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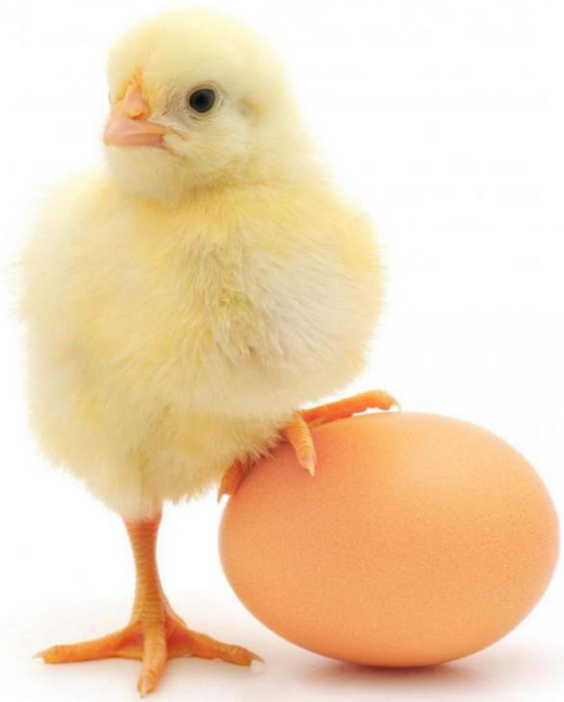

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Effect of Supplementation of *Moringa oleifera* (LAM) Leaf Meal in Layer Chicken Feed

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Abstract: The purpose of this study was to investigate the effect of supplementing *Moringa oleifera* leaf meal (MOLM) at different levels in layers feed. Layers mash was formulated using raw materials obtained from local feed manufacturers and MOLM was included in the various diets at levels of 0% (T1), 1.25% (T2), 2.5.% (T3), 5% (T4), 7.5% (T5), 10% (T6). Diet 1 (T1) was added Canthacol® at a rate of 1 g/kg of feed while diet 7 (T7) was a commercially prepared feed. Twenty eight thirty week-old ISA Brown layer birds were selected from a flock and randomly allocated to seven treatment groups with 2 replicates of two birds each and the diet feeds introduced. Feed intake, weight gain, egg production, egg yolk color, egg weights, egg yolk color acceptability were determined. Eggs from randomly selected outlets of 4 leading supermarkets had their egg yolk colour score determined. The increase in MOLM levels had no effect on feed intake, weight gain, acceptability of boiled eggs by consumers and egg weights ($p<0.05$). The average egg yolk color score and the total eggs laid in the various treatments were significantly different ($p<0.05$) depending on the levels of MOLM in the diets. However, there was no significant difference in egg yolk colour score between the eggs from MOLM diets and those from supermarkets. There is need to investigate further the factors responsible for the yellow-orange colour of the eggs and the possibility of utilization of MOLM in commercial layers feed production.

Key words: *Moringa oleifera* leaf meal, layers birds, feed intake, egg production, egg yolk colour, layers mash

INTRODUCTION

Poultry production performance largely depends on nutrition and environmental factors. Protein supplementation is very important for egg production with the main sources being the soya bean meal and fish meal in Kenya. These two sources are however not always available to farmers because of the high demand from rapidly growing human population coupled with their escalating costs. It has therefore become necessary to look for alternative feed sources that need to be identified and evaluated (Nuhu, 2010). Poultry feed should ideally comprise cereals but this is not possible because there is no surplus of cereals in low income food deficit countries (Gueye and Branckaert, 2002). As such, there need to use other feed resources that can make chicken perform at the same level as when fed on conventional feeds.

Some tropical legume browse plants act as cheap sources of protein but their extensive use is restricted by high crude fibre and antinutritive compounds (Nuhu, 2010). In the recent past, there has been great interest in the use of Moringa (*Moringa oleifera*) as a source of protein for livestock (Makker and Becker, 1997). The leaves of Moringa have components that make them suitable for replacement for soya bean meal or fish meal in non-ruminant diets (Nuhu, 2010). Large amounts of Moringa forage can be obtained from easily established plots in the field without expensive inputs. Moringa is also a perennial plant that can be harvested several times in a year. Leafy tips of *Moringa oleifera*, per 100 g contain 78% water, 268 Kj energy, 9.4 g protein, 1.4 g fat, 8.3 g carbohydrates, 2.0 g dietary fibre, 185 mg calcium, 147 mg magnesium, 112 mg phosphorous, 4.0 mg iron, 0.6 mg zinc and several vitamins including vitamin A, Thiamine, Riboflavin, Niacin, Folate and Ascorbic acid (Grubben and Denton, 2004). Although Moringa leaf meal has very high crude protein, there is not enough information on how it be used as an alternative supplement for laying chicken.

