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Growth performance and profitability of pekin duck (*Anas platyrhynchos* F) fed with *Moringa oleifera* leaf meal as soybean oil meal substitute under mixed orchard farming system

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Key words: Growth performance, Profitability, Pekin duck, *Moringa oleifera* leal meal (MOLM), Mixed orchard farming system.

Abstract

A The study was conducted to determine the growth performance, carcass yield, and meat quality analysis, and profitability of pekin duck fed different levels of *Moringa oleifera* leaf meal as soybean substitute under mixed-orchard farming system. A total of 150 F1 growing Pekin ducks were randomly distributed into 15 ranged pens under mixed orchard equally representing 5 dietary treatments to evaluate the growth performance, carcass yield and profitability of ducks fed different levels of *Moringa oleifera* leaf meal (MOLM) as soybean oil meal (SOM) substitute. The study was undertaken from February 6 to March 5, 2016 at Centro 02 Sanchez Mira, Cagayan, Philippines. The treatments were: Treatment To (control) 100% SOM as protein source, T1-25% MOLM substitution of SOM, T2- 50% MOLM substitution, T3- 75% MOLM substitution, T4- 100% MOLM. The study was done in CRD with three replications per treatment. Significant results were found on the body weight, weight gain and feed consumption parameters. Significant results were found out on the feed conversion ratio and feed conversion efficiency. Pekin Duck fed T1, T2 and T3 performed best based on their low FCRs and high FCEs. It was therefore concluded that partial substitution of MOLM from 25% to 75% for SOM could be used on the diet of pekin duck. However, substituting 25% MOLM for SOM is highly recommended under mixed-orchard farming system because it had the best results on all growth and income parameters.

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Introduction

In commercial poultry production system, profit can be maximized by minimizing feed cost which accounts the major cost of production. In the Philippines, the major sources of protein for poultry production are Fishmeal (FM) and Soybean Meal (SOM). However, these are imported and becoming more scarce, expensive and used extensively by other livestock and humans. Prices of these conventional protein sources have soared so high in recent times that it is becoming uneconomical to use them in poultry feeds. Nutrition accounts for 60-70% of the total production cost in modern poultry production systems. Further, feeding has a great effect in poultry growth, egg production and meat quality. This situation has created a need to look for cheap, locally available and less competitive substitutes to some ingredients of poultry feeds and in particular, sources of protein. There is continued scarcity and consequent high prices of conventional protein (soyabeans) and energy sources and this hinders poultry production.

There is a need therefore, to look for locally available and cheap sources of feed ingredients. One possible source of cheap protein is the leaf meal of tropical legumes. Many studies have been conducted using various sources of leaf meal proteins for broilers (Iheukwumere *et al*., 2008; Wude and Berhan, 2009; Onyimonyi *et al*., 2009). Leaf meals do not only serve as source of protein but also provides some necessary vitamins, minerals and oxycarotenoids (D'Mello *et al*., 1987; Opara, 1996). One plant that can serve as source of leaf meal in the diet of poultry is *Moringa olifera* tree (Kakengi *et al*., 2007; Olugbemi *et al*., 2010b). *Moringa oleifera* leaves are packed with nutrients important both for humans and animals. A crude protein percentage of 25-27% is suggestive that the leaves are a good source of protein for livestock. Moringa tree is indigenous to many provinces in the Philippines. This tree thrives well in Sanchez Mira, the site of this study because of its being a coastal area with sandy loam and clay loam types of soil. Moringa is well known for its multipurpose attributes, wide adaptability and ease of establishment.

The tree is fast growing and high yielding, initial trial in Nicaragua have shown a high biomass production of up to 120 tonnes dry matter/ha/year in 8 cuttings after planting one million seeds/hectare (Makkar and Becker, 1997). The tree bears for 30-40 years. The drought tolerant nature of the tree makes it particularly suited to those marginal areas where the cost associated with cultivation and harvesting of other commercial crops like soyabeans is high. The tree is resistant to most pests and diseases, thus making it a cheap source of feed for animals.

Moringa tree is drought tolerant, it is resistant to most diseases and pests, it has a high biomass yield per hectare, it can grow well in marginal areas and it has a high protein value which can support livestock production. All these facts make it a cheap feed source compared to soyabeans, which is a cash crop and it is expensive to produce by the small-scale farmer in marginal areas. Under such conditions, *Moringa oleifera* becomes the crop of choice to explore in livestock production.

