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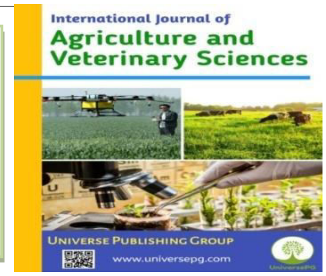

Productive Performance of Layer Chickens Fed Diets Containing Enzyme Fortified Feather Meal

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ABSTRACT

The research was conducted to investigate the replacement value of enzyme-fortified feather meal (EFFM) for fish meal in the layer chicken diets. A total of one hundred and fifty (150) ISA Brown birds of thirty-five (35) weeks old were used for this study. The birds were randomly assigned to five treatment groups in a completely randomized design. Each treatment was replicated three times. In each experiment, 1, 2, 3, 4 and 5 layer diets were formulated such that diet one (1) contained 0% of enzyme-fortified feather meal, while diets 2, 3, 4 and 5 contained 1, 2, 3 and 4% levels of EFFM respectively. Each level of EFFM was used to partially replace fish meals in the experimental diet, while treatment effects were assessed over the experimental period. Results obtained showed that the initial weights were similar *(P>0.05)* between the treatment groups. However, final weight, weight gain and average daily feed intake differed significantly *(P<0.05)* between treatment groups. Birds on diet T_5 had significantly lower egg numbers than the control, while maintaining similar egg length and shell weight with the control. The egg internal quality characteristics showed that the treatment effects for the yolk height and albumen weight were significantly *(P<0.05)* reduced in T_5 and T_4 birds compared to the other groups, while the rest were similar (*P>0.05*) with each other. Feeding of EFFM forced down (*P<0.05)* the cost of producing the layer diet per kg of feed with the lowest cost being recorded for T_5 (4.00% EFFM). A similar trend was also observed for feed cost/kg of egg produced which was also reduced with increasing inclusion of EFFM in the diets. Thus, the returns from sales were increased as EFFM increased in the poultry diet.

Keywords: Isa brown layer chicken, Egg production, Experimental diet, and Productive performance.

INTRODUCTION:

Poultry meat offer considerable potential in bridging the gap between supply and demand for animal protein especially in developing countries like Nigeria (Jiya *et al.,* 2013). Poultry products such as eggs and meat are considered to be excellent sources of protein necessary to meet the protein requirements of man, but ever-increasing population has placed a great demand on agriculture to provide adequate food for man and livestock (Olawumi *et al.,* 2012). However, the industry is faced with a lot of challenges which include inadequate nutrition, high cost of feed, poor quality feed etc (Jiya *et al.,* 2013). This is as a result of stiff completion for little available conventional feed stuff, occasioned by low crop and crisis among other factors (Tuleun *et al.,* 2010). Recently, the focus of research on monogastric nutrition has been on the use of the alternative feed stuff which can either substitute directly or can be included at a certain level without being deleterious to animal's wellbeing. Hence the use of less known non-conventional feed stuff that are not edible or in direct competition with man for food have been advocated for. Some of those ingredients, which feather meal is one of them has been found to be fit for animal consumption and not competed for by humans (Haryianto *et al.,* 2017; Clapano *et al.,* 2022).

Feathers are rich in hydrophobic amino acids and important amino acids like cystine, arginine and threonine which are important in poultry production (Chen *et al.,* 2015b; Stiborova *et al.,* 2016). Increased production of poultry appears to lie in the ability of farmers to replace the feed ingredients that are expensive and highly competed for with the cheaper but nutritionally sounding unconventional feed resources which can yield similar results and at the same time be cost effective and without deleterious effects on the animals (Wagh *et al.,* 2021). By-products from the livestock industry, such as feathers, meat offal, blood, and so on have potentials and many have been used with varying degrees of success as replacement for fish meal in livestock industry (Alao *et al.,* 2017).

MATERIALS AND METHODS:

Study area

The study was conducted at the Poultry unit of Teaching and Research Farms, Imo State University Owerri, Nigeria, where the birds were raised for the purpose of this study. The research proposal was approved by the University Ethics Committee. The study area is located within the tropical rain forest zone of Nigeria, with the coordinates of longitude $7^0$03E, latitude $5^0$48'N and elevation of 73 meters above sea level. The annual evapo-transpiration is 1450mm, with a mean annual rainfall of 1750mm.