Moringa oleifera is also found to be a very good indigenous source of highly digestible protein, calcium, iron, vitamin C and carotenoids (Fuglie, 1999). *Moringa oleifera* leaves have been found to contain high values of crude protein at 43.5 and 25.1% in extracted and

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unextracted leaves (Makker and Becker, 1996). The protein found in Moringa leaves is of high quality, having significant quantities of all the essential amino acids as reported by Foidl and Paul (2008).

The leaves of *Moringa oleifera* are a rich source of proteins for all age groups and have been used in Haiti and Senegal for treatment of malnutrition in young children, pregnant women and nursing women (Price, 1985). The leaves also provide minerals whether eaten raw, cooked or dried. One hundred grams of the leaves could provide over one third of the daily needs of calcium to a woman and nearly all the quantities of iron, protein, sulphur and B vitamins (Fuglie, 2005). In a study conducted by Subadras *et al*. (1997), it was found that 20-40% of protein is retained when the leaves are sundried and 50-70% retained when the leaves are dried under shade.

The safety and nutritional efficacy of Moringa leaf meal on White-leghorn type chicks was evaluated by Ashong and Brown (2011) The experimental diets were formulated to contain 0% (control), 10, 20 and 30% Moringa leaf powder. During the 5 weeks experimental period, there were no signs of abnormal behavior, toxicity or mortality. The control group had a higher feed intake ($p<0.05$) with a corresponding higher weight gain ($p<0.0001$) compared with other treatment groups. The control group also had significantly higher levels of cholesterol, triglyceride and uric acid. Although the incorporation of Moringa leaf may reduce intake and rate of gain, the ingredient was reported to be non toxic to growing poultry and the effect on blood lipid profile may be useful to human nutritionist.

Gakuya *et al*. (2014) evaluated the effect of supplementation of *Moringa oleifera* leaf meal (MOLM) on broiler chicken diet. In the formulation of broiler starter and finisher diets, MOLM was incorporated at 0, 7.5 and 7.5% (without methionine and lysine), 15 and 30% and designated as treatments T1, T2, T3, T4 and T5, respectively. Broiler chicks were fed on the experimental diets up to 38 days and their feed intake, weight gain, feed conversion efficiency, abdominal fat pad, feed digestibility and lipid profiles determined. The studies concluded that MOLM was well tolerated by the chickens but it can only be included in the feed to levels of up to 7.5% as higher levels affected weight gain, feed intake and dry matter digestibility. Increased levels of MOLM in the diet had no effect on the digestibility of crude fibre, crude protein and NFE but the levels above 7.5% lowered the abdominal fat pad. It was also concluded that the increase in the yellow color of the carcass with the increased levels of MOLM may be attributed to high levels of carotenoids.

Gadzirayi and Mupangwa (2014) studied the performance of indigenous chicks fed on diet with *Moringa oleifera* leaf meal (MOLM) as a protein supplement. Using treatment diets with MOLM at 0, 5, 10 and 15%, chicks fed on 0% MOLM had a higher average weekly feed intake and weight gain than the rest of the treatments. Feed conversion ratio was similar in all the groups. Chicks fed on MOLM at 5% had a better performance than at 10 and 15% and they recommended inclusion of MOLM at 5%.

In a study conducted by Kakengi *et al*. (2007), it was found that feeding laying hens at 10-20% of *Moringa oleifera* leaf meal as a substitute to sunflower seed meal significantly ($p<0.05$) increased feed intake and dry matter intake and decreased egg mass production. Egg production percentage decreased with an increase of Moringa *oleifera* leaf meal while egg weight increased on inclusion of 5% *Moringa oleifera* leaf meal. However, lower egg weight was noted at 20% MOLM level. Increase in feed intake and feed conversion ratio and decrease in egg mass production, egg production percentage and egg weight at higher levels of *Moringa oleifera* leaf meal was attributed to low digestibility of energy and protein (Kakengi *et al*., 2007).

