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A regression model for egg production in Isa-brown layers fed with *Moringa oleifera* leaf powder supplement

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Abstract A model for predicting egg production in Isa-brown layers fed with a known quantity of *Moringa oleifera* leaf powder supplement at a given period was developed. The coefficient of the model indicated that whenever the percentage of *Moringa oleifera* inclusion was known and the week was specified, the number of eggs that was laid by the birds that predicted with a minimal error. The result of the indicated that *Moringa oleifera* inclusion and time (weeks) significantly (p-value = 0.000 < 0.05) predicted the number of eggs. The coefficient of determination value (R^2) of 0.935 implied that 93.5% of the entire variation in the number of eggs was accounted for by the percentage of moringa inclusion and the weeks of feeding.

Keywords: Additive, Chicken, Egg, Experimental design, Prediction, Regression model

Introduction

Feed supplement has been used in the past and present to influence the performance of farm animals. Chlorella algae was successfully used to increase the yellow pigment of egg yolk but consequently decreased egg yolk size while peppermint leaf meal in the feed of laying chicken improved egg weight, egg number, egg mass and feed consumption (Abdel-Wareth and Lohakare, 2014). So many researches have reported the use of *Moringa oleifera* to improve the performance of farm animals. The study on the growth of broilers fed with *Moringa oleifera* leaf powder supplement as a protein replacement to soybean meal indicated a significant difference in the feed intake of the broilers (Gadzirayi *et al.*, 2012). Pullets fed 2.5% M. oleifera leaf mead had the highest final body weight but did not statistically differ from the other treatment groups (Ugwuoke *et al.*, 2020). Feed utilization efficiency and tissue accretion in broilers were found to be improved by the addition of Moringa oleifera leaf powder in the diet

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(Nkukwana *et al.,* 2014). It was found out that the highest average weight was recorded in post-weaning rabbits when moringa was supplemented (820.62 g), and slightly followed by the mixture of supplements (658.75 g) and then the standard supplement (632.75 g) (Djakalia *et al.,* 2011). There was an improvement in egg production in Vanaraja laying hens by the addition of 0.5 kg of Moringa oleifera leaf meal (Swain *et al.*, 2017).
However, egg production in Isa-brown layers can also be influenced by time. Most layers commence egg production from 19 or 20 weeks of age. The number of eggs produced in a batch increases as time progresses. Arifin (2016) affirmed that egg production reaches 18.11% at the early stage and rises to the production percentage of 87.45% at the second stage but declines to 44.75 % at the final stage. Chickens according to Growel Agrovet (2015), start commercial egg-laying from 18 to 19 weeks old and continue laying until 72 to 78 weeks old. The study aimed to develop a model for predicting egg production in Isa-brown layers fed with Moringa oleifera leaf powder supplement over a period of time.

Materials and methods

The experiment was carried out following the regulatory guidelines of the University of Nigeria Animal Care Ethics Committee (UNN/ACEC/0067). The study was conducted in the Department of Agricultural Education poultry farm, University of Nigeria, Nsukka. A completely randomized design (CRD) was adopted where 240 pullets were randomly selected and randomly placed in 12 pens. The 12 pens were randomized into four treatments with each replicated three times. T1 was the control while T2, T3 and T4 were supplemented with 2.5%, 5% and 7.5% *Moringa oleifera* leaf powder respectively. Feeds were given daily to the hens at the same time. The experiment lasted for 31 weeks. Harvesting and processing of moringa leaves into powder were done according to the procedure described by Mishra *et al*. (2012).

The feeds were formulated using feed formulation software called FeedWin developed by PTC+, located in Barneveld, the Netherlands while dosing, grinding and mixing were done in Chidera Feed Mill, Nsukka, Nigeria. A multiple linear regression model was fitted to the data collected from the experiment to predict the number of eggs produced when a known quantity of *Moringa oleifera* was added over a period of time.

Multiple regression analysis was used to evaluate the relationship between one dependent variable and two or more independent variables. The general multiple linear regression model in a compact form is expressed as

$$\boldsymbol{Y} = \boldsymbol{\beta X} + \boldsymbol{\varepsilon} \quad (1)$$

More explicitly, the multiple regression model is presented as
$y_i = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + e_i$ (2)
y_i is the number of eggs laid
α is the model intercept.
β_1 is the slope due to the percentage of moringa inclusion.
β_2 is the slope due to the week.
e_i is the error associated with the number of eggs laid
x_1 and x_2 are the percentage of moringa inclusion and the week respectively.

Statistical modelling and inference form the basis for objective generalizations from the experimental data (Jammalamadaka and SenGupta, 2001). Thus, we want to implement the regression model which was given above on the egg number.

Also, a one-way analysis of variance (ANOVA) was used to ascertain the factorial effect of *Moringa oleifera* and time in the experiment. All the statistical analysis in this work was done using the Statistical Package for Social Sciences (SPSS) version 20.0 software (IBM Corp., Armonk, NY, USA).

Results

Table 1. Coefficients estimates of the regression model for egg production in Isa-brown layers fed with *Moringa oleifera* leaf powder supplement

Model	Coefficients	P-value
Constant (α)	-9.03	0.14
Moring inclusion (β_1)	-6.72	0.000
Week (β_2)	17.29	0.000

Thus, the fitted model can be expressed as
$Y = -9.03 - 6.72X_{1i} + 17.29X_{2i} + e_i$
(3)

The p-value of the constant in the model as it is captured in Table 1 is equal to 0.14. This value is large (>0.05), thus the constant is not significant in the model. The prediction model is therefore given as:
$Y = -6.72X_{1i} + 17.29X_{2i}$ (4)

With this model, whenever the percentage of moringa inclusion is known and the week specified, the number of eggs that will be laid by the birds can be predicted with a minimal error (Table 1).