Sources and Processing of Experimental Materials

The poultry feathers were sourced from commercial slaughter houses in Owerri, Imo State. The feathers were washed and boiled under high pressure until the resulting process of hydrolysis coverts the feathers into a more soluble form. After boiling, the feathers were washed, sundried and milled to produce feather meal. The fish meal (FM) and other feed ingredients used for this study were procured from a reputable farm feed mill in Owerri. Proximate analysis of the feather meal (EFFM) and fishmeal (FM) were conducted at Precision Analytical and Research Laboratory Ibadan, Nigeria. The mineral analysis was carried out by the method described by Grueling, (2000) while the gross energy was determined with Gallencamp Oxygen Adiabatic Bomb Calorimeter (AOAC, 1995).

Experimental Diets

Five experimental layer diets were formulated, such that T_1 which served as the control contains 0.0% enzyme fortified feather meal, while diets, T_2, T_3, T_4 and T_5 contained 1.0%, 2.0%, 3.0%, and 4% enzyme fortified feather meal (EFFM) with 100g of biozyme® per 100kg weight of feed respectively replacing fishmeal. The ingredient composition of the experimental diet is shown in **Table 1**.

Experimental Birds and Design

One hundred and fifty (150) 35-weeks old ISA Brown hens were used for this purpose. They were divided into five treatment groups of thirty (30) birds each and each group was randomly assigned to one of the experimental diets in a completely randomized design (CRD). Each treatment group was further sub-divided into three replicates of ten (10) birds.

Management Operations

The birds were housed on a deep litter pen. Feed and water were provided *adlibitum,* vaccination and medication schedule were strictly adhered to. Biosafety was also ensured. Daily routine management of wash-ing of the feeder and drinker were done. Litters were changed as at when due. Prior to the commencement of the experiment, birds were weighed to obtain initial weight. The feeding trial lasted for ninety (90) days.

Data Collection

Data were collected on the following performance characteristic parameters.

Feed intake

Feed intake was determined as the difference between the quantity of feed supplied and the leftover.

Weight gain

The birds were weighed on weekly basis. Total body weight gain was calculated by subtracting the initial body weight from the final body weight while daily body weight was determined by dividing the total body weight by the number of days the experiment lasted.

Feed conversion ratio

The feed conversion ratio was computed by dividing the average daily feed intake by the number of eggs produced.

$$FCR: \frac{\text{Average daily feed intake}}{\text{Average daily body weight}}$$

Percentage hen day egg production (%)

$$\frac{\text{Total No of eggs laid/day}}{\text{No of birds alive}} \times \frac{100}{1}$$

External egg quality measurements

Egg weight (g)

Eggs collected from each replicate were weighed with electronic digital scale

Egg length (cm)

Egg length was measured as the distance between the broad and narrow ends of the eggs using Vernier caliper

Egg width (cm)

The egg width was measured at the broad cross-sectional region of the egg

Average egg weight

$$\frac{\text{Total weight of eggs}}{\text{No of eggs}}$$

Internal egg quality measurements

Albumen and yolk heights

Albumen and yolk heights were measured at the widest expanse and midway between the yolk edge and the external edge of the thick albumen using a micrometer screw gauge and Vernier calipers respectively.

Shell weight (g)

The weights of the cleaned and dried shell (without membrane) were taken using electronic digital scale.

Percentage shell (%): This was calculated by dividing shell weight by egg weight and multiple by 100

Albumen index: $\frac{\text{Albumen height}}{\text{Albumen width}}$

Yolk index: $\frac{\text{Yolk height}}{\text{Yolk width}}$

Shell thickness (mm): dry egg shells were measured at three different points (narrow, middle and broad portions) with micrometer screw gauge.

Yolk weight: an egg separator was used to separate the yolk from the albumen and weighed with a sensitive weighing balance.

Albumen weight: albumen weight was calculated by subtracting yolk and dry shell weights from the whole egg weight. Albumen weight relative to the individual egg weight calculated.

Haugh unit (Hu): $100 \log 10(H - 1.7w^{0.35} + 7.6)$

Where,

Hu = Haugh unit (%)

H = Observed albumen height (mm)

W = Egg weight (g)

Data Analysis

All data collected were analyzed using the one-way analysis of variance (ANOVA) and the differences between means separated by the Duncan's Multiple Range Test as outlined by SPSS Analytical package (SPSS, 2012).