Olugbemi *et al*. (2010) in their studies found that supplementation of *Moringa oleifera* leaf meal up to 10% in cassava chip based diet to laying hens had no effect on feed intake, feed conversion and laying percentage. Egg weight increased as a result of supplementation of *Moringa oleifera* leaf meal as compared to the control diet.

Inclusion of *Moringa oleifera* leaf meal at 0, 5, 10 and 15% in layers feed caused linear decrease in egg laying percentage and egg mass while egg weight and feed intake showed a quadratic trend with increased levels of *Moringa oleifera* leaf meal (Abou-Elezz *et al*., 2011). In a study conducted by Abbas (2013), it was found that *Moringa oleifera* leaf meal can be used to the level of 6% of the diet of growing layer chicks, up to 10% of laying hens diet and up to 5% of the diet of broilers. The objective of this study was to assess the effect of supplementation of *Moringa oleifera* leaf meal on feed intake, weight gain, egg production, egg weight, yolk colour and consumer preference of egg yolk colour in laying chicken.

MATERIALS AND METHODS

This experiment was carried out at the Department of Animal Production, which is located in the College of Agriculture and Veterinary sciences, University of Nairobi.

Acquisition of raw materials and diet formulation: The raw materials which included ground maize, soya bean, wheat pollard, fish meal (omena), limestone, cattle salt and premixes were purchased from a reliable feed manufacturer. *Moringa oleifera* dried leaves were sourced from a farmer in Mtito Andei division, Kibwezi district in Makueni County and milled into a fine powder using a commercial grinding mill. The proximate analysis was done on *Moringa oleifera* leaf meal (MOLM) before feed formulation. The layers mash was formulated using the raw materials and MOLM incorporated at 0% (T1), 1.25% (T2), 2.5% (T 3), 5% (T 4) and 7.5% (T5) and 10% (T6). A commercial prepared layers mash from a reliable feed manufacturer was also included in the experiment and designated as diet T 7. Diet 1 (T1) (MOLM 0%) was also added Canthacol(R) (10 gm of canthaxanthen/1 kg) at a rate 1 g/kg of feed. All the diets were analyzed using proximate analysis to determine their chemical composition.

Twenty eight birds were randomly selected from a 30 week old laying flock of Isa brown and randomly allocated to the seven treatment groups with each group having 2 replicates with 2 birds each.

Experimental birds and their management: The experimental laying birds were housed in a battery system and each of the replicate of two birds was put in a separate cages. After one week of acclimatization, the seven experimental diets were randomly assigned and fed to the layers *ad libitum* for a total of four weeks. The body weights of the layers were determined for the whole replicate on the onset of the experiment and once a week till the end of the experiment. This data was used to calculate weight gain. Each of the 2 replicates of the treatment group (T1, T2, T3, T4, T5, T6 and T7) had its feed and bucket weighed and then the groups was fed *ad libitum*.

The feed intake was determined by weighing the bucket and feed before and after consumption before the next refilling of the bucket. Egg production was monitored on daily basis and recorded for each replicate. The eggs were stored separately in well marked plastic containers corresponding to each group. The eggs from each treatment group were weighed at two-day intervals to determine the weight. One egg from each replicate was randomly selected and broken to determine the egg yolk colour score on a two day interval. This was done using a Roche colour fan and a score ranging from one to fifteen (yellow-orange) given individually by four readers then an average score for each treatment group determined.

At the end of the experiment, eggs were randomly selected from each every treatment group and boiled. They were then split into two and availed to 23 volunteers to score them into position 1, 2 and 3 according to their colour preferences. Eggs were purchased from 2 randomly selected outlets of the 4 leading supermarkets. For each outlet, 6 eggs of each of the two categories classified as yellow and ordinary were purchased. These eggs were broken and scored using the Roche colour fan as previously described. Their egg yolk colour score was compared to the different levels of Moringa.

Data analysis: All the data was entered and stored using MS Excel and later managed and analyzed using R-Studio Version 3.0.3 (2014).

RESULTS

Chemical composition of the experimental diets: *Moringa oleifera* leaf meal (MOLM) had a crude protein of 23.33%. Results of proximate analysis done on the treatment diets are shown in Table 1. Dry matter (DM) content ranged from 90.46% in T4 to 91.93% in T7. Crude protein (CP) was lowest in both T7 and T2 at 11.97 and 12.65%, respectively and there was little variation in crude protein content in the other treatment diets. Crude fibre (CF) was highest in T7 at 9.01% but varied between 4.64% in T3 and 5.86% in T6 in the other treatments. Ether extract (EE) was highest at 6.0% in T7 but did not vary much in the other treatment diets (3.12% in T5 to 4.19% in T6). Nitrogen free extracts (NFE) was lowest in T7 at 50.88% and highest in T4 at 66.78%.