In poultry production, the raising of chickens and other species organically by free range or pasture management is now becoming popular because of its higher demand. Health conscious consumers prefer organically grown poultry than commercial broilers because of its satisfying flavor and aroma. Recent researches revealed substantial increases in nutritional value of pastured poultry, particularly in Omega-3 Fatty Acids and Vitamin A, and a significant decrease in total fat thus becoming better food to eat (Lee, 2001). In the Philippines, the main sources of protein for poultry production are fishmeal and soybean oil meal. However, these are imported and becoming more scarce, expensive and used extensively by other livestock and humans. Prices of these conventional protein sources have soared so high in recent times that it is becoming uneconomical to use them in poultry feeds.There is a need therefore, to look for non-conventional, locally available and cheap sources of protein for poultry production. One possible source of cheap protein is the leaf meal of tropical legumes which are abundant in the Philippines.

One plant that can serve as source of leaf meal in the diet of poultry is *Moringa oleifera*. It leaves are packed with nutrients important both for humans and animals. A crude protein percentage of 25-27% is suggestive that the leaves are a good source of protein for livestock.

With these, *Moringa oleifera* leaf meal must be verified if what levels of its inclusion in the diet could significantly affect the growth, carcass yield, meat quality, and profitability of ranged pekin ducks. This study will benefit poultry raisers especially duck growers because they would be given options to lower down their production cost through the use of alternative protein source for feeds. Likewise, the consumers because of healthy, better tasting and possibly cheaper poultry meat from duck produced in the range and fed with nutritious *Moringa oleifera*.

The study generally aimed to evaluate the growth performance and profitability of pekin ducks under mixed orchard given pelletized formulated rations with different levels of *Moringa oleifera* leaf meal (MOLM) as substitute for soybean meal (SBM).

Materials and methods

The Experimental Animals

One hundred fifty 14-day old pekin ducklings, meat type were randomly selected and distributed to treated and control groups with 10 animals per group. The ducks are placed in individual open-ranged pens under mixed orchard farming system. To ensure uniformity of stocks, the experimental birds were purchased from Superior F1 Genetic Enterprise owned by free-range poultry specialist Dr. Erwin J. S. Cruz.

Experimental Treatments and Design

A completely randomized design (CRD) was used with 5 dietary treatments (control, and 4 levels of MOLM substitute diets) with three replications per treatment. For each of the replication, there were 10 randomly selected pekin ducks in each of the 15 pens (total of 150 heads). The birds were fed according to the type of experimental diet assigned to each treatment as follows: T0–Control -100% SOM as protein source, T1–25% MOLM substitution of SOM, T2–50% MOM substitution of SOM, T3–75% MOLM substitution of SOM, and T4–100% MOLM as protein source.

Statistical Analysis

Statistical analyses were performed, pre-processing live weights, feed consumption, feed conversion, feed conversion efficiency, dressing percentage, chilled carcass weight, breast, thigh, wing, and drum weights; as well as moisture, protein, and fat values for breast and thigh meat. Carcass yield values were evaluated on a weight basis and as a percentage of pre-processing live or chilled carcass weight as appropriate. Statistical analysis (ANOVA) in Completely Randomized design (CRD) was carried out using computer programs e.g. Statistical Tool for Agricultural Research (STAR). The statistical model included effects of treatments, with the experimental unit being the pen. The mean values that were obtained for the pekin duck fed soybean meal as protein source were compared with those fed malungay leaf as protein source diets at the 5% and 1% level of significance using a protected Fisher's least significant difference test (Fisher, 1949).After two weeks of brooding, 10 day old ducklings were randomly distributed to each rearing house/range area. The allocation of the rations was based on the randomized procedure for CRD.

Experimental Area

The experimental animals were ranged under mixed orchard to partly cover the birds from direct sunlight. The area is an ideal site to raise ranged poultry with coconut as the predominant crop, and other trees such as citrus, gmelina, molave, and mahogany. In addition, under the trees are mixture of native grasses and edible weeds, which are good sources of other nutrients for the birds' growth. The appearance and vegetation of the area is uniform.

Brooding & Rearing Area

An existing house was used for the brooding of ducklings for two weeks. A rearing house with a dimension of 1.0m x 1.5m was constructed for each replication to accommodate 10 heads during the experimental period.

The structure was built using wood, bamboo and G.I sheet. Five inches deep rice hull was provided as litter materials. The rearing area served as shed for the birds during night time and inclement weather.

Preparation of the Experimental Area

The range area is four (4) sq m. per bird. A total of 150 heads of ducks was used for the whole duration of the study. The total area used in this study is 600 square meters which was divided into 15 experimental units to come up with 40 square meters per experimental unit. The experimental area was enclosed and divided with poultry nets to prevent transfer of birds to other groups and likewise protect them from predators.

