# PERFORMANCE AND EGG QUALITIES CHARACTERISTICS OF EGG TYPE CHICKENS FED AIR- DRIED *Moringa oleifera* LEAF MEAL SUPPLEMENTED WITH MAXIGRAIN®ENZYME.

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**Abstract**
A total *number of* three hundred and sixty (360),Yaffa brownlaying birds with average weight (1286.66g to 1360.00g) were randomly distributed into eight treatment groups each comprising of three replicates with forty-five (45) birds per treatment having fifteen (15) birds per replicate in *a* 4 × 2 factorial arrangement of 4 levelsofMOLM replacing soybean meal, protein for protein (0%, 5%, 10% and 15%) with and without *Maxigrain*® enzyme at 0ppm and 100ppm.The birds were fed with growers mash until they started dropping eggs before they were subjected to the experimental diets for forty-five weeks. *The result obtained showed a significant increase in feed intake* from 105g/bird at early-lay to 124.66g/bird at late- lay, noticeable increase in bird weight at early- lay through mid-lay to late- lay and decrease of ≠ 6.09k per kilogramme feed at 15% MOLM compared to control diet (0 % MOLM) given kg feed/dozen egg (1.65-2.02), least feed cost with highest number of eggs. Hen-day production increases as the layers' ages with highest number of eggs recorded at mid-lay. Dietary effect of MOLM was also observe*d* on egg weight ≥60g, yolk weight ≥15g and improvements in yolk colour from pale in control diet to golden yolk in layers on 15% MOLM likewise a noticeable increase in Haugh units *and* shell thickness with MOLM supplementation. Cholesterol, triacylglycerol, high density lipo-protein and low density lipo-protein values were inversely related with MOLM levels in the diet. The result obtained indicated that inclusion of Moringa in layers' diet improve production, yolk to the consumers' delight, reduce the risk of heart attack and cracks during handling.
**Keywords:**Moringaoleifera, Maxigrain® enzyme, lipid profile, pigmentation,haugh unit, Kg feed/dozen egg.

## Introduction

The importance of egg cannot be overemphasized as chicken egg is the most commonly eaten egg that is capable of supplying all the essential amino acids for humans while also providing several vitamins such as vitamin A, riboflavin (vitamin B2), folic acid (vitamin B9), vitamin B12, choline and minerals such as iron, calcium, phosphorus and potassium (Chris, 2005). All of the fat soluble vitamins (A, D, E and K) are found in the egg yolk. Egg yolk also contains the long chain omega-3-fatty acid DHA (deoxyhydroxynucleic acid) which is necessary for the brain and proper retina function in the eye, and the long chain omega-6-fatty acid arachidonic, which is required for the healthy skin, hair, libido, reproduction, growth and response to injury (Chris, 2005). Eggs are good source of low cost high quality protein, providing 6.3grams of protein (13% of the daily value of protein) in one egg for a caloric cost of only 68calories (Oluyemi and Robert, 2000). The science of nutrition involves providing a balance of nutrients that best meets the need of an animal for optimal growth, and ensuring effective metabolic activities (Ranjhan, 2001), especially for layers which are very sensitive to nutrition such that inadequacies in nutrient supply often lead to fall in egg production and even cessation of lay. However, increasing competition between man and animals for available grains, inadequate supply of feedstuffs, poor quality feeds among others have been a perennial problem in livestock production.The use of local, cheap, and readily available material, particularly those that are not directly utilized by man has received particular attention as the only viable alternatives to the use of conventional feedstuffs (Nwakpu*et al.*, 2000, Ekenyem 2002, Odunsi 2003). The list of possible leaf meals which has found application in poultry nutrition are *Leucaenaleucocephala,* cassava leaf meal, *Lablab purpureus, Tithoniadiversifolia, Microdesmispuberula, Ipomoeaasarifolia*among many others. (Lopez 1986, Odunsi 2003, Odunsi*et al.*, 1996, Esonu*et al.*, 2003;Ekenyem and Madubuike 2006).

Moringa is an attractive broad leaved evergreen tree with high nutritional quality containing 80% DM, 29.7% CP,22.5% CF, 4.38% EE, 27.8% Ca and 0.26% phosphorus. Apart from nutritional and health benefits,Olugbemi*et al*. (2010) reported hypocholesterolemic properties, Antimicrobial properties was observed byFahey*et al*. (2001) while Greg (2008) reported on the natural digestive enzyme in Moringa leaves. Leaf meals also provide some essential vitamins such as vitamin A and C, minerals and oxycarotenoids which cause yellow colour of broiler chickens skin, beaks, shanks and egg yolk (Opara, 1996).However, the incorporation of substantial amount of foliage to the feed of poultry has largely not been promoted in the context of protein supply due to low nutrient concentration, high fibre, low energy and presence of toxic factors (Lopez, 1989). It then becomes imperative to develop ways of improving the utilization of these numerous potential feed resources by inclusion of enzyme. Supplementation of enzymes will not only reduce the anti-nutritive effects of leaf meals, but also releases some locked nutrients which could be easily utilized by the birds (Balamurugan and Chandrasekaran, 2009). Maxigrain® enzyme contains (10,000iu) cellulase, (200iu) Beta-glucanase and(10,000iu) xylanase and (2500 cfu) phytase has been identified to optimize the use of non-conventional feed ingredients by improving weight gain and feed conversion ratio in broilers, improve litter quality and egg production as well as shell quality. It also reduces levels of dicalcium phosphate incorporation in the feed substantially (Polchem Innovative Solution, 2013.This study is therefore geared towards determining the performance of laying birds and their egg quality characteristics to maximize the benefit ofMoringa leaf meal supplemented with enzyme.

