EVALUATION OF *Moringa olifera* LEAF MEAL AS AN ALTERNATIVE PROTEIN FEED INGREDIENT IN LAYERS RATION

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ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled "**EVALUATION OF *Moringa olifera* LEAF MEAL AS AN ALTERNATIVE PROTEIN FEED INGREDIENT IN LAYERS RATION''** submitted in partial fulfillment of the requirements for the degree of Master's with specialization in Animal Production, Department of Sciences, College of Agriculture and Natural Resource, and has been carried out by Fikadu Desse ID. No AGPGR 014/12, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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As Research Thesis advisor, I /we hereby certify that all given comment by reviewer have been considered, read and evaluated the thesis entitled **"EVALUATION OF *Moringa olifera* LEAF MEAL AS AN ALTERNATIVE PROTEIN FEED INGREDIENT IN LAYERS RATION''** we recommend that it can be submitted as fulfilling the MSc thesis requirement**.**

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DEDICATION

I dedicated this thesis manuscript to my family for their moral and encouragement in the study period in particular and throughout my life in general.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my bonafide work and that all sources of materials used for the thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirement for MSc degree at Wolkite University and is deposited at the University Library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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LIST OF ABBREVIATIONS ANDACRONYM

AH	Albumen Height
AOAC	Association of Official Analytical Chemist
AR	Albumen Ratio
BWC	Body Weight Change
BWG	Body Weight Gain
DBWG	Daily Body Weight Gain
CF	Crud Fiber
CP	Crude Protein
CSA	Central Statistics Agency
CRD	Completely Randomized Design
DM	Dry Matter
EE	Ether Extract
ENTAG	Ethio- Netherland Trade For Agricultural Growth
EW	Egg Weight
FAO	Food and Agricultural Organization
FI	Feed Intake
HU	Haugh Unit
HDEP	Hen Day Egg Production
HHEP	Hen House Egg Production
Kcal	Kilo Calorie
Kg	Kilogram
masl	Meter Above Sea Levels
ME	Metabolisable Energy
MOLM	Moringa Olifera Leaf Meal
MSLM	Moringa Stenopetala Leaf Meal
NCD	New Castle Disease
NI	Net Income
NSC	Noug Seed Cake
SAS	Statistical Analysis System
SNNPRS	South Nation, Nationalities Peoples Regional State
TC	Total Cost
YR	Yolk Ratio

BIOGRAPHICAL SKETCH

The author was born on July 1983 in Cheha Wereda, Gurage Zone, Southern Nations and Nationalities Regional State. He attended his elementary and secondary education in Emdibir Junior Elementary and in Emdibir secondary school respectively. After passing the Ethiopian School Leaving Certificate Examination, he joined Wolayita ATVET College in 2003and graduate with Advanced Diploma in Animal Sciences in July 2005.

After graduation, he was employed by Cheha woreda Agricultural development office in September 2006and served as Development agent, animal production expert and Supervisor for six years in the Department of Animal Science. After six years, he joined Dilla University of Agriculture in September 2011 and graduated with BSc degree in Animal Sciences in November 2015. After graduation, he worked there as beekeeping expert until June 2015.

Since June 2015the author was transferred to Gurage zone agriculture and rural development department of livestock and fishery and served at beekeeping expert, poultry production expert at zonal level until he joined Wolkite University to pursue my post graduate studies in Animal production and Technology in September 2020.

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ABSTRACT

The study was conducted to evaluate effects of Moringa Olifera Leaf Meal (MOLM) inclusion in layers ration on egg laying performance, egg quality parameters and the economic feasibility of using MOLM as alternative protein source in the ration of Bovans brown hens. A total of One hundred and eighty Bovans Brown hens aging 18 weeks were used for the experiment. The experiment was arranged in a completely randomized design with four treatments, each replicated three times with 15 hens each. The layers were fed with ration containing MOLM at the levels of 0 in (T_1), 5 in (T_2), 10 in (T_3) and 15% in (T_4). The experiment lasted 11 weeks. The amount of feed intake per hen per day was 117.3gm in T1, 116.37gm in T2, 119.74gm in T3 and 115.32gm in T4.Feed conversion ratio was 0.26 in T1, 0.29 in T2, 0.33 in T3 and 0.29in T4. Average egg weight was 59.94g in T1, 63.79g in T2, 65.65g in T3 and 62.84g in T4. The hen day egg production was 50.9 in T1, 51.43 in T2, 63.21 in T3 and 52.58% in T4. Most of the egg quality parameters were higher in T3 except egg shape index, albumin height, yolk height, albumin height and albumin ratio that were similar ($P > 0.05$) among treatments. Higher yolk color was observed for T3 and T4 compared with T1. Yolk length was higher ($p<0.05$) for T2 and yolk ratio was higher ($p<0.05$) for T1. The partial budget analysis indicated that the inclusion of 10% (T3) of MOLM reduces total feed cost compare to the control treatment and other treatments. Therefore, it is concluded that addition of 10% of MOLM cloud be used in the layers diet as recommended level as an alternative protein source to enhancing the productivity and to reduce the feed cost in the poultry industry.

Key words: *Egg Production; Egg Quality; Layer; Moringa Olifera Leaf Meal*

1. INTRODUCTION

1.1. Background of the study

Poultry production is one of the most important agricultural subsectors for rural communities in Ethiopia. It is the vital to meet food security by producing a high quality animal source protein and being income source to most rural population (melesse, 2014). Poultry production contributes important socio economic roles for food securities, income generating and religious/cultural purpose (Salem, 2005).

In Ethiopia the poultry production system categorized in to three groups. These are industrial, integrated (medium and large scale intensive system) and family production system (FAO, 2019b). Family poultry production system is suitable enterprise for women and poor household due to small quantity of land needed and low starting cost. Family poultry production systems are classified into four groups based on market access, production objectives, level of specialization/technology use, flock size, etc. These are large scale commercial farm, small scale intensive, semi-intensive and extensive/scavenging (FAO 2014, Wondimeneh *et al.,* 2017).

The intensive system uses improved breeds but the extensive or scavenging system is common in rural areas and usually keeps indigenous chickens. The indigenous chickens are important source of quality meat and eggs as food and cash income for the majority of the people living in the rural areas (Njenga 2005). Even if, the indigenous chicken are better to adapt the harsh environment, tolerant to many diseases and are good brooders, they are poor in their reproductive and productive performance. Therefore, in order to improve the performance of the indigenous chickens, the exotic chickens are imported and then crossed with local chickens (Nigussie, 2011).

There are different type of exotic breeds are introduced to Ethiopia in the past years. Even if, there is no record or evidence indicating the exact time and locations of introduction of the first batch of exotic breeds of chickens into the country for genetic improvement, it is widely believed that the importation of exotic breeds of chicken goes back to the early 1950s. It has been reported that many exotic breeds of chicken (White and brown Leghorns, Rhode Island Red, Bovans, Sasso, Potchefstroom Koekoek, New Hampshire, Cornish, Australoup and Light Sussex) were introduced (Tamir et al.,2015).

Among the different type of exotic breeds, Bovans brown breed is the most familiars and widely distributed breed and used layer hybrid in both urban and rural area of the current study area. According to the data Gurage Zone Livestock and fishery resource department (GZLSFR) 2019, Bovans brown breed is the most familiar and more distributed to farmer in the study area next to Sasso breed. According to the product guideline of the breed, the breed is formed from the four family were Bongers, Van Duijnhoven, Van Lankveled and Van derlinden in the year of 1954 at Netherland (Bovans @ Hendrix - gentices.com).

The total population of poultry in Ethiopia estimated to be about 57 million, of which 78.85, 12.02, 9.11 % were reported to be indigenous, hybrid and exotic, respectively (CSA, 2020/21). About34.9, 55.7 and 9.4% of the egg production come from indigenous, hybrid and exotic breeds of chickens in Ethiopia, respectively (CSA, 2019/20).According to the data collected by ENTAG (2020), annual egg production is estimated to be 1.83 billion eggs or about 73,357 tons and Poultry meat production is conservatively estimated to be 7,750 tons per year.

1.2. Statement of the problem

Even if, In Ethiopia there is a huge number of poultry population, the total production and productivity per unit of hen is relatively low. There are different factors like predators, diseases, lack of proper healthcare, feed source and poor marketing information that decrease the productivity of the poultry in most area of the country. Among the above factors, scarcity of quantity and quality (consequent high price of conventional energy and protein sources) feed are the main constraints incriminated for reduction of total numbers and compromised productivity (Aberra *et al*., 2011). Due to the rising price of feed ingredients it is becoming uneconomical to use them widely in poultry feeding in Ethiopia. So, there is a need to search for locally available source of protein feed ingredients among the non-conventional feed staff with potential of improving poultry performance (Farinu *et al*., 2008).

It has widely been reported that leguminous plant has a potential of provide protein source (Sanchez-Machedo et al., 2006, Iheukwumere et al., 2008 and Moyo et al., 2011). According to Fasuyi *et al*., (2005) leaf meals not only serve as protein source but also provide some necessary vitamins, minerals and oxycaretenoids which cause yellow color of egg yolk. Many finding shows that, Leaf meals of various plants have been incorporated in the diets of poultry as a means of reducing the high cost of conventional protein sources (Kakengi *et al*., 2007; Nworgu and Fasogbon, 2007). Among the leaf meals of various plants Moringa Olifera Leaf Meal (MOLM) is the one which has a potential of provide protein source (Fahey, 2005).