Sources of Feed Ingredients

The ingredients such as SOM, fish meal, coco oil, molasses, DL-methionine, L-Lysine, diCal.Phos, and vitamin premix were bought at Decena Feed Mill in Enrile, Cagayan. Salt, copra meal, and yellow corn were purchased locally.*Moringa oleifera* leaves were collected from the locality, sun dried to 13-14% and milled to form into MOLM.

Physical Appearance

The pekin ducks used in the study are F1 meat-type, fast growing that are procured from F1 Superior F1 Genetic Enterprise owned by free-range poultry specialist Dr. Erwin J. S. Cruz. This strain of duck is usually raised in confinement. During the experimental period, they grew fast even when in range and achieved an average of 2.4 kilograms in five weeks. Ducks fed with MOLM exhibited faster growth than the control group.

Pigmentation

During the study, ducks fed with MOLM have more prominent yellow beak and shank than the ducks fed with full soybean. Likewise, ducks fed with moringa have cleaner and smoother feathers than the control group. Moringa oleifera leaf meal does not only serve as protein source but also provide some necessary vitamins and oxy carotenoids which cause yellow color of broiler skin, shank and egg yolk (www.United caribbean.com. 2003).

The yellow pigment is highly visible in the skin of dressed ducks fed with moringa than the control group which exhibited slightly yellow skin. Generally, there was a pronounced intense yellowish coloration of the beak, legs, carcass cuts, abdominal fat and feathers of broilers that received dietary MOLM than birds that got no MOLM. This presumably may be due to the high content of beta-carotene in MOLM. The yellow color in the body and products of broilers observed in this study is an indication of the efficient absorption and utilization of the pigment xanthophyll present in MOLM. Similarly, Ayssiwede *et al.* (2011) observed that dietary MOLM inclusion to have produced yellow coloration of the skin and abdominal fat of growing indigenous chickens. The birds were experiencing yellow colouration of body parts which was mainly attributed to the presence of xanthophylls and carotenoid pigments in MOLM as in other tree and shrub leaf meals as outlined by Austic and Neishen (1990).

Livability

The ducks stayed on range from day 15 to day 37 under mixed orchard. There was no mortality observed during the experimental period even though there was intermittent rain and the temperature was very cold. This means that the feeds given and the range system of raising them have no adverse effect on their livability. However, it was observed that in the control group, feed consumption decreased on the 1st to 2nd day of the 2nd week of rearing, but recovered on the 3rd day of that week. In the treatment groups, there were no cases of any sickness even there was an adverse conditions experienced by the ducks in their range environment. This implies that the birds were easily acclimatized to their environment after they were transferred from the brooder to the range area.

Feeding and Grazing Behavior

Feeds are given at 6:00 in the morning for all the treatment replications throughout the study period. Refill of feeds was done any time when necessary or if they already consumed their feed allotment for the day. On their first day at the range area, the birds appeared to be very nervous and huddled together around their rearing houses.

As the day progress, they tend to adapt their new environment as they started to feed and graze. Throughout the study period, the birds generally exhibited normal feeding and grazing behavior. They fed and graze in the range alternately during the day and back to the rearing house to roost at night time. Lights were not provided at the rearing houses.

Results and Discussion

Initial and Weekly Body Weight

The initial and weekly body weight of pekin duck fed different levels of *Moringa oleifera* leaf meal as soybean substitute under mixed-orchard farming system is presented in Table 1. The initial weight of birds ranges from 845.8 to 903.3 grams. The body weight of ducks on the first week of feeding ranged from 1271.7 to 1485 grams and had different trend with the body weights of duck on the second week with body weight ranged from 1786.7 to 2038.7 grams. The body weight of ducks on the second week and third week of feeding followed the same trend. On the third week of feeding, birds in T_1 (25% MOLM) had a body weight of 2602.8 grams, followed by T_2 (50% MOLM) 2418.9 grams, T_0 (SOM) 2389.5 grams, T_3 (75% MOLM) 2374 grams and T_4 (100% MOLM). During the fourth week of giving the feeds, birds in T_1 (25% MOLM) recorded 2952.7 grams, followed by T_3 (75% MOLM) 2811.4 grams, T_0 (SOM) 2751.9 grams, T_2 (50% MOLM) 2740.8 grams and T_4 (100% MOLM) 2638 grams.