## Materials and Methods

### Processing of *Moringaoleifera* leaf

Fresh leaves of*Moringaoleifera* were harvested from an established farm in Alaari village, a sub-burb of Ipokia local government of Ogun state, Nigeria before flowering. The branches were threshed carefully to separate leaves from twigs. The separated leaves were air-dried before milling (0.2mm sieve) to obtain *Moringaoleifera* leaf meal (MOLM) using a Thomas –Willey milling machine. Air drying processing methods was done by spreading the leaves under a shade where there was no direct contact with sunlight.

### Proximate analysis

Moisture content was determined by placing the samples in an oven for 24h at $60^0$C. Proximate constituents of the various MOLM samples were determined according to the standard procedures of the AOAC (2000). Sample was analysed for crude fibre (CF), ether extract (EE) and ash (AOAC, 2000, ID 7.101, 7.048, 7.016). The nitrogen fraction of the samples was determined using the Kjeldahl method and crude protein (CP) determined by multiplying the N value by 6.25. Fibre fractions of the sample were determined using the standard procedure of van Soest*et al.* (1991). The hemicellulose was calculated as the difference between NDF and ADF while cellulose was calculated as the difference between ADF and ADL.

### Experimental birds and management

A total number of three hundred and sixty (360), Yaffa brown, laying birds which had been raised from day old were randomly distributed into eight treatment groups each comprising of three replicates with forty five (45) birds per treatment and fifteen (15) birds per replicate in a4 × 2 factorial arrangement of 4 levels of MOLM replacing soybean meal, protein for protein (0%, 5%, 10% and 15%) with and without enzyme at 0ppm and 100ppm.The birds were fed with growers mash until they started dropping eggs before they were subjected to the experimental diets for forty-five weeks. Birds were managed intensively with feed and water *ad- libitum.* The feed was balanced within the recommended range (NRC, 1994).

**Parameters measured includes.**

**Laying Performance**

At the onset of the experiment (i. e. 20th week of the birds), the initial weight of the birds was taken to the nearest 0.01g. Records of daily feed consumption and egg production on replicate basis were kept starting from the two weeks in lay to 42 weeks in lay. Weekly egg production per replicate were pooled and expressed as percentage Hen –day egg production (HEP). It is expressed as the percentage of the ratio of number of egg laid to the number of hen days (NAPRI, 2002)

$$\text{Hen-day production} = \frac{\text{Number of eggs laid}}{\text{Number of birds housed}} \times \frac{100}{1}$$

### External egg qualities

Fifteen (15) eggs from each treatment were selected daily on weekly basis for early, mid and late lay phases. Egg quality assessment was done within 24 hours of lay. Egg collected were also recorded, weighed to the nearest .01g using electronic weighing balance while the linear measurements were taken with Vernier calipers to the nearest 0.01cm viz:

i. **Egg Weight**- The weight of each egg sample was determined with a sensitive weighing scale (saltex ® electronic balance) to the nearest 0.01g.

ii. **Egg length**- The length of egg was taken as the longitudinal distance between the narrow and the broad ends. A Vernier caliper with an accuracy of 0.1cm was used to determine the egg length.

iii. **Egg breadth-** The diameter of the widest cross –sectional region was taken as the egg breadth. It was measured with a vernier caliper to the nearest 0.1cm

iv. **Egg shape index**- Egg shape index was calculated from the measurement of egg length and egg breadth from individual egg sampled. It is the ratio of egg breadth to its lengthas expressed below.

$$\text{Egg shape index} = \frac{\text{Width of egg}}{\text{Length of egg}} \times \frac{100}{1}$$

**Shell weight**- Egg shells were air-dried for 72 hours in egg trays at room temperature. Individual eggshell was weighed using weighing scale (Saltex® electronic balance with sensitivity of 0.01g).

**Shell thickness**- The thickness of the shell was measured with a micrometer screw gauge to the nearest 0.01mm.

**Internal egg quantity**

The internal egg characteristics were measured by the destructive procedure: Egg contents were poured into a flat plate, weighed and thereafter, the albumen was separated from the yolk using a separation funnel and weighed using 0.01g sensitive electronic weighing balances.

i. **Albumen height-** The height of the egg white was measured off the chalazae at a point above mid-way between the inner and other circumference of the thick white with a spherometer having an accuracy of 0.01mm
ii. **Yolk weight-** The yolk was separated from the albumen using a plastic egg separator. Yolk weight was measure using sensitive weighing scale (Saltex ® electronic balance with sensitivity of 0.01g).
iii. **Albumen weight-** The albumen weight was taken as the difference between the eggs Weight and the combined weight of the yolk and dry egg shell for individual egg sample.

**iv.Yolkcolour-** Yolk colour was scored for individual egg yolk (on treatment basis) by comparing the colour of yolk with the colour of the chips of a Hoffman-La Roche yolkcolour fan rated 1-15 with colour intensity ranging from pale yellow to deep orange(Hoffman-La Roche 1984).