Moringa can easily be established in the field, has good coppicing ability and good potential for forage production. Furthermore, there is the possibility of obtaining large amounts of high quality forage from Moringa without expensive inputs due to favorable soil and climatic conditions for its growth (Makker and Becker 1999; Sarwatt *et al*., 2002). The use of Moringa as a protein resource have numerous advantages, 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). Moringa Olifera is a fast-growing tree. It can reach a height of 10-12 m and the trunk can reach a diameter of 45 cm (Olson and Cariquist 2001). The tree is often called 'multipurpose' due to the fact that all parts include leaves, pods, seeds, flowers, fruits and roots are edible (Orwa *et al*., 2009).

In Ethiopia Moringa Olifera tree is widely cultivated in different zones of the country and farmer use for different purpose in the south Nation Nationality people (SNNP)(Reta, 2016).In the study area the matured moringa tree leaves harvest five times per year. The minimum productivity of moringa tree leaves 85 k/g per year per tree. Farmers do not sell the moringa tree leaves but they use for home consumption and give to everyone who wants the moringa leaves with minimum cost.The cost of MOLM is cheaper than other conventional protein sources in the farmer level because farmers can easily harvest the leaves from their back yard with minimum cost. Based on the above information provided, MOLM used as an alternative protein source ingredient can potentially improve the production performance and egg quality of layer chicken as well it can also contribute towards minimizing the feed cost.

The previous works showed that substitution of SBM with MOLM up to 15% resulted improvements in egg production, feed intake and average daily gain in dual purpose Koekoek Chicken (Wubalem, 2016). MOLM is used as an alternative ingredient to replace SBM in the diet of Hubbard classic (Etalem *et al*., 2013), and inclusion of MSLM on ration of RIR increased the nutrient intake and growth performance of dual purpose Rhode Island Red (RIR) chicks(Abera.*et al*., 2011). However, there is scarcity of information regarding effect of substitution of protein source other than SBM with MOLM on performance and egg quality of Bovans brown layer hybrid chickens in Ethiopian condition.Therefore, this study was designed to use*MO*LM as an alternative protein feed ingredient to substitute NSC in Bovans brown layers ration with the following objectives.

1.3. Objectives

General objective

- To investigate the egg production performance and egg quality of layers fed varying dietary levels of MOLM used as an alternative protein source.

Specific objectives

- To investigate the effects of feeding of varied levels of MOLM on egg production, feed intake, body weight change and feed conversion ratio of Bovans brown chicken.
- To investigate the effects of feeding MOLM on egg quality of Bovans brown chicken.
- To evaluate the economic feasibility of MOLM used as alternative protein source in the ration of Bovans brown hens.

2. LITERATURE REVIEW

2.1. Description of Moringa Olifera Tree

Moringa Olifera tree is the most widely cultivated species of a monogeneric family, Moringaceae, and includes 13 species of trees and shrubs native and distributed in sub-Himalayan regions of India, Srilanka, North Eastern and South Western Africa, Madagascar and Arabia (Monera *et al*., 2008). Moringa Olifera tree is native to Ethiopia, and it is known by various vernacular names. It is called "*Haleko*" in Gofa, Gamo and Wolayita areas, "*Shelagda*" in the Konso language, and "*Shiferaw*" in Amharic (Engels and Goettsch, 1991 and Jahn, 1991).Many studies have been conducted on its nutritional and phytochemicals composition (Juliani *et al*., 2010, Nuinnuka et al., 2005). Moringa Olifera tree has different names based on their purpose in different area. Moringa Olifera is often called "cabbage tree" and is an important indigenous vegetable in south western Ethiopia where it is cultivated as a food crop. Moringa Olifera tree is one of the species from the different species in the Moringaceae family and it is a multipurpose tree of significant economic importance, as it has vital nutritional, industrial, and medicinal applications (Jahn, 1991; NRC, 2006).

Moringa olifera is an extremely fast-growing tree. According to Abou El, (2011) moringa tree can reach up to 4 m (15 ft.) in a year, reaching an eventual height of 6-15 m (20-50 ft.). It is advisable to prune trees frequently to a shrub form, or they will become lanky and difficult to harvest. It has good coppicing ability after pruning, and a capacity to produce high quantities of fresh biomass up to 120 tones dry matter/ha/year at high planting densities (Abou El, 2011). It is propagated either by planting or by seeding. It is drought tolerant and grows with rainfalls of 250-1500 mm (10-60 inches) per year. An altitudinal ranges below 600 m (2000 feet) is best for the Moringa olifera and in the sub-tropics. A good temperature range for moringa tree is 25-35º C (77-95º F) but Moringa can tolerate up to 48ºC (118ºF) for limited amounts of time. Moringa Olifera is adapted to a wide range of soil types and conditions, neutral to slightly acidic soil (pH range of 5.0 to 6.5) it grows best in sandy soils, sensitive to water logging and frost(Aregheore, 2002).

According to Sanchez *et al*., (2006) the Moringa olifera tree gave higher yields when harvested at a 75-day cutting interval. The green matter is harvested when plants reach a height of 50 cm or more (every 35-40 days). To harvest the green matter it should be cut at a height of 15-20 cm above the ground. Although losses of seedlings may be 20-30% in the first year, the vigorous regrowth of the remaining seedlings will produce 3 or 5 new shoots after each cutting. Up to nine time harvests can be obtained annually. Harvesting was carried out every 40–75 days, but this varies due to differences in the climatic conditions in which Moringa Olifera is grown (Newton *et al.*, 2006).

2.2. Uses of Moringa Olifera Tree Leaves

Moringa used as forage when during the time of unavailability of feed or during dry seasons and there are nutritional imbalances in feed (Essien*et al* 2016). According to Price (2000), Moringa leaves are used to feed cattle, pigs and poultry. When Moringa leaves constituted 40 to 50% of feed, the milk yields for dairy cows and daily weight gains for beef cattle increased by 30% and the birth weight of calve increased by 3 to 5 kg. In West Africa Moringa Olifera leaves appeared to be an alternative source of protein for ruminant production and can be used as supplement to diets based on crop residues/poor roughage (Nouala *et al*., 2006). Moringa Olifera leaves could be utilized as a source of feed supplement to improve growth performance and health status of poultry. However, the high protein content of Moringa leaves must be balanced with other energy feeds. Moringa Olifera leaves should be mixed with SBM, wheat middling, corn grain, or whatever else is locally available feed (Martin, 2007).

Some animals such as chickens will not voluntarily consume Moringa leaves or Moringa leaf powder due to high protein content in moringa. So, about half of the protein content can be extracted from the leaves in the form of a concentrate which can be added to chicken feed. Due to the presence of high crude protein and availability of the protein and low content of anti-nutritional compounds make it ideal for use as fodder. Using moringa as forage during dry season there is unavailability of feed and there is a nutritional imbalance in feed (Essien*et al.*, 2016).

Saponins present in some plants have adverse effect on the growth of animal but those present in Moringa do not show hemolytic activity. Moringa tree has medicinal uses. Leaves of Moringa Olifera are also known to have anti diabetic and anti-obese properties. Studies have shown that on orally administering the ethanolic leaves extract to the obese rats for 12 consecutive weeks, decreased the body weight and this treatment also normalized the insulin and blood glucose level of the obese group of rats (Metwally *et al.,* 2017). Moringa can also be useful in treatment of

Hyperthyroidism since aqueous leaf extract has been found to regulate thyroid hormone (Anwar *et al.*, 2007).

In addition moringa has socioeconomic value. In some parts of southern Ethiopia, especially among the Konso people, the abundance of Moringa species in the garden or on farmland indicates the social status of the owner among the society. The one with many Moringa trees in the garden or on farmland has a higher social status and also considered as rich man (Reta, 2016).The different part of the plant which includes root, bark, seed, flowers, pods, leaf, has potential food, agriculture and industrial uses.

Moringa Olifera leaves are a rich source of nutrients like protein, carbohydrate, fiber, Beta carotene, vitamin A, B, C and minerals like calcium, potassium, iron and phosphorous. They are recommended for pregnant and nursing mothers as well as young children (FAO, 2014).Moringa Olifera leaf powder is used for the re-nutrition of infants suffering from malnutrition (Bosch, 2004; Orwa *et al*., 2009; Radovich, 2009; FAO, 2014).The leaves are used in the treatment of anemia in the Philippines due to their high iron content (Orwa *et al*., 2009).The leaves of the moringa tree are the preferred part for use in animal diets as leaf meal. Research was conducted to study the effect of this leaf meal on the growth performance of layer (Melese *et al.,* 2011).

2.3. Chemical Composition of Moringa Olifera Tree Leaves

Many researches showed that Moringa Olifera tree have different chemical compositions. The of moringa tree are rich in nutrients like iron, potassium, calcium, and multivitamins, which are essential for livestock weight gaining and milk production(Newton *et al*., 2010; Mendieta *et al*., 2011). Oduro *et al.*, 2008 reported that Moringa Olifera leaves meal contains 27.5 crude protein, 19.25 crude fiber, 2.23 crude fat, 7.13 ash, 76.53 moisture, 43.88% carbohydrate and 1296.00 KJ/g calories. Similarly Yameogo *et al*., 2011 reported that Moringa Olifera leaves contained 27.2 protein, 5.9 moisture, 17.1 fat, and 38.6% carbohydrates. Anwar and Rashid 2007 noticed that Moringa Olifera seeds contained 34.80 ether extract, 31.65 protein, 7.54 fiber, 8.90 moisture, and 6.53% ash contents. Moringa leaves also contain 21.8 crude protein (CP), 22.8 acid detergent fibers (ADF), and 30.8% neutral detergent fiber (NDF), as well as 412.0 g kg^{-1} of crude fat, 211.2 g kg–1 of carbohydrates, and 44.3 g kg–1 of ash (Oliveira *et al*., 1999; Sanchez *et al*., 2006). All these compounds are useful to increase livestock production. Moreover, low-quality livestock fodders or rations can be improved by adding moringa leaves as a supplement, which increases the dry matter intake (DMI) and the digestibility of the fodder by livestock, as well as increasing the protein intake in fish diet (Richter *et al*., 2003).