The analysis of variance of the data on weights on the first, second week and the fourth week showed no significant ($p>0.05$) differences among treatment means. This finding showed the different levels of MOLM as soybean substitute on their diet did not in any way affect their weekly weight performance during the first two weeks and during the fourth week. On the fourth week, although the difference is insignificant, there was reason to believe that the partial substitution of SB with MOLM from 25% to 75% could enhance the body weight of pekin duck which was shown by the performances of T_1 (2952.7 grams), T_3 (2811.4 grams) and T_2 (2740.8 grams), which are greater than the performance of the to (control).

Further, there was a reason to believe that full (100% substitution) of SB with MOLM could depress the performance of pekin duck which was shown by the performance of T_4 (100% MOLM) 2638 grams which got the lowest body weight.

However, the analysis of variance on the weight of ducks on the third week feeding revealed significant ($p<0.05$) differences among treatment means. This shows that the different levels of MOLM as soybean substitutes on their diets affects the weekly weight performance of ducks at the end of the study. Comparison between means revealed that T_1 significantly ($p<0.05$) differed with T_0 (control) and the other treatments. On the other hand, T_0 (control) is not significantly ($p>0.05$) differed with T_2, T_3, and T_4. The highest weight (2602.8 grams) was recorded by ducks given diets with T_1 (25% MOLM) as partial substitute to soybean while the lowest weight (2275.2 grams) was recorded by ducks given diets with T_4 (100% MOLM) as soybean substitute.

There was no significant ($p>0.05$) difference in the body weight between ducks fed diets T_0 (control), T_2 (50% MOLM), T_3 (75% MOLM) and T_4 (100% MOLM). This result implies that substituting soybean beyond 25% up to full replacement with moringa leaf meal significantly decreased the body weight of ducks.

The lower body weight in $T_3$and T_4 was attributed to the higher levels of crude fiber in the mixture and the findings agree with literature that monogastrics cannot utilize high crude fibre diets efficiently.

The depression in growth with increased MOLM inclusion level agree with the general similar observations noted before with leaf meal inclusion in the diet of poultry (Ash and Akoh, 1992; Opara, 1996), even when maize oil was used to compensate for the low metabolizable energy value of the leaf meal (Opara, 1996). However, up to 24% inclusion level of MOLM in the diet of growing indigenous Senegal chicken with no negative impact on body weight, average daily weight gain and feed conversion ratio was reported (Ayssiwede *et al.*, 2011).

Table 1. Initial and Weekly Body weights of (g) of Pekin Duck fed different levels of *Moringa oleifera* Leaf Meal (MOLM) as soybean substitute under mixed-orchard farming system.

Treatments	Weekly Body Weight (g)				
	Initial	1st	2nd	3rd	4th
To (SB)	903.3	1485.0	1853.5	2389.5[a]	2751.9
T1 (25% MOLM)	877.4	1391.0	2038.7	2602.8[b]	2952.7
T2 (50% MOLM)	853.0	1410.0	1871.5	2418.9[a]	2740.8
T3 (75% MOLM)	845.8	1305.7	1889.2	2374.0[a]	2811.4
T4 (100% MOLM)	902.0	1271.7	1786.7	2275.2[a]	2638.0
ANOVA Result	ns	ns	ns	*	ns
C.V. (%)	4.16	6.31	6.79	3.88	4.46
$LDS_{0.05}$				170.44	

ns = not significant

* = significant at 5% level

Note: Means with common letters are not significantly different with each other using LSD.

Cumulative Gain in Weight

The cumulative gain in weight (grams) of pekin duck fed different levels of MOLM as soybean substitute is presented in table 6. Based on the result, the range of the gain in weights attained by the ducks given diets with different levels of MOLM as soybean substitute on the first week was 369.7 grams to 581.8 grams with the T_0 (control) gained 581.8 grams, followed by T_2 (50% MOLM) 557.0 grams, T_1 (25% MOLM) 513.6 grams, T_3 (75% MOLM) 459.9 grams and T_4 (100% MOLM) with 369.7 grams.

On the 2nd week of feeding the duck with different levels of MOLM as soybean substitute, the range on their cumulative gain in weight was 884.8 grams to 1161.3 grams. T_1 had a cumulative gain of 1161.3 grams. T_1 (25% MOLM) 1161.3 grams, T_3 (75% MOLM) 1043.4 grams, T_2 (50% MOLM) 1018.5 grams T_0 (contro) 950.2 grams and T_4 (100% MOLM) 884.8 grams. On the third week of the study, T_1 (25% MOLM) had the total gain of 1725.4 grams, followed by T_2 (50% MOLM) 1565.9 grams, T_3 (75% MOLM) 1528.2 grams and T_4 (100% MOLM) with 1373. 3 grams. On the fourth week, T_1 (25% MOLM) recorded a weight gain of the analysis of variance on the cumulative gain in weight on the first and second week revealed that there were no significant ($p>0.05$) differences among the treatment means. This finding showed the different levels of MOLM as soybean substitute on their diet did not in any way affect their weight gain performance during the first two weeks. However, it is evident that partial substitution of SB with MOLM from 25% to 75% could enhance the growth of pekin duck which was shown by the performances of T_1, T_2 and T_3, 1161.3, 1018.5 and 1043.4 grams, respectively, which are greater than the performance of To (control). Further, although not significant, there was a reason to believe that full (100% substitution) of SB with MOLM could depress the performance of pekin duck which was shown by the performance of T_4 (100% MOLM) 884.4 grams which got the lowest weight gain.