Table 1: Ingredient Composition of the Experimental Layer Diets (%).

			Diets		
Ingredients	**T_1 (0.00%)**	**T_2 (1.00%)**	**T_3 (2.00%)**	**T_4 (3.00%)**	**T_5 (4.00%)**
Maize	46.00	46.00	46.00	46.00	46.00
Soybean	12.00	12.00	12.00	12.00	12.00
Fish meal	4.00	3.00	2.00	1.00	0.00
EFFM	0.00	1.00	2.00	3.00	4.00
Groundnut cake	6.00	6.00	6.00	6.00	6.00
Palm kernel cake	11.20	11.20	11.20	11.20	11.20
Bone meal	4.00	4.00	4.00	4.00	4.00
Oyster shell	2.00	2.00	2.00	2.00	2.00
Lime stone	3.00	3.00	3.00	3.00	3.00

Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.10	0.10	0.10	0.10	0.10
Vitamin/mineral premix	0.25	0.25	0.25	0.25	0.25
Common salt	0.30	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Nutrient Content of the Experimental Feed					
Crude protein	18.81	18.85	18.90	18.95	18.99
Calcium	3.41	3.40	3.39	3.38	3.37
Phosphorus	0.99	0.98	0.97	0.96	0.94
Crude fibre	4.35	4.34	4.32	4.31	4.29
ME (Kcal/kg)	2653.24	2662.95	2672.66	2682.37	2692.08

ME = Metabolisable energy

RESULTS:

Table 2: Proximate and Mineral Composition of Fish meal and Feather meal.

Nutrients	Values	
	Fish meal	**Feather meal**
Dry Matter (%)	94.06	90.75
Crude protein (%)	55.93	60.44
Crude fat (%)	5.91	20.79
Crude fibre (%)	1.84	0.32
Total ash (%)	23.10	7.31
Nitrogen free extract (%)	8.80	4.21
Moisture (%)	5.94	6.93
Metabolisable energy (Kcal/kg)	3085.35	4086.36
Mineral compositions		
Calcium (%)	6.09	1.87
Phosphorus (%)	3.05	0.71
Magnesium (%)	2.00	0.08
Iron Fe (%)	1.50	0.05
Copper cu (%)	3.70	0.001
Zinc (%)	0.003	0.012

Performance Indices

The result of the performance indices of laying hens fed varying levels of enzyme fortified feather meal (EFFM) for fish meal replacement is shown in **Table 3**. Some of the parameters measured were significantly *(P<0.05)* different, these include the final weight, the weight change and the average daily feed intake. Non-significant differences *(P>0.05)* were recorded for other parameters measured between the control and EFFM diets. Non-significant difference *(P>0.05)* was observed in final weight between birds in control diets (T_1,) birds fed diets containing 2.00% EFFM (T_3) and birds fed diets containing 4.00% EFFM (T_5) with birds in T_5 having the highest weight. Change in weight was most observed with birds that fed 0.00% EFFM diet (control) (T_1), though non-significant difference was observed between them and birds that fed 1.00% EFFM (T_2) and those that fed 2.00% (T_3) EFFM. Non-Significant difference *(P<0.05)* was observed for average daily feed intake between the birds in control diet (T_1), those that fed 1.00% (T_2), those that fed 2.00% (T_3), and those that fed 3.00% (T_4) EFFM respectively. Though the birds in T_5 had the most values, the values were decreasing with increasing level of EFFM inclusion. Non-significant differences *(P>0.05)* were observed for the egg weight, egg mass, feed conversion ratio and hen day production among the treatment means. No mortality was equally recorded in all the treatment groups.

Table 3: Performance indices of laying hens fed enzyme fortified feather meal for fish meal.

Parameters	T_1 (0.00%)	T_2 (1.00%)	T_3 (2.00%)	T_4 (3.00%)	T_5 (4.00%)	SEM
Initial Weight (g)	1870.62	1843.57	1865.78	1843.73	1880.03	8.53
Final Weight (g)	1950.12^{a}	1913.33^{b}	1944.67^{a}	1913.92^{b}	1950.56^{a}	8.66
Weight Change (g)	79.11^{a}	79.76^{a}	78.89^{ab}	70.21^{b}	73.22^{b}	3.13

Average daily feed intake (g)	117.78[a]	117.59[a]	117.50[a]	117.39[a]	113.66[b]	0.62
Egg Weight (g)	60.89	61.01	61.27	60.99	61.81	0.27
Egg mass	50.54	50.30	50.69	50.19	50.63	0.27
FCR	2.33	2.34	2.32	2.34	2.24	0.02
Hen Day Production (%)	83.00	82.46	82.74	82.30	81.93	0.32
Mortality	0.00	0.00	0.00	0.00	0.00	0.00

a, b mean values on the same horizontal row with different superscripts are significantly different ($P<0.05$).
SEM: Standard error of mean.