Table 1Chemical composition of dried Moringa Olifera tree leaves as reported by different scholars

	Source				
Nutritive value	Busani M.*et al.*, 2011	Oduro*et al*., 2008	Wei Lu *et al*;.2016	Etalem *et al.*, 2013	Etalem *et al.*, 2018
Moisture (%)	95	76.53	86.73	90.9	86.9
Crude protein (%)	30.29	27.51	21.95	28.2	29.2
Ash (%)	7.64	7.13	8.51	11.9	12.9
Ether extract	Nd	Nd	9.42	6.6	5.6
Crude fiber	Nd	Nd	2.5	6.5	10.5
Calcium	Nd	Nd	Nd	0.76	2.76
Phosphorus	Nd	Nd	Nd	0.3	0.35
ME	Nd	Nd	Nd	3247	2247

NA: data not available

Moringa olifera leaves could be highly digestible because of its immense nutritional qualities such as its chemical composition (neutral detergent fiber (NDF); acid detergent fiber (ADF); crude protein (CP); gross energy (GE); ether extract (EE)) and amino acids profile (Rubanza *et al*., 2005). Moringa leaves contain more Vitamin A than carrots, more calcium than milk, more iron than spinach, more Vitamin C than oranges, and more potassium than bananas," and that the protein quality of Moringa leaves rivals that of milk and eggs(Fuglie, 1999& Fuglie,2000). Moringa Olifera leaves are rich in carotenoids, ascorbic acid and iron. The leaves are widely recognized as a food source for humans and a dry season feed for animals because of the nutrient contents it contains. Equally important is the fact that some parts of the tree contain toxins and other anti-nutritional factors that might decrease its potential as a source of food for animals or humans. For instance its bark contains tannins, alkaloids, saponins and inhibitors (Foidl *et al*., 2001). The protein content of the dried Moringa Olifera leaf powder is equivalent to the protein content of some pulses viz. moth beans, soybeans, kidney beans etc., which contain (22 - 24%) protein, thus used in food (Makker and Becker, 1990). Moringa Olifera used as a supplement can improve voluntary intake, digestibility and livestock performance (Aregheore, 2002).Moringa is able to extend the period of food containing fat due to the presence of several sort of anti-oxidant compounds such as Flavonoids, ascorbic acid, carotenoid and phenolic (Dillord and Germon 2000, Siddhuraju and Becker, 2003). Moringa Olifera has been reported to possess several nutrients including amino acid, minerals, fatty acid.

Amino acid composition

The dry Moringa olifera leaves could serve as a protein supplementary source in animal and human diets. This protein content is of particular nutritional significance since it has been suggested that amino acids supplementation is important in meeting a substantial proportion of an animal's protein and energy requirements (Brisibe *et al*., 2009). Diets rich in amino acids help to boost the immune system against gastro intestinal parasites infestations (Kyriazakis and Houdijk, 2006). Proteins are also essential for continuous replenishment of the endogenous protein that is lost due to infections with gastro-intestinal helminthes (Coop and Holmes, 1996).

Table 2Amino acid composition of dry Moringa Olifera Leaves

	Amino acid	In gm/kg	mg/100g	Source
1	Arginine	1.78	1325	Coop and Holmes, 1996,Nouman*et al.*, 2013
2	Serine	1.087	NA	Coop and Holmes, 1996
3	Aspartic acid	1.43	NA	Coop and Holmes, 1996
4	Glutamic acid	2.53	NA	Coop and Holmes, 1996
5	Glycine	1.357	NA	Coop and Holmes, 1996
6	Threonine*	1.533	1188	Coop and Holmes, 1996,Noumanet al., 2013
7	Alanine	3.033	NA	Coop and Holmes, 1996
8	Tyrosine	2.650	NA	Coop and Holmes, 1996
9	Proline	203	NA	Coop and Holmes, 1996
10	Ho- Proline	0.093	NA	Coop and Holmes, 1996
11	Methionine*	0.297	350	Coop and Holmes, 1996, Nouman *et al.*, 2013
12	Valine*	1.413	1063	Coop and Holmes, 1996, Nouman *et al.*, 2013
13	Phenylalanine*	1.64	1388	Coop and Holmes, 1996, Nouman *et al.*, 2013
14	Isoleucine*	1.177	825	Coop and Holmes, 1996, Nouman *et al.*, 2013
15	Leucine*	1.96	1950	Coop and Holmes, 1996, Nouman *et al.*, 2013
16	Histidine	0.716	613	Coop and Holmes, 1996, Nouman *et al.*, 2013
17	Lysine*	1.637	1125	Coop and Holmes, 1996, Nouman *et al.*, 2013
18	Cysteine	0.01	NA	Coop and Holmes, 1996
19	Tryptophan*	0.486	425	Coop and Holmes, 1996, Nouman *et al.*, 2013

* Essential amino acids, NA: data not available

Minerals

Mineral compositions of Moringa Olifera, the contents of phosphorous (P), magnesium (Mg) and trace minerals zinc (Zn) and copper (Cu) were significantly higher than those found in seed-removed pods. However, concentrations of sodium (Na) and trace mineral iron (Fe) were significantly higher in seeds-removed pods. No significant differences in the contents of calcium (Ca), Ca:P ratio, potassium (K) and manganese (Mn) was observed between whole and seeds-removed pods.

Table 3Mineral contents of dried Moringa Olifera leaves

Mineral	Quantity of mineral in dry leaf	Source
Calcium (%)	18747.14	Nouman *et al*., 2013, Abenet *et al*.,2014
Phosphorus (%)	1121	Nouman *et al*., 2013, Abenet *et al*.,2014
Magnesium (%)	106.2	Nouman *et al*., 2013, Aykroyd, 1996
Potassium (%)	20718.5	Nouman *et al*., 2013, Abenet *et al*.,2014
Sodium (%)	2241.17	Nouman *et al*., 2013, Abenet *et al*.,2014
Sulphur (%)	1370	Nouman *et al*., 2013.Aykroyd, 1996
Zinc (mg/kg)	22.05	Nouman *et al*., 2013, Abenet *et al*.,2014
Copper (mg/kg)	9.483	Nouman *et al*., 2013, Abenet *et al*.,2014
Manganese (mg/kg)	83.73	Nouman *et al*., 2013,
Iron (mg/kg)	379.83	Nouman *et al*., 2013, Abenet *et al*.,2014
Selenium (mg/kg)	27.12	Nouman *et al*., 2013, Newton *et al*.,2010

Many grain legumes form which leaves are used as livestock fodder But Moringa leaves are unique because of their tremendous amounts of minerals but lower amounts of harmful compounds. In moringa, tannins and phytates are 12 and 21 g kg–1 of DM, respectively (Udom and Idiong 2011).

2.4. The Utilization of Moringa Olifera Leaf Meal as Poultry Feed ingredient

2.4.1. Effect of MOLM supplementation on the laying performance of hens

A study conducted by Kakengi *et al.,* (2007) indicated that inclusion of moringa Olifera leaf meal to the laying hen diet at higher level increases the feed intake and egg weight but egg mass production and egg production percentage are decreased when the level of moringa leaf meal is included at a ratio of 20% to egg laying hen diet and consequently the feed conversion ratio increased. According to Olugbemi *et al.,* (2010), the supplementation of moringa Olifera at level of 10% in cassava chip-based diet to laying hens had no significant effect on feed intake, feed conversion ratio and laying percentage but egg weight significantly increased. The inclusion of different levels of Moringa Olifera leaf meal (0, 5, 10, and 15%) in the laying hens' diets decreased egg-laying percentage and egg mass, while egg weight and feed intake increased with the absence of a significant effect on feed conversion ratio(Abou-Elezz et al.,2011).The same author also conceded that the use of Moringa Olifera leaf meal up to a level of 10% had no negative effect on the productive performance of laying hens, but levels above that (15% and 20%) are expected to produce adverse effects. According to Wubalem *et al*., 2016, hens fed on diet containing 5% MOLM has higher total egg weight and hen day egg production (HDEP), Where ashen housed egg production (HHEP) was lower at 10% MOLM compared to 5% MOLM. Diets containing MOLM at 0, 5 and 10% showed a non-significant effect on HDEP (Olugbeni *et al.,* 2010).According to Etalem *et al*., (2014), the diet containing 5% MOLM in layer ration has a non-significant effect on HDEP.

According toMelesse *et al*., 2011the inclusion of MOLM in amounts of up to 10% in the diet of growing chicks to replace expensive conventional protein sources has no negative effects on the chicks. But at higher level of moringa Olifera leaf meal decreased the total egg weights; egg production percentage and average egg weight due to the presence of low digestibility of energy and protein in the moringa Olifera leaf meal (Olugbemi *et al*., 2010). Similarly, Austic &Neishemi, (2004) suggest that higher level of MOLM decreased egg production percentage. Kakengi *et al.,* (2007) also indicated that inclusion of MOLM in layer diet at higher level, results in decreased egg mass production, egg production and egg weight due to low digestibility of energy and protein. The response of high level of moringa Olifera leaf meal is decrease in total egg weight, egg production percentage, and average egg weight. Inclusion of different levels of Moringa Olifera leaf meal (0, 5, 10, and 15%) in the laying hens' diets linearly decreased egg-laying percentage and egg mass, while egg weight showed a quadratic trend with the increased levels of MOLM (Olugbemi *et al*., 2010).

