

DEVELOPMENT OF FEATHER WEIGHT PREDICTION MODEL USING ARTIFICIAL NEURAL NETWORK OF BROILER CHICKENS

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ABSTRACT

Despite low cost of chicken feathers, abundant availability, worldwide applicability and unique properties, there hasn't been any economic means of utilizing it in Nigeria. Based on this background, this research attempted to develop a model using neural network for prediction of chicken feather weights in Nigeria. The model used body weights at different stages in predicting the feather weights. An Experiment was conducted by raising 1000 chicken from day old to 7 weeks. The Chicken's body weights were measured 7 times at an interval of 1 week. These weights were used as input data for developing the model. A two layer feed forward network with 4 sigmoid hidden Neurons and 1 Output Neuron were used. The data was divided into 3 sets (70% training sets, 15% testing sets and 15% validating sets). The network was build using MATLAB Software and was subjected to Levenberg-Marquardt algorithm. The model Simulink equation was generated using the MAPMINMAX preprocess link and the output was calculated from the MAPMINMAX reverse mask. A good agreement between the predicted weights and the experimental weights was achieved with 0.8546 as the coefficient of determination (r^2) and the sensitivity results ranged from 0.04 to 0.6 for the validated model. In model validation, results revealed (r^2) value and MSE of 0.88033 and 0.0007679 respectively. Therefore the feather weights of broiler chicken in metropolitan Kano can be best predicted using the developed ANN model. Modeling the production of chicken feather would enhance the economic means of its utilization.

Keywords: Broiler chicken, ANN, model, chicken's body weight, chicken feathers

1 INTRODUCTION

Poultry production is gaining popularity in developing countries due to its role in bridging the protein malnutrition in their diets [1]. Among the different breeds of poultry produced, chicken is the most predominant. Poultry production has become a full time business across the world and is considered to be a commercially viable enterprise that contributes to the Gross Domestic Product (GDP). Nigeria has the highest number of poultry production centers in Africa. It is recorded that the poultry industry contributes about 25% of the agricultural GDP [2]. Following the ban on importation of poultry products by the Federal Government of Nigeria, as a policy to revive the economy and encourage local poultry farmers, there has been an increase in the number of poultry processing farms in the country [3]. Processing of poultry consist of five unit operations which includes slaughtering, scalding and de-feathering, evisceration, washing, packaging and chilling. Each operation has a distinct by- product. Among these, only feathers are believed to be the major by

product [2]. Feathers are parts of birds that act as protective covering, shielding them against cold, rain, sun and injury. They also provide warmth [2]. Chicken feathers are waste products of the poultry industry. Several tonnes of waste feathers are produced annually by poultry processing plants thereby causing a serious solid waste problem [3]. Heavy dumps of these feathers are found disposed in all processing and marketing centers. The generated waste feathers are mostly disposed off in dumpsites, burnt or recycled to make animal feed, organic fertilizers and feed supplements of low quality and grade [4]. Chicken feathers possess unique properties which include low relative densities, good thermal and insulating properties which could be used advantageously. When processed, chicken feathers can be used in various ways and have positive impact on several fronts. This could serve as an alternative to feather waste disposal. Chicken feather is a renewable material whose supply is reliable and non-depleting. Therefore chicken production contributes significantly to food security, poverty alleviation, and ecologically sound management of natural resources [5]. Artificial neural network (ANN) is used in predicting the relationship between producing features in animals such as cows, sheep and chickens [6]. It is introduced as powerful tools for modeling system of planning. ANN offers an alternative to regression analysis for biological modeling [7]. [6] compared modeling of Gompertz nonlinear regression equation and modeling of ANN using data related to growth of chickens and concluded that ANN is relatively better for curve of growth of chickens. [8] used an ANN for explaining increase in weight of sheep has been done using multi forms of genes and weight. [9] also used ANN in predicting growth in sheep and concluded that the network model was accurate and more reliable than nonlinear regression models. Nigeria's poultry processing clusters process various poultry birds locally. Several tonnes of feathers are generated by this industry which is considered to be waste. Currently, methods employed for disposal include dumping, land filling and incineration, and these result in handling problems, environmental pollution, diseases and loss of useful nutrients like protein, enzymes and lipids [4]. Industries/ventures that would utilize the poultry feather waste within Nigeria would require studies among which the quantity of the product (feathers) shall be of paramount importance. Researchers only limit their works to body weights predictive models. There have been very limited studies on applying neural network in predicting overall feather weight of chickens. In this work, model equation will be developed using the artificial neural network software that will be able to predict the feather weight of chickens if other parameters such as body weights, blood weights, and breed, age and carcass weights are known.