External egg quality

The external egg quality indices of laying hens fed enzyme fortified feather meal (EFFM) diets for fish meal replacement is shown in **Table 4**. Results obtained showed that egg number, egg length, shell thickness and shell weight were significantly different *(P<0.05)* among the treatment means. For egg number, non-significant difference *(P>0.05)* was observed between the birds in control diets (T_1), birds fed 1.00% (T_2), 2.00% (T_3), and 3.00% (T_4) EFFM diets respecttively, with birds in T_1 having the highest number of eggs. However, significant difference *(P<0.05)* was observed between these birds and those fed 4.00% (T_5) EFFM diets, which recorded the least value of egg number. Birds in control diet (T_1), birds fed 1.00% (T_2), 2.00% (T_3), and 3.00% (T_4) EFFM diets were non-significant *(P>0.05)* for egg length, as well as birds in T_1, T_3, T_4, and T_5, while birds in T_2 recorded significant difference *(P<0.05)* with birds in T_5. While birds fed 1.00% (T_2) EFFM diets had the highest mean value for egg length, followed by birds in T_1 (control diet), those in T_5 recorded the least value. In shell thickness, non-significant differences *(P>0.05)* were observed for the birds in control diet (T_1), 1.00% (T_2), 3.00% (T_4) and 4.00% (T_5) EFFM fed birds respectively. While birds in T_5 (4.00%) had the highest mean value of the shell thickness, T_4 (3.00%) birds trailed behind it. Non-significant differences *(P>0.05)* were also observed between birds in T_5 (4.00%), T_1 (control diet), T_3 (2.00%) and T_4 (3.00%) and between birds in T_1 (control diet), T_2 (1.00%), T_3 (2.00%) and T_4 (3.00%) in shell weight but between birds in T_2 (1.00%) and T_5 (4.00%). Birds in T_5 had the highest mean value of shell weight, followed by birds in T_4, while birds in T_2 had the least mean value of shell weight. Non-significant difference *(P>0.05)* was observed in egg width and egg weight across the treatment means.

Table 4: External egg quality characteristics of laying hens fed enzyme fortified feather meal (EFFM) for fish meal replacement.

Parameters	T_1 (0.00%)	T_2 (1.00%)	T_3 (2.00%)	T_4 (3.00%)	T_5 (4.00%)	SEM
Egg number	747[a]	742.01[ab]	744.67[ab]	740.67[ab]	737.33[b]	2.85
Egg length (cm)	57.18[ab]	58.50[a]	56.86[ab]	57.95[ab]	56.68[b]	0.26
Shell thickness (mm)	39.22[a]	38.05[ab]	37.79[b]	39.36[a]	39.37[a]	0.29
Shell weight (g)	5.62[ab]	5.47[b]	5.71[ab]	5.82[ab]	6.05[a]	0.08
Egg width (mm)	43.87	43.24	44.07	43.92	44.07	0.13
Egg weight (g)	60.89	61.01	61.27	60.99	61.81	0.27

a, b mean values on the same horizontal row with different superscripts are significantly different *(P<0.05).*
SEM: Standard error of mean.

Internal egg quality

Results of internal egg quality characteristics of laying hens fed enzyme fortified feather meal (EFFM) for fish meal replacement is shown in **Table 5**. Results obtained showed non-significant difference in the yolk weight *(P>0.05)* across the different groups. All other parameters including albumen height, albumen width, albumen length, yolk height, yolk width, yolk length, albumen weight and Haugh unit differed significantly *(P<0.05)* across the different groups. For yolk length, significant difference *(P<0.05)* was observed between birds in T_1 (0.00%) and T_2 (1.00%), though non-significant difference *(P>0.05)* was observed for birds in this two groups and other treatment groups, T_1 birds recorded highest mean value, and this was followed by birds in T_4, while T_2 birds recorded the least value. Non-significant difference *(P>0.05)* was also observed in yolk heights between birds in T_1 (0.00%) and T_3 (2.00%) and between birds in T_2 (1.00%) and T_3 (2.00%). Birds in T_1 recorded the highest mean value, trailed behind by those in T_3, while birds in T_5 recorded the least value of yolk height. For albumen height, non-significant difference *(P>0.05)* was observed between birds in T_1 (0.00%), T_2 (1.00%) and T_5 (4.00%), but between birds in T_1 (0.00%) and T_3 (2.00%). While birds in T_1 recorded the most value, those in T_3 recorded the least weight. In Non-significant difference *(P>0.05)* was recorded in most treatment groups for Haugh unit, except between T_1 (0.00%) and T_3 (2.00%). T_1 birds had the highest mean value, while the T_3 birds had the least value of Haugh unit.