Table 4Summary of response of layers to different inclusion levels of MOLM

Dietary dose	Treatment effect	References
5%	Improves total egg weight Improves hen day egg production Improves hen housed egg production Improves final average weight Improves body weight change Improves feed convert ion ration	Wubalem *et al*., 2016. Etalem *et al*., 2018
	Egg weight greater than control group Feed intake decreasing from 5-15% Feed conversion rate increasing from 5-15% Egg production decreasing from 5-15%	Wei Lu *et al*., 2016
10%	Decreases total egg weight Decreases hen day egg production Decreases hen house egg production	Wubalem *et al*., 2016
	Egg weight greater than control Feed intake decreasing from 5-15% Feed conversion rate increasing from 5-15% Egg production decreasing from 5-15%	Wei Lu *et al*., 2016
15%	Decreases total egg weight Decreases hen day egg production Decreases hen house egg production	Wubalem *et al*., 2016
	Egg weight garter than control group Feed intake decreasing from 5-15% Feed conversion rate increasing from 5-15% Egg production decreasing from 5-15%	Wei Lu *et al*., 2016

2.4.2. Effect of MOLM on egg quality

According to Wubalem et al 2016, the Laying hens fed diets containing 5, 10 and 15% MOL had deeper yolk color than those fed the control diets when eggs were stored at 4 ^{0}C and 28 ^{0}C for 4 weeks. It shows higher albumen height and Haugh unit at 4 ^{0}C and 28 ^{0}C compared with hens fed the control diet. Laying hens supplemented with 15% MOL also showed a higher Haugh unit compared with those fed the control diet. The effect of MOLM on yolk and albumen measurements at different storage times indicate that different levels of dietary treatment of MOLM had significant effect on those parameters regarding with storage time. The effect of feeding different levels of dietary MOLM on yolk and albumen pH of eggs of dual purpose Koekoek hens is revealed that the yolk pH of eggs stored for a week was the lowest (Etalem *et al*., 2018).According to D'Mello *et al*., (1987) and Fasuyi *et al*., (2005) leaf meals used for a source of oxycaretenoids which cause yellow color of broiler skin, shank and egg yolk.

Table 5 Summary of effect of different inclusion levels of MOLM on egg quality.

Dietary dose	Treatment effect	References
5%	Improves total egg weight Higher egg weight Lower egg shape index Higher shell weight Higher albumin weight Higher Hough unit Egg weight garter than control group Higher yolk weight Higher yolk index	Wubalem, 2016 Etalem *et al*., 2018
10%	Decreases total egg weight Lower egg weight Lower shape index Higher egg weight than control Higher shall weight Lower albumen height	Wubalem *et al*., 2016 Etalem *et al*., 2018
15%	Decreases total egg weight Higher egg weight than control	Wubalem, 2016 Wei Lu *et al*., 2016

2.5. Description of Bovans brown breed

The Bovans Brown is a highly versatile and robust hen. Combined traits include high peak production, great laying persistency, and a flat egg weight curve, resulting in top quality dark brown eggs. The Bovans Brown has excellent feed intake capacity and robustness so that it fully expresses genetic potential in multi-age and free range environments. This is an attractive looking bird that maintains great feather cover. The Bovans Brown is an ideal bird for the commercial egg producer looking for overall solid performance. Adaptable and easy to manage, the robustness of the Bovans Brown allows it to adjust well to different climates, management programs and housing systems (*https://www.bovans.com/en/product/bovans-brown*).

Table 5.The general characteristics of Bovans Brown breed

Laying Period	(18-90 Weeks)
Liveability	95%
Age at 50% production	143 day
Peak of production	96 %
Average egg weight	63.3 g
Eggs hen housed	418
Egg mass hen housed	26.5 kg
Average feed intake	114 g/day
Cum. feed conversion rate	2.15 kg/kg
Body weight	2000 g
Shell strength	4050 g/cm²
Shell colour	15.0 Lab
Haugh units	80

Source (Bovans @ Hendrix - gentices.com)

Table 6 Per hen day production performance of Bovans brown breed

Age in weeks	% Lay	Egg weight (g)	Egg mass per day (g)	Feed intake per day (g)	Feed conversion per week
18	2	42	0.8	85	101.19
19	17	45	7.7	86	11.24
20	39	47	18.3	96	5.24
21	65	51	33.2	106	3.2
22	85	53	45.1	112	2.49
23	92	55	50.6	116	2.29
24	93.2	57	53.1	119	2.24
25	94.2	59	55.6	120	2.16
26	94.5	60	56.7	120	2.12
27	94.7	60.6	57.4	122	2.13
28	95.0	61.3	58.2	122	2.1
29	94.7	61.9	58.6	122	2.08

Source: *www.isapoultry.com*

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The experiment was conducted at Yekabdy Agro Possessing Private Limited Company (PLC) poultry farm in southern Ethiopia. The farm is located in the Gurage zone Cheha district in *Adoshna Aturche* peasant association (PA).Cheha district is located at 185km from Addis Ababa and 30km towards the southeast on Wolkite-Hosanna asphalt road. Cheha district is found between 1750 and 2500 masl. The annual mean rain fall is 1100 mm and it ranges from 801to 1400mm. The mean annual temperature is 18.8°C and with the range of 17.6 to 20°C (DANRD, 2016). The district is located at 37^{0}44' 59.9" longitudes, 8° 09'60.00'' latitude.

3.2. Preparation of Experimental Feed

Moringa Olifera leaves were harvested from farmer's backyard in the *Bora, Luke,* and *Jatu* PA in Gurage zone, southern Ethiopia. The harvested leaves were sun dried on concrete floor and allowed to dry for a period of 3 days under shade and aerated condition. The materials were turned and mixed up several times a day to break large particles and to ensure uniform drying to approximately more than 90% DM content. The leaves were separated from twigs before milling in hammer mill. At the end of the drying process, the leaves were milled in hammer mill sieve size of 5mm to produce the leaf meal. The Moringa Olifera leaves dried in such a way were kept in airtight bags and were stored until required for the formulation of the different experimental rations.

3.3. Laboratory Analysis of Feed Samples

Dried feed samples were milled to pass through 1 mm screen for chemical analysis. Samples were analysed for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash following the proximate method of analysis (AOAC, 1990). Ash was determined by combusting the sample at 550^{o}C for 5 hrs. Calcium were analysed by atomic absorption (AOAC, 1990). Total nitrogen was determined by using the micro-Kejldhahe method. CP was calculated as N x 6.25. Metabolisable energy (ME) content was calculated by indirect method from the equation proposed by Wiseman (1987) as follows: ME (Kcal/kg DM) = 3951 + 54.4EE - 88.7CF - 40.8 ash. All samples were analysed at Debrezet agricultural research centre except crud fat; which was analysed at Wolkite University Food Engineering Lab.

3.4. Experimental Rations and Treatments

The feed ingredients used in the formulation of the different experimental rations of this study were dried Moringa Olifera tree leaves, Maize grain, Noug Seed Cake (NSC), Wheat bran (WB), Soybean meal (SBM), Methionine, Lysine, premix, limestone and salt. The feed ingredients like Maize grain, Noug Seed Cake (NSC), Wheat bran (WB), Soybean meal (SBM), used for the experiment were purchased from local market and Methionine, Lysine, premix, limestone are purchased from Woliso Liben animal feed formulation center.Based on the results of chemical analysis of feed ingredients, four experimental diets were formulate using a least cost feed formulation software (*feed win*) to contain MOLM at0% (treatment 1 = T1), 5% (treatment 2 = T2), 10% (treatment3 = T3) and 15% (treatment 4 = T4) of the total ration. The four experimental rations shown in table 3 were formulated to be nearly isonitrogenous and isocaloric to meet the minimum requirement of ME 2,750 kcal/kg of DM and 16.5% of CP for laying hen (Leeson and summers, 2005).

Table 7Proportion (%) of ingredients used for formulating experimental diets

Ingredients (%)	**Treatments**			
	T1	**T2**	**T3**	**T4**
Maize	42	40	37	36
Wheat Bran	18.1	18.1	20.1	20.1
Noug seed cake	22	19	18	14
MOLM	0	5	10	15
SBM	9	9	6	6
Lime stone	7.5	7.5	7.5	7.5
Salt	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5
Methionine	0.2	0.2	0.2	0.2
Lysine	0.2	0.2	0.2	0.2
Total	100	100	100	100
DM%	92.22	92.14	92.11	92.02
CF%	7.29	7.07	6.93	5.09
EE%	5.39	5.52	5.1	4.55
Ash%	15.4	15.743	18.621	28.56
CP%	18.07	18.32	18.23	18.23
ME(kcal/kg)	2982.1	2982	2959	2987.28

MOLM: Moringa Olifera Leaf Meal; SBM: Soybean Meal; T1: No MOLM inclusion; T2: 5%; T3: 10%; T4: 15% MOLM of the total ration; EE; Ether extract; CF: Crud Fibre; CP: Crude Protein; DM: Dry Matter: ME; Metabolisable energy.

3.5. Experimental Design

This experiment employed a Completely Randomized Design (CRD). A total of 180 Bovans brown pullets with age of 18 weeks were used for the experiment. The pullets were sourced from Yekabdy Agro processing PLC poultry farm. The pullets were distributes randomly into 12 groups of 15 birds in each group with similar mean group weight. Then each group of 15 pullets were randomly housed in electrically heated 2m x 1.5m pens. The pullets were randomly allocated to four dietary treatment groups in a CRD design.