On the 3rd and 4th week, the analysis of variance revealed that there were significant ($p<0.05$) differences among the treatment means. This shows that the different levels of MOLM as soybean substitute on their diets affects the weekly weight gain performance of ducks at the end of the study. Comparison between means on the weight gain of ducks on 3rd week showed that T_1 (25% MOLM) significantly differed with T_0 (SB), T_3 (75% MOLM), and T_4 (100% MOLM) but not with T_2 (50% MOLM). Likewise, T_4 differed from T_1 and T_2 but not with T_0 and T_3. On the 4th week, comparison of means showed T_1 (25% MOLM) significantly differed from T_0 (SB) and T_4 (100% MOLM) but not with T_2 (50% MOLM) and T_3 (75% MOLM). On the other hand, T_0 (SB) significantly differed with T_1 (25% MOLM) but not with T_2 (50% MOLM), T_3 (75% MOLM) and T_4 (100% MOLM). The result of the study would mean that the different levels of moringa leaf meal up to full substitution resulted a significant ($p<0.05$) effect on the body weight gain of ducks.

The highest weight gain was recorded and maintained by ducks given diets with 25% MOLM as partial substitute to SOM while the lowest weight gain was recorded by ducks given diets with full MOLM as SOM substitute. There was no significant ($p>0.05$) difference in the body weight gain between ducks fed diets with 25% and 50% moringa leaf meal as soybean substitute. Although 50% compared favourably with 25%, it had the lesser weight gain of 1565.9 g. Although there were no significant ($p>0.05$) differences in body weight gain among the control (full soybean), 75% and 100% Moringa leaf meal, there was a reason to believe that partially replacing SOM with MOLM at T_1 (25% MOLM), T_2 (50% MOLM) to T_3 (75% MOLM) could boost the weight gain of Pekin duck which was shown by the performance of T_1, T_2 and T_3, with 2075.3, 1887.8 and 1965.5 grams, respectively which are greater than the performance of the T_0 (control) 1848.7 grams.

The full (100% MOLM) compared favourably with full soybean and 75% MOLM as soybean substitute; it had the least body weight gain which could be a reason to believe that fully substituting the SOM with MOLM could depress the growth of pekin duck. This implies that substituting soybean up to full replacement with MOLM evidently decreased the body weight gain of ducks although the difference is not significant.

Final weight and weight gained declined as MOLM level increased. This is also in line with findings from a study by Olugbemi *et al.* (2010) in inclusion MOLM to cassava based diets fed to broiler chickens. In the study of supplementing soyabean meal with MOLM, mean weight of broilers was significantly different for T_3 (50% MOLM), T_4 (75% MOLM) and T_5 (100% MOLM). However, there was no significant difference in the mean weight of broilers between T_1 (0% MOLM) and T_2 (25% MOLM). Significant weight gain differences were noted between treatment five and treatment one and between treatment two and five. The difference could be due to high fibre levels that were in treatment five with 100% MOLM in the diet as protein source. The findings agree with literature that monogastrics cannot utilize high crude fibre diets efficiently.

Table 2. The cumulative gain in weight (g) of Pekin Duck fed different levels of *Moringa oleifera* Leaf Meal (MOLM) as soybean substitute under mixed-orchard farming system.

Treatments	Cumulative Weekly Weight Gain (grams)			
	1st	2nd	3rd	4th
To (SB)	581.8	950.2	1486.2^{bc}	1848.7^{bc}
T1 (25% MOLM)	513.6	1161.3	1725.4^{a}	2075.3^{a}
T2 (50% MOLM)	557.0	1018.5	1565.9^{ac}	1887.8^{ab}
T3 (75% MOLM)	459.9	1043.4	1528.2^{bc}	1965.5^{ac}
T4 (100% MOLM)	369.7	884.8	1373.3^{b}	1736.0^{b}
ANOVA Result	ns	ns	*	*
C.V. (%)	17.75	11.16	6.39	5.88
$LSD_{0.05}$			178.44	203.4

ns = not significant;

* = significant at 5% level

Note: Means with common letters are not significantly different with each other using LSD.