Feed intake: The diets prepared using MOLM were well accepted by the birds and there were no visible side effects. The results of feed intake among the different treatment groups are presented in Table 2. Feed intake was low in all the groups during the first week but gradually increased. The average total feed intake ranged from 1.2485 kg (T5) to 1.7995 kg (T7) per replicate in the first 8 days. The average total feed intake per replicate in the next 10 days (9-18) was highest for T2 (2.6095 kg) and lowest for T6 (1.9655 kg). Similarly in the next 10 days (19-28) the average total feed intake per replicate was lowest for T5 (2.0990 kg) and T6 (2.1645 kg) and highest for T2 (2.4570 kg). Although higher levels of MOLM had a slightly lower feed intake, the difference was not significant ($p<0.05$).

Live weight gain of the layers: There was slight live weight loss in all the groups during the first week but later there was a gain in week 2 in all groups. The trend of weight gain was inconsistent in the next 2 weeks except T6 which had a weight gain in week 3 and 4. However there was no significance difference ($p<0.05$) in weight gain among the various treatment group in the 4 week period.

Effect of MOLM on egg laid, egg weight and egg yolk colour: The average total eggs laid at day 28 were highest for T1 at 51 while the least was for T6 at 36 (Table 4). There was a significant difference in egg production between the various levels of MOLM ($p<0.05$). The eggs laid in Group T1 were significant more than those of group T2, T5, T6 and T7. Eggs laid in T6 were significantly less than those of T1, T3 and T4. There was no significant difference between the rest of the groups. The average egg weight of the eggs was highest in T6 at 65.2 g and least in T1 at 60.00 (Table 4). However the

Table 1: Chemical composition of the experimental diets fed to laying hens

	Dietary treatments						
	T1	T2	T3	T4	T5	T6	T7
Analyzed (%)							
DM	90.68	90.68	90.69	90.46	90.49	90.57	91.93
CP	13.84	12.65	14.73	14.61	14.11	14.84	11.97
CF	5.38	4.85	4.64	5.37	5.52	5.86	9.01
EE	4.14	3.85	3.74	3.31	3.12	4.19	6.00
NFE	62.29	65.56	62.69	66.78	61.05	61.77	50.88
Ash	14.34	13.09	14.20	9.93	16.20	13.34	22.07

T1:0%MOLM T2:1.25%MOLM T3:2.5%MOLM T4:5%MOLM
T5:7.5% MOLM T6:10%MOLM T7:0%MOLM-Commercial feed

Table 2: Average total feed intake per replicate (kg)

Group	Days 1-8	Days 9-18	Days 19-28
T1	1.7910±0.2659	2.3450±0.3861	2.2130±0.0948
T2	1.7780±0.0481	2.6095±0.1987	2.4570±0.2772
T3	1.6045±0.4137	2.1135±0.0035	2.0890±0.0339
T4	1.6685±0.1775	2.4710±0.1980	2.4360±0.2602
T5	1.2485±0.186	2.0285±0.0375	2.0990±0.0976
T6	1.4980±0.058	1.9655±0.1987	2.1645±0.2991
T7	1.7995±0.4066	2.3405±0.5494	2.2480±0.3507
p-value	0.4128	0.3333	0.5798

T1:0%MOLM T2:1.25%MOLM T3:2.5%MOLM
T4:5%MOLM T5:7.5% MOLM T6:10%MOLM
T7:0%MOLM-Commercial feed

difference between the various treatment diets with different levels of MOLM was not significant (p<0.05).

The egg yolk colour score of all the treatment diets had minimal variation mean at onset of the experiment which ranged from 7 to 10. For the first 14 days after introduction of the treatment diets, the average egg yolk colour reading for the various diets had started to stabilize and ranged from a mean score of 7.428571 (T2) to 13.42857 (T1) (Table 4). The egg yolk colour score of T1 was significant high than those of T2, T3, T4, T5 but not of T6 and T7 (p<0.05). Treatment group T2 and T3 egg yolk colour score was significantly lower than T1, T5, T6 and T7 but not T4 or among themselves (p<0.05). The rest of the treatment groups had a similar egg yolk score reading. For the next 14 days, the average egg yolk colour score ranged from 6 (T2) to 15 (T1) and all the egg yolk colour scores in the treatments were significantly difference from each other except for T5 and T7 which were similar (Table 4). Egg yolk colour score of T1 was significantly very high that all the rest of the treatments while T2 was significantly very low than the rest of the treatment groups (p<0.05). The egg yolk colour score increased with higher levels of MOLM.