**v.HaughUnit**using the formular of haugh (1973) for individual egg sampled.

Haugh Unit (Hu) = 100 Log (H + 7.5 -1.7W0.37)

Where; H= Albumen height, W= Weight of the egg

**Egg yolk cholesterol analysis**

Eight fresh eggs per replicate were sampled at the early, mid and late phase of the laying period. The sampled eggs were weighed, hard cooked by immersion in boiling water for 10 minutes. The yolk was removed, weight as oven–dried at 70$^{o}$C. Egg total lipid was extracted with chloroform/methanol (2:1 v/v) using the procedure described by Folch*et al*, (1957). Cholesterol determination was done using a commercial test kit for cholesterol analysis (Sigma Chemical Co. St Lovis Mo USA).

**Statistical Analysis:** Data collected were laid out in 4 × 2 factorial arrangements of 4 levels of leaf meal with and without enzyme. Data obtained were analyzed using the SAS (2000) package. Analysis was done to determine the interaction effect (leaf meal inclusion levels × enzyme inclusion). A probability of P<0.05 was considered to be statistically significant.

**Results**

**Performance:** Shown in Table 2 is the performance of layers fed MOLM with and without enzyme supplementation at laying phases. The result obtained showed a significant of the diet on weight, feed intake and cost of feed. A significant increase in the average daily feed intake from 105g/bird at early lay to 124.66g/bird at late lay. A gradual increase in bird weight was observed during the laying phases, noticeable increase in bird weight gained was observed at early lay when compared to mid-lay and late lay. There was decrease in cost of feed (≠ 72.53k per kilo of feed at 15% MOLM with enzyme when compared to control diet 0% MOLM at N78.62k). The layers on 15%MOLM with enzyme supplementation recorded the highest value from kg feed/dozen egg produced (1.65-2.02) with least feed cost and highest number of eggs produced. Hen-day production increases as the layers' ages and laying progresses with highest values recorded at mid-lay.

**Egg qualities:** Interaction effect of MOLM with and without enzyme supplementation on internal egg qualities is shown in Table3. It was observed that MOLM inclusion has a significant effects on egg weight, yolk weight and yolk colour through the laying phases. The layers on 15% MOLM with or without enzyme recorded highest yolk score when compared with other treatments. It was observed that yolk of layers on control diet (0% MOLM) was pale while there were improvements in yolk colour (1-4) as MOLM level increased to give golden yolk. The layers on 15%MOLM recorded highest haugh unit at early lay, mid lay and late lay when compared with layers on other dietary treatment. There is no observed effect of dietary treatment on shell weight and shell thickness of the layers. However, observed increased in shell thickness as laying progresses.

**Egg Lipid profile:**The result as shown in table 4 indicated variations in cholesterol, triacylglycerol, high density lipo-protein and low density lipo-protein content of the eggs laid at different laying phases. It was observed that the values of these parameters decreases with increase in the inclusion level of MOLM. It was also observed that the values decrease as laying age progresses.Though there is no significant interaction effect of dietary treatment on parametersmeasured.

**Discussion**

The observed egg weights obtained in this study agrees with Olugbemi*et al*. (2009), however the egg weight values are slightly higher than the standard egg weight value of 58g at the late lay phase due to age, this could also be traced to breed effect and higher nutritive value of Moringa leaf meal (Sarwatt*et al*., 2004) as well as the natural enzyme that aid feed digestibility in Moringa (Greg, 2008) may be responsible for this result. A positive effect on egg weight observed in this study following dietary inclusion of MOLM probably might be associated with higher sulphur containing amino acids in Moringa leaves. North (1990) found a positive influence of sulphur containing amino acids on egg weight also Mellau, (1999) observed an increase in egg weight values with increase in Luceana meal up to 15% levels. Few contradicting reports on egg weight following leaf meal inclusion have been reported. Bhatnagar*et al*. (1996) found non-significant effect on egg weights at 0, 5 and 10% levels of Luecena meal. Kakengi*et al*. (2007) declared addition of 10% and 20% MOLM to the laying hens as a substitute for sunflower seed meal significantly decreased egg mass. A recent study by

Enebene*et al*. (2013) confirmed improved egg productivity and egg quality in laying hen fed Moringa leaf meal. The increase in egg mass observed in this study, most probably was associated with improved digestibility of energy and crude protein when MOLM was added in the diet leading to higher energy and crude protein availability to layers.

Hen day production; The result for percentage hen day egg production (HDEP) revealed that

increase in the level of HDEP as the level of MOLM increased in the diet of the birds suggest the possibility of an increase blood flow to the ovaries thereby leading to more ovarian follicle formation which ultimately increased egg production most especially at mid lay. This result also is in line with the work carried out by Ogbamgba*et al*. (2007) who worked with *Mansoniaaltissima*on laying birds.

The result obtained for feed cost shows declining effect as the level of MOLM increases in the diet of the birds across the treatment group. This could be as a result of the lower cost attached to the test ingredient used in the study, since it is readily available and lower cost attached to its transportation to where the experiment was conducted.