Having fitted a regression model to the experimental data, it is pertinent to examine the goodness of the fitted model. This goodness of fit test aims at knowing whether the true statistical relationship between the number of eggs, the percentage of moringa inclusion and the period (week) are reflected in the fitted model. Here, we carry out the test under the null hypothesis that each of the parameters $B = 0$ (the parameters are all equal to zero) against the alternative that at least one of the parameters is not equal to zero.

Table 2. Analysis of Variance of the Egg Production of Is-Brown Layers Fed With *Moringa oleifera* Leaf Powder Supplement

Source of variation	**DF**	**SS**	**MS**	**F**	**P**
Regression	2	147159.407	73579.703	297.002	<0.001
Error	41	10157.389	247.741		
Total	43	157316.795			

The *p*-value (<0.001) of the test is very small (smaller than any significance level one can imagine) (Table 2). This implies that *Moringa oleifera* and time (weeks) add significant information to the prediction of the number of eggs. Therefore, none of the model parameters is statistically equivalent to zero (apart from the constant), the true linear relationship between the variables is reflected and the model optimally mimics the observations. In addition to the result above, the coefficient of determination (R^2) was also considered to ascertain the proportion of the total variation in the number of eggs that is explained by the percentage of moringa inclusion and the period (week). The coefficient of determination is captured as follows:

$$CD = \frac{SS_{regression}}{Total\ sum\ of\ square}$$

From the Analysis of variance table above,

$$CD = \frac{147159.407}{157316.795} = 0.935.$$

This value (0.935) implies that 93.5% of the entire variation in the number of eggs is accounted for by the percentage of moringa inclusion and the week, and the remaining 6.5% is attributed to the uncontrollable factors which the experimenters are not interested in.

From the model in equation 4, the coefficient of moringa inclusion is negative while that of the laying period is positive. This implies that the higher the moringa inclusion, the lower the number of eggs laid if the laying period is kept constant. However, if the laying period increases, the number of eggs laid increases when the moringa inclusion is kept constant. Let us assume that 3% of moringa ($X_{1i} = 3$) is added to the feed. At the tenth laying week (X_{2i} = 10), the number of eggs that will be laid by 185 birds considered in the experiment can be predicted with minimum error as follows:

$$Y = -6.72(3) + 17.29(10)$$
$$-20.16 + 172.9 = 152.74 \approx 153 \text{ eggs}$$

Discussion

The result shows that regression model sufficiently predicted the number of eggs that would be laid by Isa brown layers when the percentage inclusion of *Moringa oleifera* is known and production week specified. The general multiple linear regression model is found to be superior to other prediction models like back-propagation-3 and Word-5, as it is efficient, simple to apply, does not need bulky data, and feasible in farm management situations to predict egg production in layers (Ahmad, 2011). Regression is a robust statistical tool which was used by Chaudhary *at al*. (2019) to effectively estimate morbidity and mortality in pigs that resulted from swine fever. Palmer and O'Connell (2009) noted that regression analysis is a vital statistical tool to predict and better understand the cardiorespiratory status of an organism. Regression models according to Prairie (1996) are predominantly applied in aquatic sciences for prediction purposes. Similarly, regression analysis was used to predict stock price which attracted investors in share market and stock exchange (Sahoo and Charlapally, 2015). The regression coefficient and the level of statistical significance of model accurately predicted the egg surface area, egg volume and egg shape index (Shaker *et al*., 2021).

The study equally found the percentage of *Moringa oleifera* inclusion and time significantly added information to the prediction of the egg production in Isa brown layers. Performance of layers are generally affected by age (weeks) of the birds. Hy-Line Brown (2015) noted that at 18 weeks of age the percentage hen-day production is 4-18%, while at 27 weeks of age the percentage hen-day production is 95-96%. The production capacity of laying hens at the early stage is low, but progressively increase to reach the peak and gradually decline with age. Dogara *et al.* (2021) reported that age had significant effects on the quantity of eggs produced, egg weight, egg mass, hen day production and hen housed production of different strains of Noiler chickens, and the traits increased with increase in production period. Similarly, hen-day production and egg weight increased with stage of production and age of the layers (Ezieshi *et al.,* 2003). Quadratic model was applied to predict the optimal performance of Isa brown layer where body weight, feed intake, cumulative egg number, hen-day egg production, hen-housed egg production and body weight were found to attain optimal limits at ages 64.93, 66.67, 53.49, 53.30, 54.23 and 81.28 weeks of laying respectively (Yakubu and Aguda, 2020).

The inclusion of *Moringa oleifera* in the feed of laying hens has been found to induce the egg production performance. In line with the findings, Mohammed *et al*. (2012) observed that *Moringa oleifera* fed layers had higher egg laying rate and egg mass than the control. Ugwuoke *et al.* (2022) reported that supplementation of *Moringa oleifera* leaf power increased the egg weight, egg length, shell thickness and feed intake. Higher egg production and heavier egg weight were reported by Teteh *et al*. (2016) when one percent moringa leaf meal was supplemented to 600 days Isa brown laying hens. Supplementation of 2-6% *Moringa oleifera* leaf powder according to Bidura *et al*. (2020) increased egg production, egg mass, feed efficiency and shell thickness.

Conclusively, the number of eggs produced by Isa-brown layer birds can be efficiently predicted when the quantity of *Moringa oleifera* leaf powder supplement and laying period (weeks) are known. The accurate prediction will help poultry farmers envisage the economic return in the business and calculate when the egg production will decline below the profit margin. A regression model is efficient in the prediction as it is easy to use.

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