Feed Consumption

The feed consumptions of pekin ducks were not comparable during the first two weeks of the feeding period. During the first week, the feed intake of pekin ducks ranged from 1265.3 grams to 1377.1 grams and on the second week, the feed intake ranged from 1411.9 grams to 1787.3 grams. The analysis of variance on the cumulative feed consumption revealed that there were significant ($p<0.05$) differences among the treatment means. This shows that the different levels of MOLM as soybean substitute on their diets affects the feed intake performance of pekin ducks. Comparison between means showed that T_1, (25% MOLM) and T_0 (SB) are significantly ($p>0.05$) differed with T_3 (75% MOLM) and T_4 (100% MOLM) but not with T_2 (50% MOLM).

The highest feed intake was recorded by pekin ducks given T_1 (25% MOLM) and this feed intake is comparable with the feed intake of pekin duck given diets T_0 (SB). The least feed intake was recorded by pekin ducks given diets T_2 (50% MOLM).

On the third and fourth week, the analysis of variance revealed insignificant ($p>0.05$) differences among treatment means. This finding showed that the pekin duck given different diets had comparable feed intake on the third and fourth week.

On the total feed intake from week 1 to week 4, the analysis of variance revealed significant ($p<0.05$) differences on the means of the total feed intake of pekin. The highest feed intake was recorded by pekin duck given T_1 (25% MOLM) of 6291.1 grams. The least was recorded by T_0 (SOM) 5955.9 grams and this feed intake is comparable with the feed intake of pekin duck in T_2 (50% MOLM), T_3 (75% MOLM) and T_4 (100% MOLM). This result means that the feed intakes of pekin ducks were not the same and this is affected in any way by the different level of MOLM as SOM substitute. These finding is in accordance with the study of Paguia *et al.* (2012) that fed *M. oleifera* leaf and twig powder (MLTP) to force molted hens and assessed their performance.

The authors found no effect of MLTP on feed intake, feed efficiency, egg sensory evaluation (egg flavour and egg acceptability score) but reported significant effect on egg weight and feed cost per kilogramme of eggs produced. In another study, the influence of MOLM on growth performance of broilers was assessed and treatment was found to have no effect on average cumulative feed consumption, final live weight, FCR, feed cost per kilogramme of broiler produced, and income over feed and chick cost.

This finding is also supported by results from studies of substitution on sunflower seed meal with MOLM in diets of laying hens by Kakengi *et al.* (2007) that indicated significant progressive increase in feed intake were on birds fed 10% and 20% MOLM levels. The results show that there was no significant difference in mean feed intake between T1 (0% MOLM) and T2 (25% MOLM) as demonstrated by Kakengi *et al.* (2007) where dietary treatments did not show any significant effect on feed intake and dry matter intake up to 5% MOLM.

Table 3. The cumulative feed consumption (g) of Pekin Duck fed different levels of *Moringa oleifera* Leaf Meal (MOLM) as soybean substitute under mixed-orchard farming system.

Treatments	Weekly Feed Intake (grams) Cumulative				
	1st	2nd	3rd	4th	Feed Consumption
To (SB)	1371.7^{a}	1594.4^{b}	1277.1	1712.7	5955.9^{b}
T1 (25% MOLM)	1377.1^{a}	1787.3^{a}	1543.8	1582.9	6291.1^{a}
T2 (50% MOLM)	1322.3^{ab}	1411.9^{c}	1544.8	1719.0	5997.9^{b}
T3 (75% MOLM)	1265.3^{b}	1649.9^{ab}	1321.1	1734.2	5970.5^{b}
T4 (100% MOLM)	1274.0^{b}	1644.9^{ab}	1436.0	1765.6	6120.5^{b}
ANOVA Result	*	*	ns	ns	**
C.V. (%)	3.16	6	14.51	5.02	1.37
$LDS_{0.05}$	76.13	176.66			201.26

ns = not significant

* = significant at 5% level

** = significant at 1% level

Note: Means with common letters are not significantly different with each other using LSD.

Feed Conversion Ratio and Efficiency

The Feed Conversion Ratio (kg/kg) and Feed Conversion Efficiency (%) of Pekin Duck fed Different Levels of MOLM as SBM substitute under mixed-orchard farming system is highlighted in Table 4.