The feed consumed per dozens of eggs is the yardstick used for the measurement of feed efficiency (Oluyemi and Roberts, 1979) meaning total egg production and total feed intake. The best feed efficiency was recorded at 10% MOLM inclusion while the poorest feed efficiency was recorded for control diet. This could be as a result of the phytochemical constituents (source of beta-carotene, vitamin C, protein, iron, and potassium) Jed, (2005) in Moringaleaves**.**

The albumen height has a correlative relationship with the Haugh's units point to the desirability of diet fed to the laying hens. It was observed that dietary inclusion of MOLM was beneficial to albumen height as an egg quality index at 10%. The height of the albumen determines the Haugh's unit of the egg. The higher the height of the albumen, the greater the numerical value of Haugh's unit and the better the quality of the egg (Oluyemi and Roberts (1979). The range of values obtained for haugh unit in this study was higher than values of 83.92-84.78 reported by Olabode and Okelola, (2014). The average value of haugh unit obtained in this study conforms with standard commercial egg production guides. Oluyemi and Robert (2000) also reported that an haugh unit score of 72 and above has been graded as the best quality. Haugh units of 72 and above are indications of freshness in eggs – an index of ability of albumen to remain viscous (Uchegbu*et al*., 2011).

The egg shell thickness is also an indicator of the specific gravity (relative density of eggs, since both are positively correlated) (Oluyemi and Roberts, 1979). It is therefore suggestive that the utilization of MOLM at 10% levels of inclusion has no depressing effects on the specific gravity of eggs. As the egg shell thickness values of ≥ 0.38mm fell within normal range as reported by (Fasuyi*et al*., 2005; Uchegbu*et al*.2011; Ebenebe et al.,2013).

The colour score of egg yolk indicated improved pigmentation as level of MOLM increases in the diets due to its rich xanthophylls contentwhichagreed with studies conducted by Akintomide*et al*., (2018) and Joseph, (2016). This might be attributed to the presence of xanthophyll and carotenoid pigments in Moringa leaf meal as confirmed by(Brain *et al.*, 2006; Moyo*et al*., 2011).

The observed result of Egg LDL, cholesterol and triglyceride in this study showed a progressive decrease in value as MOLM level increases in the diet. These findings corroborated the works of Al-Harthi*et al*. (2009) and Bampidis*et al.* (2005) who reported decreasing lipid and cholesterol in laying hen fed 50g/kg mangrove leaves and reduced cholesterol in turkeys fed Oregano leaves respectively. The reduced egg lipid noticed in this study may be attributed to presence of saponin in MOLM which inhibit intestinal absorption of cholesterol (Olaleye, 2007). The reduction in triglyceride values suggested that the lower level of triglyceride may be due to the inhibition of fatty acids synthesis due to the active ingredients in Moringa which could be responsible for breaking down the fat level.

## CONCLUSION

The result therefore indicated that inclusion of Moringa improved egg production and egg quality but higher levels of inclusion resulted in lower productivity and poorer egg quality indices as chickens cannot handle appreciable quantity of vegetative material. MOLM could be counted as a feed additive which improves egg yolk colouration to the consumers' delight, reduce the risk of heart attack and their shell thickness values of ≥ 0.38mm give assurance that the eggs will not crack easily during handling / transportation.

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Table 1: **Gross composition of experimental diet**

| | **without enzyme** | | | | **with enzyme** | | | |
|---|---|---|---|---|---|---|---|---|
| **Ingredients** | 0% | 5% | 10% | 15% | 0% | 5% | 10% | 15% |
| Maize | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 | 50.00 |
| Soy bean meal | 17.00 | 12.00 | 7.00 | 2.00 | 17.00 | 12.00 | 7.00 | 2.00 |
| MOLM | 0.00 | 1.80 | 3.60 | 5.40 | 0.00 | 1.80 | 3.60 | 5.40 |
| Wheat offal | 15.00 | 12.00 | 9.00 | 6.00 | 15.00 | 12.00 | 9.00 | 6.00 |
| Fish (72%) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Limestone | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 | 8.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Salt | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Premix | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Methionine | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Lysine | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Enzyme | 0.00 | 0.00 | 0.00 | 0.00 | 100 | 100 | 100 | 100 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Determined analyses (%)** | | | | | | | | |
| Crude protein | 17.46 | 17.42 | 17.34 | 17.30 | 17.46 | 17.42 | 17.34 | 17.30 |
| Crude fibre | 6.67 | 6.71 | 6.76 | 6.80 | 6.67 | 6.71 | 6.76 | 6.80 |
| Ether extract | 3.72 | 3.94 | 4.17 | 4.39 | 3.72 | 3.94 | 4.17 | 4.39 |
| **Calculated analyses (%)** | | | | | | | | |
| Calcium | 1.70 | 1.70 | 1.69 | 1.69 | 1.70 | 1.70 | 1.69 | 1.69 |
| Phosphorus | 0.39 | 0.38 | 0.37 | 0.36 | 0.39 | 0.38 | 0.37 | 0.36 |
| Lysine | 1.02 | 0.91 | 0.81 | 0.71 | 1.02 | 0.91 | 0.81 | 0.71 |
| Methionine. | 0.48 | 0.45 | 0.42 | 0.41 | 0.48 | 0.45 | 0.42 | 0.41 |
| ME(Kcal/kg) | 2658 | 2600 | 2649 | 2649 | 2658 | 2600 | 2649 | 2649 |

Layers premix: – Vit. A 10,000,000 iu, Vit. D3 2,000,000 iu, Vit.E 23,000 Mg, Vit. K3 2,000mg, Vit. B1 3000mg,
Vit. B2 6000mg, Niacin 50,000mg, calcium Pantothenate 10,000mg, Vit. B6 5,000mg, Vit.B12 25mg, Folic acid 1000mg,
Biotin, chloride400,000mg, Mn 120,000mg, Fe 100,000mg, Zn 80,000mg, Cu 8,500mg, Co 1500mg, Se 300mg,
Anti-oxidant 120,000mg.