Table 8Experimental design

Treatments	Inclusion rate of MOLM (%)	Replicates	pullets per replicate	Total No of pullets per treatment
T1	0	3	15	45
T2	5	3	15	45
T3	10	3	15	45
T4	15	3	15	45
		Total		180

3.6. Management of Experimental Animals

Before experimental period, the hens are given one week adaption period in the experimental house. The experimental houses (pens) were partitioned with a wire mesh on deep litter concrete floors. The pens were covered with wood shavings of 5 cm depth as a bedding material. Before the commencement of the actual experimental work, the experimental house (pens), feeding and watering troughs were thoroughly cleaned; disinfected and florescent lamps were placed for lighting system to increase the lighting period to 16 h per day. The pullets were vaccinated against New Castle Disease (NCD) at the age of 18weeksby a veterinarian according to the prescription given by the manufactures (producers) of the vaccines. Before the pullets coming to the experimental house they vaccinated Gumboro, Marx and NCD Lasota vaccine. The pullets were providing clean (tap) water *ad labium* throughout the experimental periods. Watering troughs were cleaned every morning. Other health precautions and sanitary measures were also taken throughout the study period. Pullets were fed the experimental ration at an average of 133 g/bird per day but adjusting according to the age of pullets. Measured amount of feed were offered to the pullets three times a day at 7:00, 1:00and 6:00 AM and refusal were separately collected from each replicate and weighed using a sensitive digital balance and recorded every other day. A total of 3 birds have died during the experimental period (2 birds from treatment group two during week 18 and 25 and 1 bird from treatment group three during week 23)

3.7. Measurements

3.7.1. Feed intake

The experimental period lasted for 11 weeks from October21-January 07 during which the amount of feed offered and refused from hens per pen was recorded daily. The amount of feed consumed per hens was determined as the difference between the feed offered and refused. The Mean Daily feed intake by the hens were determined by using the formula feed offered minus refusal collected and divided by the number of experimental days and the number of experimental hens in each replicate.

3.7.2. Body weight gain

The pullets live weights were taken at the beginning of the experiment and recorded as initial weight. Then, the average weight per hen were measured every two weeks for each replication by weighing each hens in each pen and sum the weight of each hens in each replication. The average body weights of hens were determined by the total weight of hen in each replication divided by the total number of hens in each replication. The average daily body weight grain (ADBWG) of the hens were determined as final body weight attained minus initial BW of the hens and this value were divided by the number of experimental days and the number of experimental hens .

3.7.3. Feed conversion ratio

Feed conversion ratio was determined as a unit egg weight per unit feed consumed (Abou-Elezz *et al*., 2011).Feed conversion ratio on egg production basis was calculated as gram of eggs produced per gram of feed consumed.

FCR = Feed Consumed/BWG

$$\text{Feed conversion ratio} = \frac{\text{Gram of feed consumed}}{\text{Gram of egg produced}}$$

3.7.4. Laying performance of hens

Eggs laid in each pen were collected three times a day at 11, 2 and 5 AM hours. Daily collected eggs were weighed immediately after collection for each pen and average egg weight were computed by dividing the total egg weight to the total number of eggs. Egg mass per hen were calculated as total egg weight divided by number of hens. Hen-day egg production (HDEP) was determined according to Hunton (1995).

$$\% \text{ HDEP} = \frac{\text{Number of eggs collected per day}}{\text{Number of Hens alive on that day}} \text{X } 100$$

$$\% \text{ HHEP } = \frac{\text{Number of Eggs \ \ Produced \ per \ day}}{\text{Number of Hens housed initially}} \text{X } 100$$

3.8. Egg quality

Egg quality is important for layers and breeders flock. It is influenced by both genetic and environmental factors. Egg weight, yolk color and shell thickness are the most important traits of consumed egg (Stadelman 1995, Aberra *et al.*, 2012). There for, Effect of inclusion of MOLM on both external and internal measurement of egg quality parameters were evaluated in this study.

3.8.1. External egg quality

For the evaluation of external egg quality traits, 60 fresh eggs were collected (five eggs from each replication) at the age of 28 weeks. To evaluate the external egg quality the following measurements were taken (egg weight, egg length, egg width, and shell weight and shell thickness). Egg weight and shell weight were measured by using digital weighing balance (g). Other external egg quality traits like egg length, egg width and shell thickness were measured by using Digital Caliper (mm). The shell thickness was measured at the three point (center, broad and narrow end) and the average of the three point was used. The egg shell and yolk shape indexes were computed according to (Safaa *et al.*, 2008a) and (Ebrahimi *et al.*, 2012), respectively.

$$\text{Shell (\%)} = \frac{\text{Shell weight}}{\text{Egg weight}} \text{X } 100$$

$$\text{Shape index (\%)} = \frac{\text{Width of egg}}{\text{Length of egg}} X\ 100$$

3.8.2. Internal egg quality

A total of 60 eggs were used to determine the internal egg quality traits. The eggs were carefully broken onto a flat surface. The albumen and yolk height were measured by using tripod micro meter. The thick albumen height (AH) was measured at its widest part at a position half way between the yolk and the outer margin. Yolk height was measured at the center part of yolk. The yolk was carefully separated from the albumen. Albumen and yolk weight were determined by weighing with electronic sensitive balance separately. The yolk color was determined by using the Roche Color Fan with a standard colorimetric system ranged 1-15. Individual Haugh Units (HU) was calculate from the two parameters; AH and egg weight (EW) (Haugh, 1937) using the formula.

$$HU=100\log (AH–1.7EW^{0.37}+ 7.6)$$

Where, HU = Haugh Unit

AH= Albumen height in millimeters

EW= Egg weight in grams

To estimate Yolk Ration (YR) and Albumen Ratio (AR) the following formula were used:

$$\text{Yolk (\%)} = \frac{\text{Yolk weight}}{\text{Egg weight}} \text{X } 100$$

$$\text{Albumen (\%)} = \frac{\text{Albumen weight}}{\text{Egg weight}} \text{X } 100$$

3.9. Economic Consideration

In order to estimate the economic benefits of inclusion of MOLM in Bovans brown hybrid layer ration, the partial budget was analyzed taking into consideration the feed cost per dozen of eggs, feed cost per egg mass and egg sale to feed cost for dozen of eggs. The costs of feed ingredients and rations which were used to calculate the feed cost are given in Appendix Table 17.

3.10. Statistical Analysis

Data was analyzed using by a one-way analysis of variance using the general linear model (GLM) procedures of Statistical Analysis Systems software (SAS).Differences between treatment means were separated using Turkeys Kramer test (SAS, 2009). Significant differences were declared at ($p<0.05$). The following model was used for the analysis:

$Y_{ij} = \mu + T_i + e_{ij}$

Where, Y_{ij} = individual measurement on each bird

μ = overall mean effect

T_i = effect due to the i^{th} dietary treatment

e_{ij} = error term.

4. RESULT

4.1. Chemical Composition of Feed Ingredients and Experimental Rations

The results of chemical analysis of feed ingredients as shown in table 10 revealed that the CP content of MOLM is higher than other ingredients next to SBM. The ME content of MOLM was almost similar to that of WB while SBM and maize has the highest value and NSC the least energy value. The DM content of MOLM is higher than maize and wheat bran, but lower than SBM and NSC. The ash content of MOLM was higher than other ingredients. MOLM had relatively lower content of CF compared with WB and NSC. The current result also revealed that MOLM has higher mineral content than all the other ingredients with a better Ca content. The chemical composition of the formulated feeds is also indicated in the table below. The DM, EE, CP and ME contents were similar across treatments, since the diets were formulated to be iso-nitrogenous and iso-caloric.

Table 9Chemical composition of the feed ingredients (%)

Ingredients	DM	CP	ME	EE	Mineral	Ca	P	CF
Maize	90.73	10.22	4010.60	5.28	2.74	2.20	0.3	1.76
WB	90.47	16.40	3191.01	4.41	4.81	1.10	1.15	9.06
NSC	94.17	24.85	2344.25	16.50	7.97	2.83	0.05	20.89
SBM	96.93	43.06	3906.08	9.54	6.29	2.75	0.65	3.51
MOLM	93	38.89	3160.67	4.89	12.33	3.94	0.3	6.24

Where: MOLM: Moringa Olifera Leaf Meal; SBM: Soybean Meal; EE; Ether extract; CF: Crud Fibre; CP: Crude Protein; DM: Dry Matter: ME Kcal/kg DM = Metabolisable Energy kilo calorie per kilogram of Dry Matter

The chemical composition of the formulated feeds is also indicated in the table 11 below. The DM, EE, CP and ME contents were similar across treatments, since the diets were be iso-nitrogenous and iso-caloric.

Table 11 Proportion (%) of chemical composition used for formulating experimental diets formulated to

Chemical composition	Treatments			
	T1	T2	T3	T4
DM%	92.22	92.14	92.11	92.02
CF%	7.29	7.07	6.93	5.09
EE%	5.39	5.52	5.1	4.55
Ash%	15.4	15.743	18.621	28.56
CP%	18.07	18.32	18.23	18.23
ME(kcal/kg DM)	2982.1	2982	2959	2987.28

Where: DM = Dry Matter, CF = Crude Fiber, CP = Crude Protein, EE = Ether Extract, ME Kcal/kg DM = Metabolisable Energy kilo calorie per kilogram of Dry Matter; T1: No MOLM inclusion; T2: 5%; T3:10%; T4: 15% MOLM of the total ration

4.2. Feed Intake, Body Weight Gain and Feed Conversion Ration

The effects of feeding of varied levels of MOLM on feed intake, body weight change and feed conversion ratio of Bovans brown hens is presented in Table 12below. Total feed consumed per hens (TFC) during the whole period of the experiment was higher ($p<0.05$) for hens kept on T3 as compared to that of T4 but didn't show significant different with that of the control and T2.Average initial body weight was similar across the treatment groups. Hens kept on T3 and T4 achieved significantly ($p<0.05$) higher Final Body Weight (FBW) and Body Weight Gain (BWG) compared to the control diet whereas T2 didn't bring about any significant difference in FBW and BWG compared to the control group. The feed conversion ratio (kg feed/kg egg) was higher ($P<0.05$) for T1 than the rest of the treatments, with no differences ($P>0.05$) between T2 and T4. Feed conversion ratio in terms of total feed consumed (kg) and body weight gain (kg) is significantly lower for T3 compared to the control diet while no significant difference was observed among the other treatment groups.