Consumer preference based on yolk colour of eggs: In the cumulative customer score on the boiled egg, 23 preferred to eat eggs from T5 with mean Roche colour score of 11.85714. While 12, 10, 8, 6, 4 and 2 people preferred to consume eggs from T6, T7, T4, T3, T1 and T2, respectively. These results indicated that many consumers would prefer eggs with Roche yolk colour score of 8 and above. However there was no statistically significance difference between these preferences among treatment groups (p<0.05).

Yolk colour scores in eggs bought from local Supermarkets: The average egg yolk colour score for egg classified as yellow from randomly selected outlets of 4 leading supermarkets ranged from 11 to 13 while those classified as ordinary ranged from 5-11. When the egg yolk colour score of the two classes of eggs were compared with those of the 5 experimental diets with MOLM (T2, T3, T4, T5 and T6), there was no statistically significant difference (p<0.05).

DISCUSSION

The crude protein of powdered Moringa leaves of 23.33% was lower than those reported by various authors at 25.1% (Makker and Becker, 1996), 26.4% (Gupta *et al.*, 1989), 27.51% (Oduro *et al.*, 2008) and 29.55% (Nuhu, 2010). The commercial diet (T7) varied with the rest of the diets by having higher percentage of dry matter, crude fibre and ether extract but low crude protein and Nitrogen free extract. The rest of the diets processed within the experiment had similar values except for lower crude protein (T2) and crude fibre (T4).

The feeds with MOLM included were well tolerated by the birds. This was also observed by Gakuya *et al.* (2014); Ashong and Brown (2011); Djakalia *et al.* (2011) and Nuhu (2010). Feed intake was low in the first week and this could be attributed to stress associated with change in environment and also to introduction of new feed in T1 to T6. Feed intake improved in the following 10 days perhaps due to adaptation to the new environment and had also got used to the new diets. Although there was a decreasing trend of feed intake with increase of MOLM in the layers diet, the decrease was not statistically significant. This was also reported by Nuhu (2010) where various diets formulated with MOLM in weaner rabbits did not affect feed intake. Gakuya *et al.* (2014) reported that inclusion of MOLM in broiler feed did not affect feed intake up to 7.5%. Similarly Olugbemi *et al.* (2010) reported that MOLM added up to 10% to cassava chips based diet in laying birds had no effect on feed intake.

The weight gain of the layers in the 4 weeks period was not statistically different among the 7 treatment groups. This implied that MOLM inclusion did not affect the weight gain. This could be due to the fact that the birds were mature as opposed to those which are growing. The weight gain differed with studies of Ashong and

Table 3: Average weight gain (kg)

Group	Week 1	Week 2	Week 3	Week 4
T1	-0.15±0.0707	0.175±0.0354	0.15±0.00	-0.075±0.0354
T2	-0.25±0.0707	0.25±0.0707	0.075±0.0354	-0.05±0.0707
T3	-0.25±0.0707	0.075±0.2475	-0.01±0.2687	0.035±0.1626
T4	-0.375±0.0354	0.275±0.0354	-0.2±0.00	0.175±0.1061
T5	-0.375±0.1061	0.125±0.1768	0.15±0.00	-0.075±0.1061
T6	-0.325±0.0354	0.1±0.0000	0.075±0.1061	0.05±0.0707
T7	-0.225±0.1768	0.075±0.1061	0.15±0.2121	-0.1±0.4243
p-value	0.2692	0.5704	0.2408	0.75

T1:0%MOLM T2:1.25%MOLM T3:2.5%MOLM T4:5%MOLM
T5:7.5% MOLM T6:10%MOLM T7:0%MOLM-Commercial feed