**Table 2. Performance characteristics of egg type chickens fed air- dried *Moringaoleifera*leaf meal supplemented with Maxigrain® enzyme.**

| Parameter | MOLM WITHOUT ENZYME | | | | | MOLM WITH ENZYME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Laying phases(wks) | 0% | 5% | 10% | 15% | 0% | 5% | 10% | 15% | SEM |
| Initial weight (g/bird) | 0 | 1360.00$^{a}$ | 1360.00$^{a}$ | 1340.00$^{b}$ | 1322.33$^{c}$ | 1340.00$^{b}$ | 1360.00$^{a}$ | 1286.66$^{b}$ | 1330.00$^{bc}$ | 5.22 |
| | 15 | 1545.00$^{c}$ | 1618.66$^{a}$ | 1580.00$^{b}$ | 1603.33$^{a}$ | 1510.00$^{de}$ | 1512.66$^{de}$ | 1503.33$^{e}$ | 1525.00$^{d}$ | 8.95 |
| | 29 | 1620.00$^{ab}$ | 1630.00$^{a}$ | 1603.33$^{b}$ | 1630.00$^{a}$ | 1600.00$^{b}$ | 1600.00$^{b}$ | 1603.33$^{b}$ | 1600.00$^{b}$ | 3.27 |
| Final weight (g/bird) | 0-14 | 1544.50$^{c}$ | 1620.00$^{a}$ | 1580.00$^{b}$ | 1603.33$^{a}$ | 1510.00$^{de}$ | 1512.00$^{de}$ | 1503.33$^{e}$ | 1525.00$^{d}$ | 9.01 |
| | 15-28 | 1620.00$^{ab}$ | 1630.00$^{a}$ | 1603.33$^{b}$ | 1630.00$^{a}$ | 1600.00$^{b}$ | 1600.00$^{b}$ | 1603.33$^{b}$ | 1600.00$^{b}$ | 3.27 |
| | 29-42 | 1670.00$^{b}$ | 1680.00$^{ab}$ | 1693.33$^{ab}$ | 1680.00$^{ab}$ | 1640.00$^{c}$ | 1700.00$^{a}$ | 1690.00$^{ab}$ | 1700.00$^{a}$ | 4.36 |
| Weight gain (g/bird) | 0-14 | 185.00$^{fg}$ | 260.00$^{ab}$ | 240.00$^{bc}$ | 281.00$^{a}$ | 170.00$^{g}$ | 166.00$^{g}$ | 210.00$^{de}$ | 195.00$^{fg}$ | 8.50 |
| | 15-28 | 75.00$^{b}$ | 11.33$^{c}$ | 23.33$^{c}$ | 26.66$^{c}$ | 86.66$^{ab}$ | 87.33$^{ab}$ | 100.00$^{a}$ | 75.00$^{b}$ | 8.34 |
| | 29-42 | 50.00$^{bc}$ | 50.00$^{bc}$ | 90.00$^{ab}$ | 66.66$^{abc}$ | 40.00$^{c}$ | 100.00$^{a}$ | 86.66$^{abc}$ | 100.00$^{a}$ | 5.96 |
| Feed intake (g/bird) | 0-14 | 105.14$^{c}$ | 106.20$^{a}$ | 105.70$^{ab}$ | 105.60$^{b}$ | 106.10$^{ab}$ | 106.10$^{ab}$ | 105.73$^{ab}$ | 106.20$^{a}$ | 0.08 |
| | 15-28 | 121.33$^{ab}$ | 119.96$^{b}$ | 121.33$^{ab}$ | 120.33$^{ab}$ | 121.16$^{ab}$ | 121.00$^{ab}$ | 122.00$^{a}$ | 119.50$^{b}$ | 0.23 |
| | 29-42 | 121.33 | 122.33 | 123.66 | 122.33 | 123.33 | 124.66 | 124.00 | 121.50 | 0.36 |