Table 12 Feed intake, body weight change and feed conversion efficiency of hens fed on different dietary levels of MOLM.

Parameter	Treatment				Sig
	T1	T2	T3	T4	
TFC/hen(kg)	9.03[ab]	8.96[ab]	9.22[a]	8.88[b]	*
IBW(kg)	1.22	1.23	1.21	1.22	NS
FBW(kg)	1.55[c]	1.67[bc]	1.94[a]	1.70[b]	*
BWG (kg)	0.37[b]	0. 43[b]	0.73[a]	0.48[b]	*
FCR (TFC/BWG)	24.4[a]	20.84[b]	12.63[d]	18.5[c]	*
FCR(kg feed /kg egg)	3.84[a]	3.39[b]	3.07[c]	3.42[b]	*

Where: TFC = Total Feed Consumed, IBW = Initial Body Weight, FBW = Final Body Weight, BWG = Body Weight Gain, FCR = Feed Conversion Ratio.

The effects of feeding of varied levels of MOLM on Bovans brown hens, the level of feed intake in week during experimental period of is presented in figure 1 below. The total amount of feed intake in T1 tends to increasing from the age of 18 to 26weeks, while the total amount of feed intake in T2 was the lowest for the first 7 weeks of the experimental period with a sharp increase during the final weeks of the experiment. Similarly birds kept of T3 showed better feed intake compared to the other groups doing the first 8 weeks of feeding.

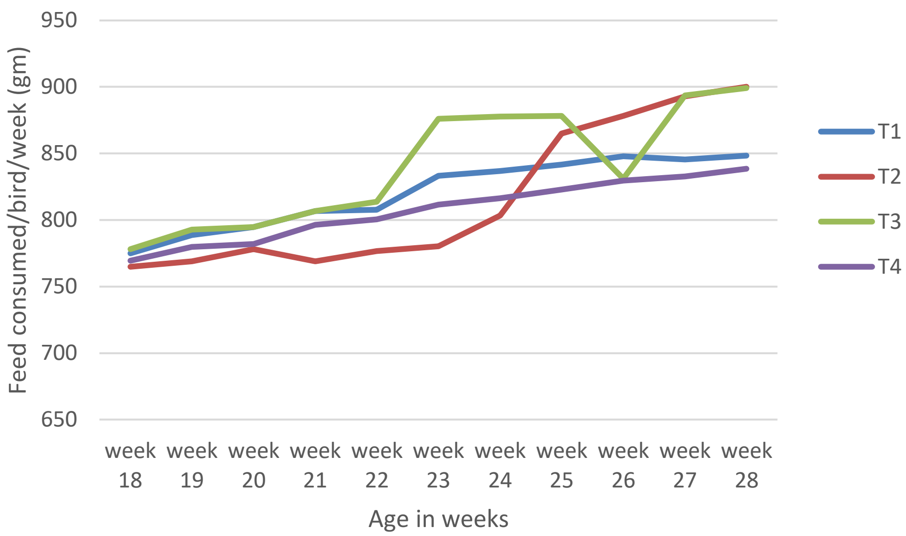


Figure 1.Weekly feed consumption during the experimental period

4.3. Egg Laying Performance

The inclusion of 10% MOLM in hens' ration resulted significantly higher ($p<0.05$) amount of total egg weight (TEW) compared to the control diet. HDEP for the same treatment group T3 was also significantly higher ($p<0.05$) compared to all the other treatment groups. Hens under T3 also attained significantly higher ($p<0.05$) values of HHEP compared to T2 but not statistically different with either the control group or T4 (Table 13).

Table 13 Egg production performance of Bovans brown hen fed on different dietary levels of MOLM

	Treatments				**Sig**
parameter	**T1**	**T2**	**T3**	**T4**	
Egg mass(kg)	2.35^{b}	2.64^{ab}	3.00^{a}	2.60^{ab}	*
HDEP (%)	50.91^{b}	51.43^{b}	63.21^{a}	52.58^{b}	*
HHEP (%)	50.91^{ab}	46.78^{b}	61.82^{a}	52.58^{ab}	*

Where: TEW = Total Egg Weight, HDEP = Hen Day Egg Production, HHEP = Hen Housed Egg

The weekly average hen day egg production of Bovans Brown chicken fed on different level of MOLM is presented in figure 3 below. The weekly average hen day egg production of Bovans Brown hens in control diet is lower than the other treatments during the experimental period. The weekly average hen day eggs production of Bovans Brown hens in T4 higher than control diet

(T1) and T2 during between the ages of 21 to 24 weeks. After the age of 24 weeks the average hen day egg production of T4 is lower than the average hen day egg production of T2 but higher than the control diet group. On the other hand, the weekly average hen day egg production of Bovans Brown chicken in T3 is higher than the other treatment during experimental period.

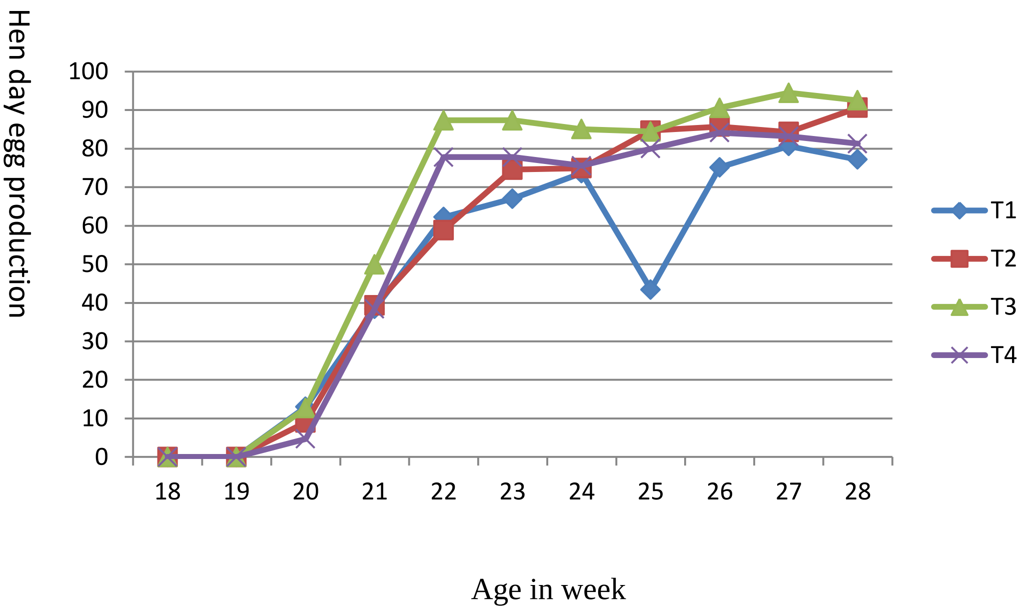


Figure 2.Weekly average hen-day eggs production of Bovans brown hens

4.4. Egg Quality Characteristics

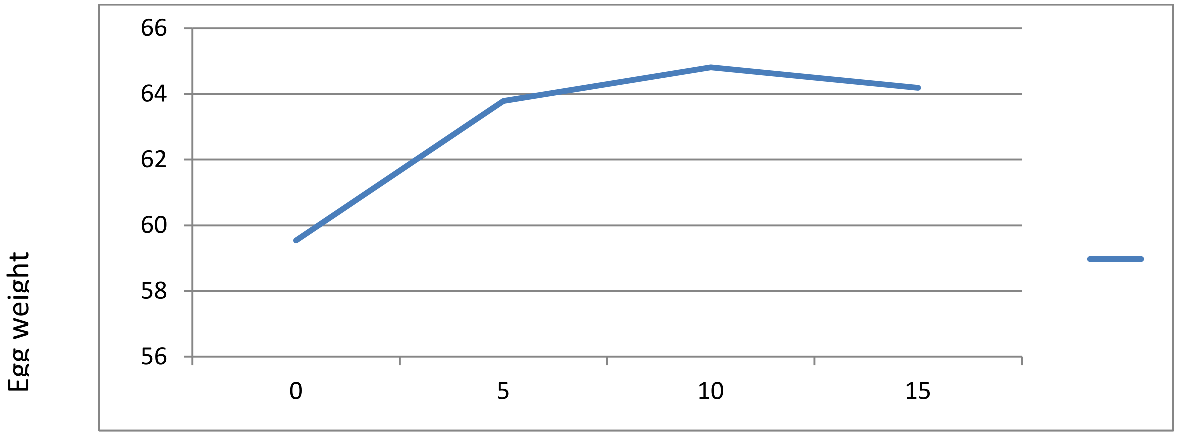
Egg quality parameters of 28 weeks aged Bovans brown hens fed varied dietary levels of MOLM is presented in Table 14. Egg weight was significantly higher (P<0.05) in T3 than the rest treatment groups and no significant difference was observed in egg weight among the groups kept on the other experimental diets. Egg width was significantly higher (P<0.05) for T2andT3 compared to the control group. Egg length was also significantly higher (P<0.05) for T3 than the control group. No significant difference was observed for egg shape index across the treatment. Egg shell weight was of T3 also significantly higher (P<0.05) as compared to the control and T2. Inclusion of MOLM didn’t bring about any significant effect on egg shell thickness compared to the control group while shell ratio was significantly improved for T3. Similarly albumen height, yolk height, albumen weight and albumen ratio were not significantly affected due to the inclusion on MOML in layer diet. Haugh unit measurement as well as yolk weight was also significantly higher for T3 compared to control group. The results of egg quality analysis also indicate that inclusion of MOLM in layer ration at 10% and 15% significantly improves the color of the yolk.