The feed conversion ratio and efficiency varied among the treatments. The feed conversion ratio ranged from 3.04 to 3.53. T_1 (25% MOLM) and T_3 (75% MOLM) recorded 3.04, T_2 (50% MOLM) 3.19, T_0 = (SBM) 3.23 and T_5 (100% MOLM) 3.53.

The feed conversion efficiency ranged from 28.38% to 32.96%. T_5 (100% MOLM) recorded 28.38 and T_1 (25% MOLM) recorded 32.96%.

The analysis of variance on the feed conversion ratio and feed conversion efficiency revealed significant ($p<0.05$) differences among the treatment means. The FCR of T_1, T_2, and T_3, are significantly differed with T_4 but not with T_0. The FCE of T_1, T_2, and T_3, are significantly differed with T_4 but not with T_0 and the FCE of T_2 is comparable with the FCE of T_4. This finding showed the different levels of MOLM as soybean substitute affect in any way the feed conversion ratio and feed conversion efficiency of pekin duck. Pekin duck fed diets T_1 (25% MOLM) and T_3 (75% MOLM) performed the best because of lowest FCR and highest FCE of 3.04 and 32.96%, respectively. Since the FCR and FCE of T_2 are comparable with that of T_1 and T_3, then T_2 may be regarded best.

This implies that substitution of SBM by MOLM by 25 % up to 75% improves the conversion ability of the birds. This could be explained by the literature that Moringa is not only concentrated in nutrients, but it seems to reduce the activity of pathogenic bacteria and molds and improves the digestibility of other foods, thus helping chickens to express their natural genetic potential (Gaia, 2005). This could also be supported by the study conducted in Botswana, Kwedibana (2008) who evaluated the effects of MOLM at 10% inclusion level on the growth rate of broilers and found that commercial broiler diet significantly ($P<0.05$) promoted higher weight gain (1.04kg) than MOLM. Feed intake was also higher for birds fed commercial diets than those on MOLM. On the other hand, FCR was higher for birds on MOLM than those fed commercial diets.

The findings are also in accordance with a study conducted in Zimbabwe and with the experiment conducted by Portugaliza and Fernandez. In Zimbabwe, Gadzirayi *et al.* (2012) investigated the effects of supplementing soya bean meals with MOLM as a protein source in poultry and found no significant differences in feed intake of broilers, however, significant differences in FCR were noted. It was concluded that inclusion of MOLM as protein supplement in broiler diets at 25% promoted more growth than commercial diets. Portugaliza and Fernandez (2012) supplemented Cobb broiler diets with varying concentrations of *M. oleifera* aqueous leaf extract (MoALE) through drinking water and found that at 90 ml MoALE, feed intake of broilers was consistently lower than that of control group (commercial diet). The live weight of broilers given 30 ml, 60 ml and 90 ml MoALE were significantly higher than the control group. The MoALE treated broilers were more efficient converters of feeds into meat than the control group.

The study concluded that MOLM could be used as a source of plant protein since it was highly accepted by the birds even at high dietary inclusion levels.

Table 4. The Feed Conversion Ratio (kg/kg) and Feed Conversion Efficiency (%) of Pekin Duck fed Different Levels of *Moringa oleifera* Leaf Meal (MOLM) as Soybean substitute under mixed-orchard farming system.

Treatments	Feed Conversion Ratio (kg/kg)	Feed Conversion efficiency (%)
T0 (SB)	3.23^{ab}	31.04^{ab}
T1 (25% MOLM)	3.04^{b}	32.96^{a}
T2 (50% MOLM)	3.19^{b}	31.42^{ac}
T3 (75% MOLM)	3.04^{b}	32.92^{a}
T4 (100% MOLM)	3.53^{a}	28.38^{bc}
ANOVA Result	*	*
C.V. (%)	5.47	5.57
$LSD_{0.05}$	0.319	3.175

* = significant at 5% level

Note: Means with common letters are not significantly different with each other using LSD.

Return Above Feed Cost

The cost per kilogram of feeds for the different treatments showed that Treatment 4 (100% MOLM) had the least cost with P22.11, followed by Treatment 3 (75% MOLM) with P22.29, Treatment 2 (50% MOLM) with P22.59, T1 (25% MOLM) with P22.91 and the highest cost of feeds was attained by Treatment 0 (Control) with P23.52 . It is evident that the higher the MOLM content of the ration, the lower will be the cost of feed production, thereby commanding a lower price per kilogram of feed. The cost of duck and feed for the different treatments showed that T_1 had the highest cost, followed by T_0, T_4, T2, and T_3 with costs of P 231.86, P230.41, P225.55, P220.25, and P217.64, respectively.