| Total feed intake (g/bird) | 0-14 | 10303.72$^{b}$ | 10391.27$^{a}$ | 10358.60$^{ab}$ | 10348.8$^{ab}$ | 10397.80$^{a}$ | 10397.89 | 10342.27$^{ab}$ | 10348.20$^{ab}$ | 8.48 |
| | 15-28 | 11888.00$^{ab}$ | 11763.27$^{ab}$ | 11890.67$^{ab}$ | 11792.67$^{ab}$ | 11874.33$^{ab}$ | 11858.00$^{ab}$ | 11956.00$^{a}$ | 11711.00$^{b}$ | 23.29 |
| | 29-42 | 11890.67 | 11988.67 | 12120.00 | 11988.67 | 12086.67 | 12217.33 | 12119.33 | 11858.00 | 36.05 |
| Hen day production (%) | 0-14 | 57.14 | 61.11 | 64.73 | 62.08 | 62.93 | 61.36 | 61.22 | 60.10 | 1.05 |
| | 15-28 | 78.59 | 78.88 | 79.34 | 79.29 | 76.59 | 78.84 | 80.31 | 85.34 | 1.37 |
| | 29-42 | 59.45 | 59.36 | 60.02 | 59.27 | 58.27 | 63.78 | 66.55 | 56.19 | 1.11 |
| Cost of feed | 0-14 | 78.62$^{c}$ | 78.30$^{e}$ | 77.96$^{f}$ | 72.13$^{h}$ | 79.02$^{a}$ | 78.70$^{b}$ | 78.36$^{d}$ | 72.53$^{g}$ | 0.56 |
| | 15-28 | 78.62$^{a}$ | 78.30$^{ab}$ | 77.96$^{ab}$ | 72.13$^{h}$ | 79.02$^{a}$ | 78.70$^{a}$ | 78.36$^{ab}$ | 72.53$^{c}$ | 0.56 |
| | 29-42 | 78.62$^{c}$ | 78.30$^{e}$ | 77.96$^{f}$ | 72.13$^{h}$ | 79.02$^{a}$ | 78.70$^{b}$ | 78.36$^{d}$ | 72.53$^{g}$ | 0.56 |
| Kg feed/dozen egg | 0-14 | 1.70 | 1.62 | 1.52 | 1.54 | 1.58 | 1.61 | 1.61 | 1.65 | 0.58 |
| | 15-28 | 1.44 | 1.42 | 1.43 | 1.41 | 1.47 | 1.43 | 1.42 | 1.31 | 0.38 |
| | 29-42 | 1.90 | 1.92 | 1.91 | 1.92 | 1.9 | 1.82 | 1.74 | 2.02 | 0.94 |
| Total feed cost (₦) | 0-14 | 810.08$^{cd}$ | 813.63$^{bc}$ | 807.55$^{d}$ | 746.45$^{f}$ | 821.63$^{a}$ | 818.30$^{ab}$ | 810.42$^{cd}$ | 752.92$^{e}$ | 8.84 |
| | 15-28 | 934.84$^{a}$ | 921.06$^{b}$ | 926.99$^{b}$ | 850.60$^{c}$ | 938.64$^{a}$ | 933.22$^{a}$ | 936.87$^{a}$ | 849.39$^{c}$ | 7.55 |
| | 29-42 | 934.84$^{a}$ | 938.71$^{a}$ | 945.12$^{a}$ | 864.74$^{b}$ | 955.08$^{a}$ | 961.50$^{a}$ | 948.66$^{a}$ | 860.06$^{b}$ | 7.95 |
| Total eggs produced. | 0-14 | 735.00 | 785.00 | 832.70 | 798.58 | 804.41 | 789.25 | 787.50 | 777.06 | 15.54 |
| | 15-28 | 1010.91 | 1014.70 | 1020.54 | 1019.95 | 985.25 | 1014.12 | 1033.08 | 1097.69 | 20.19 |
| | 29-42 | 764.75 | 763.58 | 772.04 | 762.41 | 749.58 | 820.45 | 856.04 | 722.75 | 16.40 |