Table 14 Effects of feeding different dietary levels of MOLM on egg quality parameters of Bovans brown breed

Parameter	**Treatments**				**Sig**
	T1	**T2**	**T3**	**T4**	
Egg Weight (gm)	59.94^{b}	63.79^{ab}	64.8^{ab}	62.84^{ab}	*
Egg width (mm)	42.41^{c}	46.46^{ab}	48.61^{a}	44.14^{bc}	*
Egg length (mm)	53.16^{b}	56.41^{ab}	58.55^{a}	55.38^{ab}	*
Egg shape index	79.79	82.42	83.06	79.83	NS
Egg shell weight (gm)	7.07^{b}	7.80^{b}	9.80^{a}	8.13^{ab}	*
Egg shell thickness (mm)	0.40^{ab}	0.40^{ab}	0.433^{a}	0.39^{b}	*
Shell ratio (%)	11.79^{b}	12.22^{b}	15.02^{a}	12.95^{ab}	*
Albumen height (mm)	7.83	8.30	9.20	8.87	NS
Haugh unit	85.70^{b}	86.60^{ab}	95.80^{a}	83.67^{b}	*
yolk height (mm)	18.23	18.23	19.27	18.63	NS
yolk length (mm)	40.24^{b}	45.47^{a}	40.89^{b}	39.82^{b}	*
yolk index	43.62^{ab}	38.71^{b}	51.24^{a}	46.73^{ab}	*
yolk color	1.53^{c}	2.47^{bc}	3.667^{ab}	4.47^{a}	*
yolk weight(mg)	16.79^{bc}	15.33^{c}	20.03^{a}	17.38^{b}	*
Albumen weight(mg)	32.77	37.40	34.56	36.43	NS
Yolk ratio (%)	28.01^{a}	24.035^{b}	27.50^{a}	27.66^{a}	*
Albumen ratio (%)	54.68	58.61	52.64	57.98	NS

*: $P<0.05$; Means followed by same letter in rows do not differ statistically. NS Non significant; T: Ration containing 0% MOLM; T2: Ration containing 5% MOLM; T3: Ration containing 10%MOLM; T4: Ration containing 15% MOLM; AST:

The effects of inclusion of different levels of MOLM in the layers ration on egg weight presented in figure 4 below. The inclusion of 10% of MOLM in the layers ration it leads higher egg weight than the inclusion of 5% and 15% of MOLM in the layers ration. In general the value of the egg weight has increasing trends with the increasing the inclusion of MOLM in the layers ration.



Levels of MOLM (%)

Figure 3.Effect of the inclusion of different levels of MOLM in the layers ration on egg weight

4.5. Economic Evaluation

The economic evaluation of current study is presented in Table 15. It shows that, there was significant difference regarding those parameters which used to determine the profitability of MOLM used as an alternative protein sourceas partial substitution of NSC. Higher feed cost per hens was calculated for T1 and lower feed cost for T4. In T4, higher change in total cost per hens and lower for T2 followed by T3 when compared with T1. This showed that by how many Birr these treatments get additional income than T1. Negative sign indicated that, the decreasing of total feed cost as increasing of unit of net income when compared with T1. On the base of this, T2 had got an additional income of 28.04 Birr than T1. Similarly, T3 and T4 get an additional income of 53 Birr and 83.9 birr than T1 respectively.

In the case of egg production, higher number of eggs was recorded in T3 and lower value for T1 but there was no statistically difference between T2 and T4. Total returns obtained from egg sale was higher ($P<0.05$) for T3 but lower for T1 due to lower egg production. There was no significant difference ($P>0.05$) between T2 and T4. Because of the revenue obtained from sale of birds was similar along with all treatments, there was no statistical difference ($P>0.05$) among treatments. Higher total return was obtained in T3 but lower in T1 and other treatments were statistically similar. In T3 calculated higher net return compared to T1. Change in net return was determined on the base of the control group (T1). For this, higher value was obtained for T3 and

T4 but lower value observed for T2. Change in total return was also determined by using T1 as reference point.

The marginal rate of return measures the increase in net income associated with each additional unit of expenditure. It is also determined relating to T1 (control group). Thus, T2 decreased its feed cost by 1.63 Birr every additional unit of net income than T1. Likewise, T3 and T4 decreased their feed cost by 1.88 and 1.1 Birr than the control group. The value of feed cost per dozen of egg in T1 was higher than other treatment groups due to higher feed cost and lower number of eggs produced. On the other hand in T3 and T4, the value of feed cost per dozens of eggs was lower because of lower feed cost incurred and higher amount of eggs produced. The value of egg sale per feed cost in T3 and T4 was higher than T1 and T2 but lower in T1. The value of feed cost per egg mass higher in T1 but lower in T3 and T4, they are no statistically difference.

Table *15* Effects of inclusion of different proportion of MOLM in Bovans brown hens ration on net income and marginal rate of return

Parameter	**Treatment**				
	T1	**T2**	**T3**	**T4**	**sig**
Cost/100 kg diet	2962^{a}	2673.58^{b}	2328.84^{c}	2067.2^{d}	*
Total feed consumed(kg)/hen	9.033^{ab}	8.9607^{ab}	9.21^{a}	8.8833^{b}	*
Total feed cost/hen(ETB)	267.56^{a}	239.52^{a}	214.56^{b}	183.62^{b}	*
Change in total cost	0	-28.04^{c}	-53^{b}	-83.9^{a}	*
Total egg production /hen	39.2^{ab}	41.9^{b}	46.4^{a}	40.5^{b}	*
Total egg sell/hen(ETB)	254.8^{c}	272.35^{ab}	301.6^{a}	263.25^{ab}	*
Total Return(ETB)	254.8^{ab}	272.35^{b}	301.6a	263.25^{ab}	*
Change in total return	0	17.55^{b}	46.8^{a}	8.45^{c}	*
Net return	-12.76^{c}	32.83^{b}	87.04^{a}	79.63^{b}	*
Change in Net Return	0	45.59^{b}	99.8^{a}	92.39^{b}	*
MRR (%)	0	-1.63^{ab}	-1.88^{a}	-1.1^{c}	*
Total feed cost per dozens of egg (ETB)	6.83^{a}	5.72^{b}	4.62^{c}	4.53^{c}	*
Egg sale/feed cost	0.95^{b}	1.14^{ab}	1.41^{a}	1.43^{a}	*
Feed cost per egg mass	113.85^{a}	90.73^{b}	71.52^{c}	70.62^{c}	*

*: P<0.05; Means followed by the same letter in rows do not differ statistically. MOLM: Moringa olifera leaf 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; T1: Ration containing 0% MOLM; T2: Ration containing 5% MOLM; T3: Ration containing 10%MOLM; T4: Ration containing 15% MOLM.

5. DISCUSSION

5.1.Chemical Composition of Feed Ingredients and Experimental Rations

The CP content of MOLM (38.89%) in the present study was higher than finding of Busani *et al.,* (2011), Oduro*et al*., (2008), Wei Lu.*et al*., (2016), Etalem *et al*., (2013) and Etalem *et al*., (2018) that had reported CP values of (30.29, 27.51%, 21.95, 28.2 and 29.2%) respectively. The difference in CP content may be due to differences in soil type and processing methods of MOLM. The CF content of MOLM (6.24%) is low as compared to the value reported by Etalem *et al*., (2018) (10.5%) but higher than the value reported by Wei Lu.*et al*., (2016)(2.5%). The ME content for MOLM (3160.67kcal/kg DM) noted in the present study is lower than the value of 3247kcal/kg DM reported by Etalem *et al*., (2013) but higher than the value of 2247kcal/kg DM reported by Etalem *et al*., (2018).

The ME content of the treatment diets (2959-2987.28kcal/kg) are higher than the minimum value of ME requirement (2750kcal/kg) recommended by management guide line of the breed. The CP content of the treatment diets(18.07-18.32%) are higher than the minimum value of the CP requirement(16.6-17.1%) recommended by management guide line of the breed (bovans@hendrix-genetic.com).In general the relatively low level of CF in MOLM and high level of CP is indicatives of its potential use as cheap protein supplement layers ration.

5.2.Feed intake, Body Weight Change and Feed Conversion Ration

In the current study the inclusion of MOLM at different level (5, 10 and 15%) in Bovans brown hens' diet showed a significant effect on their feed intake (FI), BWG and feed conversion ratio (FCR).The inclusion of 10%MOLM in layers ration shows higher feed intake than 0, 5 and 15% inclusion levels of MOLM. The current finding is similar to the results reported by Etalem et *al*., (2018), Wei Lu *et al.,* (2016) and Wubalem, (2012).The addition of 15% MOLM in the diets of layers hampers their feed intake compared to that of 10% inclusion level. Generally inclusion of MOLM did not have any negative effect on total feed intake by the hens. This finding was similar to the finding of Gadizirayi *et al*., (2012) in broilers. Their finding shows that the decrease in feed intake associated with higher inclusion levels could be explained by the impaired palatability due to the existence of higher amount of saponins when MOL was supplemented above 10%.In addition, the finding of Ayssiwed *et al.,* (2011) also confirmed that, the supplementation of high amount of MOLM (15%) reduced the feed intake due to the presence of anti-nutritional factor and phytochemicals compounds in the MOLM that might have been responsible for decreased feed intake of chickens. Birds kept on the 10% MOLM containing diet gained the highest body weight than the others. The body weight change (BWC) of layer hens in the current study increase in response to increasing level of MOLM from 5% to 10% but decreases at the level of 15% of MOLM. This is consistence to the finding of Wubalem *et al.,* (2016) who indicated that at the inclusion of MOLM at 5% and 10% MOLM, BWC was improved but decrease at the level of 15% of MOLM. The improvement in BW in the present study at 10% of MOLM may be attributed to rich content of nutrients in MOLM. The finding of Sarwatt *et al*., 2004; Kakengi *et al*., 2003 and Fahey *et al*., 2001 also indicated that MOLM contain higher amount of nutrients and antimicrobial properties of Moringa which supports better growth in birds.