The profitability would not rely primarily on the cost of duck and feeds but on the growth performance of the ducks which could compensate the cost spent on ducks and feeds. In this study, results showed that T_1 recorded sales of P 311.30 per bird followed by T_3 with P 294.83, T_2 with P 283.17, To with P277.31 and T_4 got the lowest sales of chicken with P 260.40. It can be deduced that birds fed diets with MOLM particularly 25%, 75%, and 50% MOLM levels could generate more income because of a better gain in weight which resulted in bigger birds as compared to 100 % MOLM and full soybean diet.

With respect to income per duck, again Treatment 1 (25% MOLM) got the highest income with P 79.43, followed by Treatment 3 (75%MOLM) with P77.18, which are far from the income achieved by T_4 and T_0 with 34.85 and P 46.89 respectively. It is clear that the best MOLM levels that can be used to attain a good income in ranged Pekin duck would be 25% and 75 %, which recorded the best return above feed cost.

Table 6. Return Above Feed and Bird Costs of Pekin Ducks fed Different Levels of *Moringa oleifera* Leaf Meal (MOLM) as Soybean substitute under mixed-orchard farming system.

	Treatments				
Item	$T0_{Control}$	$T1_{25\ \%\ MOLM}$	$T2_{50\ MOLM}$	$T3_{75\%\ MOLM}$	$T4_{100\%\ MOLM}$
Cost, P					
Cost/kg feed	23.52	22.91	22.50	22.29	22.11
Cost of Pekin duck/ treatment	2,709.90	2,632.20	2,559.00	2,537.40	2,706.00
Cost of feed/Treatment	4,202.48	4,323.72	4,048.44	3,991.86	4,060.61
Cost per Pekin Duck	90.33	87.74	85.30	84.58	90.20
Cost of Feed/Duck	140.08	144.12	134.95	133.06	135.35
Total Cost per Duck	230.41	231.86	220.25	217.64	225.55
Sales					
Cost/kg Duck live weight	150.00	150.00	150.00	150.00	150.00
Total Sales/Treatment	8,319.15	9,338.85	8,495.10	8,844.75	7,812.00
Total Sales/Duck	277.31	311.30	283.17	294.83	260.40
Income/Duck	46.89	79.43	62.92	77.18	34.85

Conclusion and recommendation

The study s conducted to determine the growth performance, carcass yield, and meat quality analysis, and profitability of pekin duck fed different levels of *Moringa oleifera* leaf meal as soybean substitute under mixed-orchard farming system. The study was laid out in completely randomized design with three replications for the growth performance, carcass yield parameters. Results revealed that significant results were found on the body weight, weight gain and feed consumption parameters of pekin ducks. Pekin duck fed T_1 (25% MOLM) was the heaviest, gained more weight, and consumed more feeds. Likewise, significant results were found out on the feed conversion ratio and feed conversion efficiency. Pekin Duck fed T_1 (25% MOLM), T_2 (50% MOLM) and T_3 (MOLM) performed the best as manifested by their low FCR and high FCE. Further, the growth of pekin duck fed diet with 25% MOLM significantly improved their growth parameters. However, substitution of MOLM for SOM beyond 25% declines the performance of pekin duck. Although it is insignificant, there are reasons to believe that partial substitution from 25 % up to 75% of MOLM for SOM

performed better than the control. Full replacement of MOLM to SOM has no significant effect on the growth and carcass yield parameters of pekin duck. Insignificant results were found on the carcass yield parameters of pekin duck fed different levels of MOLM as SOM substitute.

Fiannly, Pekin duck fed diet with 25% MOLM substitution recorded the highest cost income per bird followed by 75% MOLM and 50%. This implies that partial substitution from 25% to 75% for SBM gave better return above feed and duck costs than 100% substitution and full soybean diet.

For the recommendations, substituting 25% MOLM for SOM as protein source on the diet of pekin duck is recommended under mixed-orchard farming system because it had the best results on all growth and income parameters. It is also recommended that a similar study be conducted substituting fishmeal with different levels of MOLM as protein source in the diet of pekin duck and also to broiler and laying chickens. Likewise, a study on the anthelmintic property of *moringa* on poultry is also recommended.

APPENDIX

T3R1	T2R2	T1R1	T2R1	T0R1
T1R2	T3R3	T4R1	T1R3	T4R2
T4R3	T0R2	T2R3	T0R3	T3R2

Fig. 1. The Experimental Lay-out.

To – Control - 100 % SOM

T1 – 25% MOLM substitution of SOM

T2 – 50 % MOM substitution of SOM

T3 – 75 % MOLM substitution of SOM

T4 – 100 % MOLM

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