a,bcdMeans in the same row bearing different superscripts are significantly ($p<0.05$) different.

**Table 3: Egg qualities characteristics of egg type chickens fed air- dried *Moringaoleifera*leaf meal supplemented with Maxigrain® enzyme.**

| PARAMETER | | WITHOUT ENZYME | | | | WITH ENZYME | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Laying phases(wk) | 0% | 5% | 10% | 15% | 0% | 5% | 10% | 15% | SEM |
| Egg weight (g) | 0-14week | 42.13ab | 41.60ab | 36.30b | 43.10ab | 42.40ab | 41.43ab | 45.20a | 41.10ab | 0.75 |
| | 15-28 | 51.66 | 52.66 | 51.66 | 50.66 | 53.66 | 53.33 | 49.33 | 49.50 | 0.84 |
| | 29-42 | 57.83cd | 60.86c | 66.13ab | 61.56bc | 62.13abc | 66.56a | 59.80c | 58.50cd | 0.77 |
| Egg Length (cm) | 0-14 | 3.45 | 3.58 | 3.36 | 3.58 | 3.48 | 3.50 | 3.60 | 3.75 | 0.03 |
| | 15-28 | 5.06 | 5.26 | 4.86 | 5.10 | 4.93 | 5.01 | 5.01 | 5.05 | 0.04 |
| | 29-42 | 5.33ab | 5.26b | 5.70a | 5.40ab | 5.46ab | 5.36ab | 5.33ab | 5.20b | 0.04 |
| Egg Breath (cm) | 0-14 | 2.62 | 2.48 | 2.30 | 2.51 | 2.45 | 2.45 | 2.44 | 2.65 | 0.03 |
| | 15-28 | 3.96ab | 3.83ab | 3.78ab | 3.90ab | 4.019 | 3.96ab | 3.73b | 3.75ab | 0.04 |
| | 29-42 | 4.16a | 4.06ab | 4.20a | 4.03ab | 4.10ab | 4.20a | 4.00ab | 4.05ab | 0.02 |
| Albumen Height (mm) | 0-14 | 7.41 | 7.40 | 7.23 | 6.81 | 8.56 | 8.47 | 7.64 | 8.72 | 0.19 |
| | 15-28 | 9.89 | 10.11 | 10.64 | 10.04 | 10.78 | 9.91 | 10.32 | 10.00 | 0.13 |
| | 29-42 | 8.66 | 7.66 | 7.97 | 8.49 | 8.40 | 8.92 | 8.47 | 8.59 | 0.13 |
| Yolk Weight (g) | 0-14 | 10.40ab | 10.50ab | 9.16b | 9.93ab | 9.63ab | 9.63ab | 10.03ab | 9.90ab | 0.14 |
| | 15-28 | 15.20a | 14.93ab | 13.13b | 15.03a | 15.33a | 14.90ab | 14.70ab | 14.90ab | 0.19 |
| | 29-42 | 16.13ab | 16.60a | 16.96a | 16.16ab | 16.53ab | 16.03ab | 15.13b | 16.60a | 0.15 |
| Shape Index | 0-14 | 0.83 | 1.10 | 1.06 | 1.07 | 1.02 | 1.05 | 1.15 | 1.10 | 0.04 |
| | 15-28 | 1.1ab | 1.43a | 1.08ab | 1.20ab | 0.09b | 1.05a | 1.28ab | 1.30ab | 0.04 |
| | 29-42 | 1.16 | 1.20 | 1.50 | 1.36 | 1.36 | 1.6 | 1.33 | 1.15 | 0.03 |
| Albumen weight (g) | 0-14 | 26.09 | 24.87 | 25.63 | 27.01 | 26.98 | 26.01 | 28.20 | 25.06 | 0.83 |
| | 15-28 | 30.94 | 31.86 | 29.08 | 31.25 | 32.27 | 32.38 | 29.86 | 29.09 | 0.02 |
| | 29-42 | 35.84cde | 38.59c | 43.21ab | 40.02bc | 39.44bc | 44.58a | 39.80cd | 36.39de | 0.81 |
| Shell Weight (g) | 0-14 | 5.31b | 5.80ab | 5.11b | 5.36b | 5.43b | 5.30b | 6.46a | 5.79ab | 0.16 |
| | 15-28 | 5.36 | 5.22 | 5.17 | 5.00 | 5.33 | 5.47 | 4.36 | 4.94 | 0.13 |
| | 29-42 | 5.36 | 5.22 | 5.17 | 5.00 | 5.33 | 5.47 | 4.36 | 4.94 | 0.13 |
| Shell Thickness (mm) | 0-14 | 0.39 | 0.41 | 0.41 | 0.40 | 0.38 | 0.38 | 0.39 | 0.40 | 0.00 |
| | 15-28 | 0.41 | 0.38 | 0.38 | 0.38 | 0.38 | 0.39 | 0.38 | 0.39 | 0.03 |
| | 29-42 | 0.43 | 0.43 | 0.42 | 0.44 | 0.44 | 0.44 | 0.46 | 0.45 | 0.00 |
| Yolk Color | 0-14 | 1.00d | 2.00c | 3.00b | 4.00a | 1.00d | 2.00c | 3.00b | 4.00a | 0.23 |
| | 15-28 | 1.00d | 2.00c | 3.00b | 4.00a | 1.00d | 2.00c | 3.00b | 4.00a | 0.23 |
| | 29-42 | 1.00d | 2.00c | 3.00b | 4.00a | 1.00d | 2.00c | 3.00b | 4.00a | 0.23 |
| Haugh Unit | 0-14 | 90.83ab | 91.10ab | 91.89ab | 87.31b | 96.19ab | 96.39ab | 91.27ab | 97.68a | 0.96 |
| | 15-28 | 99.52 | 100.90 | 104.25 | 100.91 | 103.60 | 99.98 | 102.66 | 101.28 | 0.61 |
| | 29-42 | 93.04 | 86.80 | 86.82 | 91.28 | 90.60 | 92.24 | 91.41 | 92.57 | 0.73 |

a,bcd Means in the same row bearing different superscripts are significantly ($p<0.05$) different.