2 MATERIALS AND METHOD

2.1 Experiment to generate chicken body weights over growing period

2.1.1 Determination of body weights

1000 chickens were grown in Gezawa poultry farm to measure the body weights. The materials used for determining initial body weights of day old chicks include weighing scale, and water-proofed tape. Weights of day old chicks were recorded and each bird was tagged individually. The birds were fed Chikun Feed with diet of (21.0% crude protein, 4% crude fat, 5% crude fiber, 1.0% calcium, 0.47% phosphorus, 2900 kcal of metabolizable energy) from day 1 to 7 weeks of age. Starting from the first day, live body weights of 25 chickens from each pen were recorded up to termination of experiment in 7 weeks. The result is presented in table 1.

2.1.2 Model development

Model equation was developed by employing the artificial neural network analysis using MATLAB package to predict the feather weight on chicken and generate the model. The parameters used in data analysis are: L_{d1} = live weight day old; L_{w2} = live weight week1; L_{w7} =live weight week7 all in kg; The dependent variable is the feather weight, FW.

2.1.3 Development of ANN model

Designing and programming ANN models. Designing ANN models follows a number of systemic procedures. In general, there are five basic steps: (1) collecting data, (2) preprocessing data, (3) building the network, (4) train, and (5) test performance of model.

2.1.4 Data collection and pre-processing

Collecting and preparing sample data is the first step in designing ANN models. After collection of data, it was pre-processed into; i. Variable selection: the input variables used in the development of the model were selected by using fitting app. In fitting app, the neural network is expected to map between the data set of numeric inputs and a set of numeric targets (output). ii. Formation of training, testing and validation sets: the data sets were divided into three distinct sets called training, testing, and validation sets. The training set which comprises of 70% of the input data is the largest set (210 samples). It was used by the neural network to learn patterns present in the data. The testing set was used to evaluate the generalization ability of the trained network and comprises of 15% of the data (45 samples). A final check on the performance of the trained network was made using validation set comprising of 15% (45 samples). The number of neurons in the fitting networks hidden layer was set to different numbers of 4, 6, and 8. The network with the best performance was selected after training.

2.1.5 Building the network

At this stage, the designer specifies the number of hidden layers, neurons in each layer, transfer function in each layer, training function, weight/bias learning function, and performance function.

2.1.6 Training Network

During the training process, the weights are adjusted in order to make the actual outputs (predicated) close to the target (measured) outputs of the network. In this study, different weights of chickens were from day 1 to 7 weeks of age used for training. The MATLAB software provides built-in transfer function was used in this study; logistic sigmoid (tansig). The network was trained to fit the inputs and targets (outputs). The Levenberg-Marquardt algorithm was used.

2.1.7 Testing Network

The next step was to test the performance of the developed model. At this stage unseen data are exposed to the model. In order to evaluate the performance of the developed ANN models quantitatively and verify whether there is any underlying trend in performance of ANN models, statistical analysis involving the coefficient of determination (R^2), the root mean square error (RMSE), and the mean bias error (MSE) were conducted.

2.1.8 Programming the neural network model

In this paper MATLAB (R2010a) was used to write script files for developing MLP and ANN models and performance functions for calculating the model performance error statistics such as R^2 and MSE. The MLP program starts by reading data from an Excel file (Training.xlsx and Testing.xlsx). "xlsread" function is used to read the data specified in the Excel file.

2.1.9 Sensitivity analysis

[10] believe that sensitivity analysis means testing happenings that are occurring as a result of changing input variables of data for result value present. To see the effects of inputs on outputs, weights were being changed to obtain output results of the corresponding input. It is anticipated that the following occurs: For each input, random values are assigned, and the remaining is kept constant. Using a random command, $r = a + (b-a) \cdot \text{rand}(300, 1)$. Using $S_{i300} = [i300(:,1)+r, i300(:,2)+r, i300(:,3)+r, i300(:,4)+r, i300(:,5:\text{end})]$, inputs 1 to 4 were changed individually whereas 5-8 were kept constant. This procedure was carried out by adding 'r' to each input being changed.

2.1.10 Model Validation

To validate the model, the neural network randomly chooses data from the input samples in which 15% (45 samples) were selected. This was used to measure generalization and halts training when it stops. The output was plotted against the target values.

3 RESULTS AND DISCUSSION

3.1 Data for model developed

Table 1 shows the results of generated chicken body weights over the growing period of 7 weeks experiment. The results shows body weights from day 1 to week 7, body weights after slaughtering, carcass weights, blood weights and feather weights. Carcass weights ranges from 0.8 to 1kg. It also shows measured and predicted feather weights ranging from 0.12kg to 0.25kg. Body weights increased as week progresses subsequently.