5.3.Laying Performance of Hens

The higher level of egg production in terms of TEW in layers fed the diet containing MOLM especially at 10% inclusion level could be due to the improvement in balanced nutrient supply by MOLM in the diet. Moringa Olifera 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). The inclusion of 10% level of MOLM also improves the other egg production parameter *i.e.* HDEP and HHEP. Contrary to the current finding, a report by Wei Lu *et al*., (2016) also shows that the inclusions of 15% MOLM to layer diet decrease egg production. On the contrary, Olugbemi *et al*., (2010) showed a non-significant effect on HDEP for hens fed a diet containing MOLM at 10% of the diet. Etalem *et al*., (2014) also observed a non-significant effect on HDEP due to inclusion of MOLM at 5% in layer rations. Similarly, Abou-Elezz *et al*., (2011) reported that egg production decreased when the inclusion level of MOLM in diets was 15% which is not in line with the current finding. The results reported by Kakengi*et al*. 2007; Al-Harthi *et al*., 2009, indicated that supplementary level of MOLM incorporated into the diets of laying hens should not exceed 10%.Regardless of the possible anti-nutritional factors, the decrease in egg production with increase in level of MOLM beyond 10% could be associated with the increase in bulkiness of diets due to the increasing level of MOLM as observed in other forage leaves.

5.4.Egg Quality Characteristics

In the present study, the internal and external egg quality parameters were affected by the inclusion of MOLM in the diet of Bovans brown hens except egg shape index, albumin height, yolk height, and albumin ratio and albumin weight. Egg weight, egg width, egg length and egg shell weight increase with increasing level of MOLM up to 10%. The albumen height and Haugh unit are important items in evaluating albumen quality and egg freshness. The Haugh unit of laying hens increased in response to the increase in dietary MOLM supplementation in the current study. The Haugh unit tended to increase in group kept on diet supplemented with 15% MOLM compared with the other groups in the current study, which is similar to the report suggested by Wei Lu.*et al*. (2016). The addition of MOLM had no effect on egg shape index in the current study. This result agrees with the report by Ebenebe *et al*., (2013) and Wei Lu *et al*., (2016) but not in line with Wubalem *et al.*, (2012), who indicated that an increasing trend with the increase in level of supplementation of MOLM. According to Pasaporte *et al*., 2014, Yolk color is a preferable trait for consumers and MOLM has high concentration of xanthophylls (167.1 g/g) which is associated with the coloration of body parts. In the current study the values for Yolk color increased parallel with the increasing level of supplementary MOLM, which is in agreement with the finding of Abou-Elezz *et al*., (2011),Olugbemi *et al*., (2010) and Etalem *et al*., (2014), who recommended MOLM as a good pigmenting agent of poultry products due to its rich xanthophylls content.

5.5.Economic Evaluation

In the current study, feed cost decrease as increase the level of MOLM in the ration. This is due to the minimum cost incurred for the production and processing of MOLM, because it is harvest from the backyard. This is similar to the finding of Ayssiwed *et al*., (2010) who noticed that the lowest feed cost/kg carcass was achieved when 8% and 16% of MOLM was introduced into the diets of the hens. Contrary to the current results, the findings of Wubalem A. (2012), Onibi *et al*., (2008) and Tendonkeng *et al*., (2011) who reported that 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 increased with increasing level of MOLM. This is due to the associated improvement of egg production in relating to increasing MOLM level up to15%. This was not in agreement with the finding of Zanu *et al*. (2012) who noticed that partial replacement of fish meal with Moringa Olifera leaf meal decreased the net revenue for broilers, because of the associated reduction in weight gain. In addition to this the finding of Wubalem, (2012) show that the net return decreases as inclusion level of MOLM increases beyond 5% due to the reduction of egg production

6. CONCLUSION AND RECOMMENDATION

6.1.**Conclusion**

In the current study, moringa olifera leaf meal can be used as an alternative protein feed ingredient in Bovans brown layer ration. The inclusion of 10% level of MOLM in the diet of laying hens without deleterious effect on performance. MOLM have positive influence in improving productivity of chicken and Hen-day egg production was higher at 10% inclusion level. Inclusion of MOLM influenced positively most of the egg quality parameters including Yolk color except, yolk height, egg shape index, albumin height. The inclusion of MOLM in the layer ration can be economically accepted up to 10%. Therefore, MOLM can be incorporate in layers ration whenever there is availability of the moringa olifera tree growing areas of Ethiopia.

6.2.Recommendation

Based on the findings of this study, the following recommendations were forwarded.

- The inclusion of *Moring olifera* leaf meal up to a level of 10 % in laying hens' diet could be recommended.
- Improve awareness on the cultivation; processing and utilization of dried *Moringa olifera* tree leaves should be carried.
- Finally further research is required to explore the growth and health promoter effect and the side effect of regular consumption of Moringa leaf as layer feed ingredient.

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8. APPENDICES

8.1. List of Appendix Tables

Appendix Table 1 Analysis of variance of total egg production

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	48411.58333	16137.19444	5.96	0.0194
Error	8	21645.33333	2705.66667		
Corrected Total	11	70056.91667			

CV = 8.49

Appendix Table 2.Analysis of variance of body weight change

Source	DF	Sum of squares	Mean square	F Value	Pr. > F
Model	3	0.21986692	0.07328897	26.16	0.0002
Error	8	0.02241000	0.00280125		
Corrected Total	11	0.24227692			

CV = 10.53

Appendix Table 3Analysis of variance of feed conversion ratio

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	0.00650583	0.00216861	5.36	0.0257
Error	8	0.00323734	0.00040467		
Corrected Total	11	0.00974318			

CV = 6.86

Appendix Table 4Analysis of variance total egg weight

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	0.65230000	0.21743333	6.53	0.0153
Error	8	0.26646667	0.03330833		
Corrected Total	11	0.91876667	0.033330833		

CV = 6.89

Appendix Table 5Analysis of variance of hen day egg production

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	305.7368566	101.9122855	19.54	0.0005
Error	8	41.7308818	5.2163602		
Corrected Total	11	347.4677385			

CV = 4.19

Appendix Table 6Analysis of variance of hen housed egg production

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	362.8986214	120.9662071	5.96	0.0194
Error	8	162.2558299	20.2819787		
Corrected Total	11	525.1544513			

CV = 8.49

Appendix Table 7Analysis of variance of average egg weight

Source	DF	Sum of squares	Mean of square	F value	Pr.> F
Model	3	51.1377333	17.0459111	6.75	0.00139
Error	8	20.2157333	2.5269667		
Corrected Total	11	71.3534666			

CV = 2.52

Appendix Table 8Analysis of variance of yolk weight

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	34.82516667	11.60838889	27.68	0.0001
Error	8	3.355500000	0.41937500		
Corrected Total	11	38.18016667			

CV = 3.73

Appendix Table 9Analysis of variance of yolk length

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	61.03656667	20.34552222	8.07	0.0084
Error	8	20.17240000	2.52155000		
Corrected Total	11	81.20896667			

CV = 4.54

Appendix Table 10Analysis of variance of yolk index

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	249.9315514	83.3105171	8.63	0.0069
Error	8	77.2538368	9.6567296		
Corrected Total	11	327.1853882			

CV = 6.9

Appendix Table 11Analysis of variance of yolk color

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	15.08000000	5.02666667	20.66	0.0004
Error	8	1.946666667	0.24333333		
Corrected Total	11	17.02666667			

CV = 16.26

Appendix Table 12Analysis of variance of Haugh unit

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	260.5625000	86.8541667	6.67	0.0144
Error	8	104.1066667	13.013333		
Corrected Total	11	364.6691667			

CV = 4.1

Appendix Table 13Analysis of variance of total revenue per hen

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	7658.715906	2552.905302	19.54	0.0005
Error	8	1045.359634	120.669954		
Corrected Total	11	8704.075540			

CV = 1.99

Appendix Table 14Analysis of variance of total feed cost

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	2581305.253	860435.084	13.17	0.0018
Error	8	522477.883	65309.735		
Corrected Total	11	3103783.135			

CV = 7.77

Appendix Table 15Analysis of variance of feed cost per hen

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	11970.15531	3990.05177	702.33	0.0001
Error	8	45.44930	5.68116		
Corrected Total	11	12015.60461			

CV = 1.055

Appendix Table 16Analysis of variance of total feed intake per hen

Source	DF	Sum of squares	Mean square	F Value	Pr.> F
Model	3	0.18326667	0.06108889	5.50	0.0240
Error	8	0.08880000	0.01100000		
Corrected Total	11	0.27206667			

CV = 1.167

Appendix Table 17 Costs of feed ingredients and rations

Ingredients and rations	Cost/kg of ingredient and treatment in birr
Dry Moringa	5
SBM	60
Maize	20
Wheat bran	8
Noug seed cake	21
T1	29.62
T2	26.74
T3	23.289
T4	20.672

8.2. List of Appendix Figures

Appendix figure 1. Preparation of MOLM

Appendix figure 2. Hen body weight measuring

Appendix figure 3. Experimental pens

Appendix figure 4. Measuring egg weight

Appendix figure 5. Measuring egg yolk color

Appendix figure 6. Measuring yolk