daraji, 2011).

Similarly, Davtyan *et al*. (2006)[33], Petrosyan *et al*. (2006)[34], Hanafy *et al*. (2009)[35] and Agate *et al.* (2000)[35] reported that organic selenium supplementation of laying hens diets improved the environment of the sperm storage tubules in the hen's oviduct, allowing the sperms to live longer, increasing the length of time the sperms can be stored and increasing the number of sperm holes in the yolk layer. Supplementation of plant leaves containing selenium increased fertility and hatchability % (Osman *et al*. (2010)[37]. Liao *et al*. (2013)[38] also concluded that eggshell thickness affected hatchability. The physical characteristics of the egg, like weight, shell thickness, length and width and shape index play an important role in the embryo development and successful hatching (Narushin and Romanov, 2002)[39]. These might explain the improvement fertility and hatchability in groups fed diets supplemented with MOLM in the present study, was due to these reasons.

In the present study, supplementation of layers with MOLM improved early and mid-embryonic mortalities but, late embryonic mortality was not affected by the dietary treatment. This was similar with the finding of Etalem *et al.* (2014) who reported on Cassava root chips and *M. oleifera* leaf meal as alternative feed ingredients in the layer ration. ISA (2009), Deeming (2002)[40] and Tona *et al*. (2005)[41] reported that nutrition of the parent stock, care of the hatching egg before setting fumigation during the first days of incubation, shocking and trembling and insufficient turning are causes of early embryonic mortality. On the other hand, the turning and the care of the hatching eggs play a great part for mid and late embryonic mortality. But there are also factors which affect different stages of embryonic mortalities like, temperature, humidity and ventilation (ISA, 2009).

In the current study chick quality parameters appeared to be not negatively affected by the dietary inclusion of MOLM at different levels as replacement of SBM. Chick weight, chick length and yield percentage were improved in the diets containing MOLM than the control group. Improvement of chick weight in the present study was concurred with the finding of Etalem *et al.,* (2014) who observed higher chick weight in hens fed 5% MOLM. Similarly, Coon *et al* (2006) noted that, addition of protein in chickens' diet improves chick weight at hatching. The present study regarding egg size and chick weight at hatching was in agreement with the findings of Abiola *et al.* (2008)[42] and Malago and Baitilwake (2009)[43], who noted a positive correlation between egg size and chick weight at hatching.

Hatchability and chick quality at hatching is directly related with quality parameters of eggs the better egg size, the better yolk, the better albumen and better shell thickness resulting in best hatchability with best chick quality (Kingori, 2011)[44]. Bray and Iton (1999)[45], Wilson (2000), Silversides and Scott (2001) and Tona *et al.* (2002) have shown that egg weight is a dominant factor affecting chick weight at hatch. In the present study, inclusion of MOLM was improving chick quality by improving both internal and external egg quality parameters. Kenny and Kemp (2003) noted that, the developing embryo and the hatched chick are completely dependent for their growth and development on nutrients deposited in the egg.

In the current study, feed cost increases as increases as the level of MOLM in the diet containing 5%, 10% and 15% MOLM. This was in line with the findings of Onibi *et al*. (2008) or Tendonkeng *et al*. (2011) in which the feed costs/kg live body weight of broiler finishers were increased with *Leuceana* or *Moringa* leaves meal inclusion in the diets. The net return in the present study was decreasing as increasing of MOLM. This is due to the decreasing of egg production in relating to increasing MOLM level beyond 5%. This was comparable to the finding of Zanu *et al.* (2012) who noticed that partial replacement of fish meal with MOLM decreased the net revenue for broilers, according to their reduction in weight gain.

Controversially, Ayssiwede *et al.* (2010) noticed that the lowest feed cost/kg carcass was achieved when 8% and 16% of MOLM was introduced into the diets of the birds. Adeniji and Lawal (2012) reported as moringa is profitable for Senegal chicken and feeding for rabbit up to 100% MOLM replacing groundnut.

Conclusion and Recommendations: Generally, replacing of SBM by MOLM at 5% (T_2) dietary level improved feed conversion ratio, egg production parameters, egg quality parameters, egg shelf life, fertility and hatchability and chick quality. On the other hand, higher feed intake at 10% MOLM (T_3) and T_1 (0% MOLM) inclusion level and higher body weight change was obtained at T_2 (5% MOLM). Higher yolk color was observed for T_3 (10% MOLM) and T_4 (15% MOLM). Even if MOLM had a potential of improving these parameters mentioned above, it was not profitable due to its high price than SBM beyond 5% level of inclusion in the total diet.

Generally, replacing of SBM by MOLM at 5% (T_2) dietary level improved feed conversion ratio, egg production parameters, egg quality parameters, egg shelf life, fertility, hatchability, embryonic mortality and chick quality. On the other hand, higher feed intake at 10% MOLM (T_3) and T_1 (0% MOLM) inclusion level and higher body weight change was obtained at T_2 (5% MOLM). Higher yolk color was observed for T_3 (10% MOLM) and T_4 (15% MOLM). Even if MOLM had a potential of improving these all parameters mentioned above, it might not be profitable if only the price of moringa considered at supermarket price in the present study rather it may be profitable if considered at its niche market. Besides considering the quality eggs produced like big egg, yellow yolk, hard shell, better fertility and hatchability and prolonged egg shelf life due to addition of moringa in to the layers feed may fetch higher price and the profitability may increased. The current study did not considered these all due to the egg market situation in Ethiopia[46-66].

Based on the findings of the present study, it is recommended to further evaluate the profitability of MOLM addition in the poultry diet by considering product quality gained in the sector. In our country, there are no such findings in the area of feeding of *Moringa oleifera* leaf meal for poultry to improve their productive and reproductive performance, fertility of the cocks as well. So researchers should do further findings and give evidence for producers about the nutritional value of MOLM in the poultry industry.

Based on the above conclusion, the following recommendations are forwarded:

- From economic benefit point of view in the present study, since the study used the super market price of moringa rather than the niche market price,, it is not advised to use MOLM at the levels beyond 5% in poultry feeding. A further possibility of using MOLM at its niche market price and by increasing *Moringa oleifera* leaf production in order to exploit its benefit in poultry feeding as a result its price will be decreasing.
- In addition valuing the product quality and fetching premium price for poultry products also should be considered while using MOLM as poultry feed.

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