Table 4: Effect on total egg laid, egg weight and egg yolk colour

Parameter	Egg laid (28 days)	Egg weight (g)	Egg yolk colour score Average for Day 1-14	Egg yolk colour score Average for Day 15-28
T1	51±4.2426	60.00±0.0566	13.42857±3.047247	15±0
T2	44±1.4142	61.44±0.2263	7.428571±1.98806	6±0
T3	45.5±2.1213	60.29±1.4213	7.714286±0.755929	8.142857±0.377964
T4	45±1.4142	62.88±0.8768	9.714286±0.755929	11±0
T5	39.5±2.1213	61.62±3.3941	10.57143±1.133893	11.85714±0.377964
T6	36±0.0000	65.2±0.7637	10.71429±1.704336	12.71429±0.48795
T7	40.5±2.1213	62.63±3.1678	11.14286±1.214986	12.14286±0.377964
p-value	0.004656**	0.242	4.319e-07	2.2e-16

T1:0%MOLM T2:1.25%MOLM T3:2.5%MOLM T4:5%MOLM
T5:7.5% MOLM T6:10%MOLM T7:0%MOLM-Commercial feed

Brown (2011) using White leghorn chicks and Gadzirayi and Mupangwa (2014) using indigenous chicks who reported lower weight gains with increase of MOLM. These studies partly concurred with those of Gakuya *et al.* (2014) who reported that levels of 7.5%MOLM and below did not affect weight gain but those of 15 and 30% had significant effect in broiler chicken.

There was a decrease average egg laid as levels of MOLM were increased. They ranged from 36 in T6 to 51 in T1 at day 28. The eggs laid in Group T1 were statistically significant more than those of group T2, T5, T6 and T7. T6 had the least number of eggs laid followed by T5 implying that increased levels of MOLM had an effect on egg laid. These results concurred with those reported by other authors (Abou-Elezz *et al.*, 2011; Kakengi *et al.*, 2007; Paguia *et al.*, 2012). This could be attributed to low feed intake or low digestibility as reported by Gakuya *et al.* (2014) in inclusion levels above 7.5% of MOLM although the feed intake in all groups in this study were not statistically different. However, there was no statistical difference in the number of eggs laid between the various levels of MOLM and the commercial feed. Also levels of 5% MOLM and below had no difference on the number of eggs laid with that 0% MOLM. Average egg weight in treatment groups was not statistically significant different implying that MOLM had no influence on egg weight. This concurred with the finding of Paguia *et al.* (2012) when they reported no big differences in egg weights from layers fed on *Moringa oleifera* leaf and twig meals at different levels ranging from 0.2 to 0.8%.

Egg yolk colour using Roche yolk colour had the highest score in T1 which had the commercial Cathancol® added to the diet and no MOLM. This is was added to achieve full colour and compare it with MOLM diets (T2 to T6) and the commercial feed T7 which was added Canthacol® by manufacturers and had no MOLM. Although the egg yolk colour score in T1 was significantly very high compared with the other treatments, the commercial feed had no significant difference with the MOLM diets (T4, T5 and T6). This implies that when MOLM is included at levels above 5% there is no need of using Canthacol® in layer feed production. The increase in egg yolk colour score with increase of MOLM from T2 to T6 was in agreement with the finding of Abou-Elezz *et al.* (2011). However it varied with the studies of Paguia *et al.* (2012) who did not get a consistent trend in yolk colour as levels of Moringa leaf and twig powder were increased from 0.2 to 0.8%.

On the acceptability of eggs by consumers, most of them preferred those with egg yolk colour scores of 12 and 13 (T5 and T6) as opposed to those with light colour of below 8 (T2, T3 and T4) or deep colour (T1). However there was no statistically significant difference between the treatment groups implying that MOLM can be used in layers feed without affecting consumers acceptability. The egg yolk colour score of those eggs obtained from supermarket outlet were similar to those produced using different levels of MOLM. This implied that MOLM can be used for egg production and will not affect the commercialization of the eggs.

Conclusions: From these studies it can be concluded that MOLM inclusion up to 10% in mature layers has no effect on feed intake, live weight gain and the egg weight.

Although its inclusion has effect on the number of egg laid, those laid at levels above 5% MOLM were statistically similar to those produced by the commercial feed. MOLM inclusion also had a positive effect on the yellow-orange colour of the egg yolk and levels above 5% compared well with those of commercial feed. Therefore MOLM can be used by farmers as a source of protein and also replace Canthacol® as the egg yolk colour produced was similar to that of the eggs obtained from the supermarkets. Its acceptability by customers was also similar to that of 0% MOLM. There is a need to investigate the factors responsible for the yellow-orange colour and the possibility of utilization of MOLM in commercial layer feed production.

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