Table 5: Internal egg quality indices of laying hens fed varying levels of enzyme fortified feather meal (EFFM) for fish meal (FM).

Parameters	T_1 (0.00%)	T_2 (1.00%)	T_3 (2.00%)	T_4 (3.00%)	T_5 (4.00%)	SEM
Yolk weight (g)	21.39	21.22	21.96	22.02	21.44	0.25
Yolk length (mm)	40.70^{a}	39.77^{b}	40.46^{ab}	40.61^{a}	40.37^{ab}	0.23
Yolk height (mm)	16.65^{a}	15.69^{bc}	15.94^{ab}	15.27^{c}	15.26^{c}	0.17
Yolk width (mm)	38.18^{c}	38.63^{bc}	39.03^{bc}	40.12^{a}	39.33^{ab}	0.29
Albumen height (mm)	7.01^{a}	6.78^{a}	6.15^{c}	6.16^{b}	6.41^{ab}	0.13
Albumen width (mm)	77.88^{c}	80.56^{bc}	86.59^{a}	85.87^{a}	82.51^{b}	1.02
Albumen length (mm)	92.81^{ab}	90.53^{c}	94.08^{a}	93.74^{a}	92.42^{bc}	0.43
Albumen weight (mm)	24.54^{a}	23.85^{ab}	24.27^{a}	22.97^{bc}	22.65^{c}	0.36
Haugh unit (%)	82.89^{a}	81.13^{ab}	76.50^{b}	76.98^{ab}	78.38^{ab}	0.94

a, b, c mean values on the same horizontal row with different superscripts are significantly different (*P<0.05*).
SEM: Standard error of mean.

Nutrient Retention

Results on the nutrient retention of layer chicken fed enzyme fortified feather meal (EFFM) for fish meal replacement is presented on **Table 6**. Results obtained showed that the birds in T_3 (2.00%) recorded highest value of dry matter (82.50%) which differed significantly *(P<0.05)* from other treatment groups. This is followed by birds in T_2 (1.00%) (80.10%), T_1 (0.00%) (79.40%) and T_4 (3.00%) (78.69%) in that order, though non-significant difference *(P>0.05)* was observed amongst them. Birds in T_5 (4.00%) had the least mean value of dry matter (76.55%) which differed significantly with other treatment groups. Birds in control diet (0.00%) had the highest value of crude protein (63.40%), trailed behind by birds in T_4 (62.98%), T_5 (62.94%), T_3 (62.86%), while birds in T_2 recorded the least value of crude protein (61.89%). Ether extract and crude fibre were observed most in birds fed control diets (T_1) (81.04%) (59.89) respectively, and the values reduced with increasing level of EFFM diets across the treatment groups respectively. Ash was highest with birds in T_4 groups (59.28%), with birds in T_3 (57.25%), T_2 (56.75%), T_1 (54.80%) and T_5 (54.19%) followed behind each other.

Table 6: Nutrient Retention of laying hens fed varying levels of enzyme fortified feather meal (EFFM) for fish meal replacement.

Parameters	T_1 (0.00%)	T_2 (1.00%)	T_3 (2.00%)	T_4 (3.00%)	T_5 (4.00%)	SEM
Dry matter	79.40^{b}	80.10^{b}	82.50^{a}	78.69^{b}	76.55^{c}	0.54
Crude Protein	63.40^{a}	61.89^{b}	62.86^{ab}	62.98^{ab}	62.94^{ab}	0.19
Ether extract	81.04^{a}	79.44^{b}	75.30^{c}	74.20^{c}	71.10^{d}	0.97
Crude fibre	59.89^{a}	56.85^{b}	54.75^{c}	53.99^{c}	50.65^{d}	0.82
Ash	54.80^{cd}	56.75^{bc}	57.25^{ab}	59.28^{a}	54.19^{d}	0.16

a, b, c, d mean values with different superscripts on the same horizontal row are significantly different *(P<0.05)*.
SEM: Standard error mean.