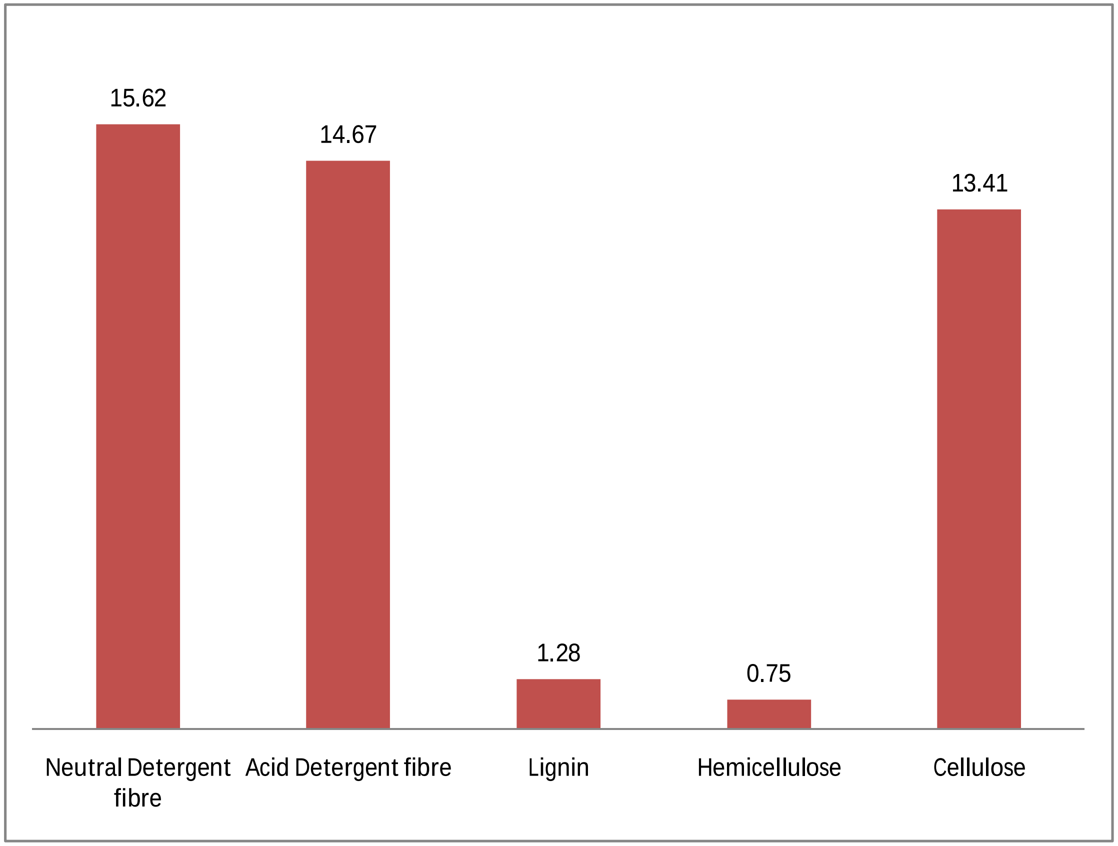
**Table 4: Egg lipid profile of egg type chickens fed air- dried *Moringaoleifera*leaf meal supplemented with Maxigrain® enzyme.**

| **Parameters** | without enzyme | | | | with enzyme | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0% | 5% | 10% | 15% | 0% | 5% | 10% | 15% | SEM |
| **0 – 14 weeks in lay** | | | | | | | | | |
| Cholesterol(mg/gDM) | 19.25 | 18.22 | 18.21 | 17.39 | 16.22 | 15.13 | 15.13 | 14.73 | 2.81 |
| Triacylglycerol(mg/gDM) | 55.14 | 32.33 | 32.09 | 29.93 | 42.74 | 36.47 | 36.47 | 33 61 | 6.73 |
| HDL(mg/g/DM) | 6.67 | 6.56 | 5.17 | 4.66 | 3.87 | 3.53 | 3.53 | 3.58 | 0.16 |
| LDL(mg/g/DM) | 13.11 | 7.51 | 5.83 | 5.40 | 7.99 | 4.67 | 4.67 | 4.67 | 0.51 |
| **15 – 28 weeks in lay** | | | | | | | | | |
| Cholesterol(mg/gDM) | 17.98 | 16.81 | 16.02 | 15.56 | 14.53 | 14.43 | 13.78 | 13.25 | 2.18 |
| Triacylglycerol (mg/gDM) | 44.98 | 37.10 | 36.85 | 31.26 | 42.43 | 31.26 | 29.38 | 28.21 | 8.33 |
| HDL(mg/gDM) | 4.83 | 5.82 | 4.98 | 3.56 | 3.09 | 3.54 | 3.25 | 2.80 | 1.47 |
| LDL (mg/gDM) | 10.67 | 6.57 | 4.36 | 4.42 | 5.12 | 5.12 | 4.05 | 3.22 | 0.20 |
| **29 – 42 weeks in lay** | | | | | | | | | |
| Cholesterol(mg/gDM) | 16.05 | 14.18 | 13.67 | 13.69 | 13.23 | 13.09 | 12.55 | 11.74 | 1.81 |
| Triacylglycerol(mg/gDM) | 48.29 | 45.40 | 30.73 | 30.73 | 39.15 | 27.72 | 26.04 | 25.14 | 7.95 |
| HDL(mg/gDM) | 1.44 | 1.12 | 0.89 | 0.89 | 2.16 | 2.07 | 1.57 | 1.51 | 0.10 |
| LDL(mg/gDM) | 6.32 | 4.53 | 4.78 | 3.64 | 4.55 | 3.68 | 2.78 | 2.78 | 1.54 |

Appendix I: Proximate **Composition of air-dried Moringa leaf meal.**

| Parameters | % | SEM |
|---|---|---|
| Dry matter | 90.40 | 0.11 |
| Crude protein | 30.36 | 0.35 |
| Fat | 6.21 | 0.05 |
| Crude fibre | 12.77 | 0.11 |
| Ash | 14.52 | 0.12 |
| Nitrogen free extract | 26.06 | 0.02 |
| *Metabolisable Energy (Kcal/kg) | 2575.41 | 2.85 |
| Gross Energy (Kcal/kg) | 2834.98 | 2.90 |

*Calculated value.




Appendix 2: Fibre fractions of air-dried Moringa leaf meal (g/kg/DM).