Cost effectiveness

Profitability of enzyme fortified feather meal (EFFM) for fish meal (FM) replacement is shown in below **Table 7**. Both the feed cost/kg and the feed cost/kg of egg produced were significantly different *(P<0.05)* and significantly reduced with increasing inclusion of EFFM in the diets. The control diet had the highest feed cost per kg and feed cost per kg of egg produced.

However, the T_2 diet had similar *(P>0.05)* feed cost per kg of egg produced with the control and both were significantly higher than the other groups, while diet T_5 (4.00% EFFM inclusion) had the least feed cost per kg of egg produced.

Table 7: Cost effectiveness of laying hens fed varying levels of enzyme fortified feather meal for fish meal.

Parameters	T_1 (0.00%)	T_2 (1.00%)	T_3 (2.00%)	T_4 (3.00%)	T_5 (4.00%)	SEM
Feed cost/kg	129.75^a	124.75^b	119.75^c	114.75^d	109.75^e	1.90
Feed cost/kg egg produced	302.32^a	291.91^a	277.82^b	268.51^b	245.84^c	5.48

a, b, c mean values on the same horizontal row with different superscripts are significantly different (*P<0.05*).
SEM: Standard error of mean.

DISCUSSION:

Replacing fish meal with EFFM at various inclusion levels in the layer diets was not deleterious to the experimental laying hens. All the treated diets returned similar performance responses as the control except for final weight which was significantly reduced in birds fed T_2 (1.00%) and T_4 (3.00%) EFFM in their diets. The change in weights of birds during egg laying was significantly reduced in birds fed higher levels of EFFM (i.e. T_4 and T_5) in their diets. The replacement of fish meal with enzyme fortified feather meal in T_5 significantly decreased feed intake while maintaining similar or no significant improvements in performance relative to the control birds. Similar observations have been reported Senkoylu *et al.* (2005), who observed no deleterious effect on hen-day production percentage, feed intake and egg mass with feather meal inclusion in layer diets but rather improved FCR and egg weight. Significant improvement in egg production, egg mass and feed conversion ratio have been reported for quail birds fed feather meal compared with the control (Al-Hummond and Mohsen, 2019). Earlier studies reported poor laying performance with the replacement of fishmeal with feather meal (El-Boushy *et al.,* 1990). However, the similarity in the FCR values of the hens placed on the experimental diets and those on control is suggestive that the complete replacement of fish meal using feather meal at high inclusion levels (4%) had no deleterious effect and could sufficiently supply the required nutrients for optimal laying performance. The varying levels of dietary replacement of fish meal with feather meal (EFFM) had no treatment effects on the external egg quality characteristics and were similar with the control values. However, the egg internal quality characteristics differed among the treatment groups, although with no clear trend as to determine if the differences were as a result of EFFM diets. However, the yolk height and albumen weight of birds in T_4 and T_5 diets were significantly *(P<0.05)* reduced below the control values. This implies that the inclusion of EFFM beyond 2.00% (T_3) in replacement for fish meal caused the laying of less densed eggs compare to the control and could impact on the Haugh unit, which is a quality parameter for determining egg internal quality (Kul and Seker, 2004). However, the replacement of fishmeal with feather meal significantly reduced the cost of feed and feed cost per kg of egg produced.

CONCLUSION:

In conclusion, fish meal which is a major ingredient in poultry feed formulation is quite expensive. In this study, replacing fish meal with EFFM at various inclusion levels in the layer diets was not deleterious to the experimental hens, it also forced down the cost of producing the layer diets. Feather is cheap and abundantly available. It is not competed for by humans and does not contain any anti-nutritional factors. Its protein can be made available through good processing method, including fortification with enzymes. Therefore, the use of this agricultural by-product in formulation of poultry diets will reduce the cost of poultry feed which invariably will reduce the price of table eggs and meat making them available and affordable even to average consumers thereby bridging the gap between supply and demand for animal protein especially in developing countries like Nigeria.

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CONFLICTS OF INTEREST:

The authors certify that there is no conflict of interest.

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