Table 1. input and output data for ANN development

SN	LW (kg) day 1	LW (kg) wk 1	LW (kg) wk 2	LW (kg) wk 3	LW (kg) wk 4	LW (kg) wk5	LW (kg) wk6	LW (kg) wk 7	BW as (kg)	Carcass weight (kg)	BL	FW
1	0.05	0.13	0.24	0.41	0.56	0.76	0.98	1.23	1.08	0.89	0.15	0.19
2	0.04	0.1	0.2	0.37	0.52	0.73	0.95	1.2	1.05	0.86	0.15	0.19
3	0.05	0.1	0.21	0.38	0.57	0.77	0.99	1.24	1.09	0.9	0.15	0.19
4	0.06	0.14	0.22	0.39	0.57	0.75	0.97	1.22	1.07	0.88	0.15	0.19
5	0.04	0.1	0.2	0.37	0.54	0.74	0.96	1.21	1.06	0.87	0.15	0.19
6	0.05	0.13	0.22	0.39	0.56	0.75	0.97	1.2	1.05	0.86	0.15	0.19
7	0.06	0.14	0.23	0.39	0.55	0.74	0.96	1.2	1.05	0.84	0.15	0.21
8	0.05	0.1	0.2	0.38	0.53	0.7	0.92	1.17	1.02	0.9	0.15	0.12
9	0.05	0.13	0.24	0.41	0.56	0.76	0.99	1.24	1.09	0.85	0.15	0.24
10	0.06	0.16	0.24	0.4	0.51	0.71	0.93	1.18	1.03	0.8	0.15	0.23
11	0.05	0.13	0.23	0.4	0.51	0.69	0.91	1.16	1.01	0.82	0.15	0.19
12	0.05	0.11	0.22	0.41	0.52	0.72	0.92	1.17	1.02	0.88	0.15	0.14
13	0.04	0.1	0.23	0.39	0.54	0.74	0.96	1.21	1.06	0.95	0.15	0.11
14	0.05	0.15	0.2	0.38	0.53	0.78	1	1.25	1.1	0.9	0.15	0.2
15	0.05	0.1	0.18	0.4	0.55	0.77	0.99	1.24	1.09	0.9	0.15	0.19
16	0.06	0.15	0.22	0.37	0.52	0.74	0.96	1.21	1.05	0.8	0.16	0.25
17	0.06	0.15	0.21	0.35	0.5	0.7	0.92	1.17	1.01	0.89	0.16	0.12
18	0.06	0.16	0.24	0.39	0.54	0.74	0.96	1.21	1.05	0.89	0.16	0.16
19	0.05	0.13	0.21	0.38	0.53	0.73	0.95	1.2	1.05	0.85	0.15	0.2
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1000	0.047	0.15	0.32	0.47	0.59	0.79	1.03	1.32	1.16	1	0.16	0.16

Note: LW= live weights of chickens, BW as = body weight after slaughtering, CW = carcass weight, BL = blood weight, and FW = feather weight.

3.2 Principal Specifications employed in ANN Modeling

Table 2 indicates some of the key parameters used in the network modeling process. Data/Data range indicate values taken in the study.

Table 2. ANN Modeling Specifications

S/N	Parameter	Data/data range	Technique/type of parameter used
1	Nos. of input Neuron	8	
2	Nos. of hidden neuron	4	
3	Nos. of output neuron	1	
4	Total no. of data	300	
5	Proportion of training, testing & validation data	210:45:45	
6	Data normalization	0.05-0.95	Min-max data normalization technique
7	Weight initialization	-0.5-0.5	Random weight initialization technique
8	Transfer function	0 & 1	Tan-sigmoid function
9	Error function		Mean squared error function

3.3 Implementation of ANN

Experimental results are used to develop an ANN model for predicting the responses. In this work, eight inputs and one output are considered for ANN model. The summary of the network trained and tested for is shown in Table 2. The software MATLAB was used to train, test and validate the network. The procedure for implementation of data and modeling the network has been given in the following steps:

3.3.1 Selection and assignment of nodes:

A back propagation feed forward neural network, with 8 input nodes, 4 nodes in one hidden layer and 1 output nodes in the output layer, has been trained in 13 iterations and performance of the network and mutation values have been recorded as 0.000997 and 100 respectively.

3.3.2 Training and testing responses:

The test data selected at random were validated with the predicted data and the deviation was found to be within acceptable range. R^2 value of 0.85 showed a good correlation of data as shown in Figure 4.

3.3.3 Error histogram

Graph in this section represents the analysis report of error. It shows the accuracy level of the of the network data. The Error histogram of the overall network is given in Figure 1. It shows instances at which error between the targets and outputs are at maximum i.e. at -0.00739.

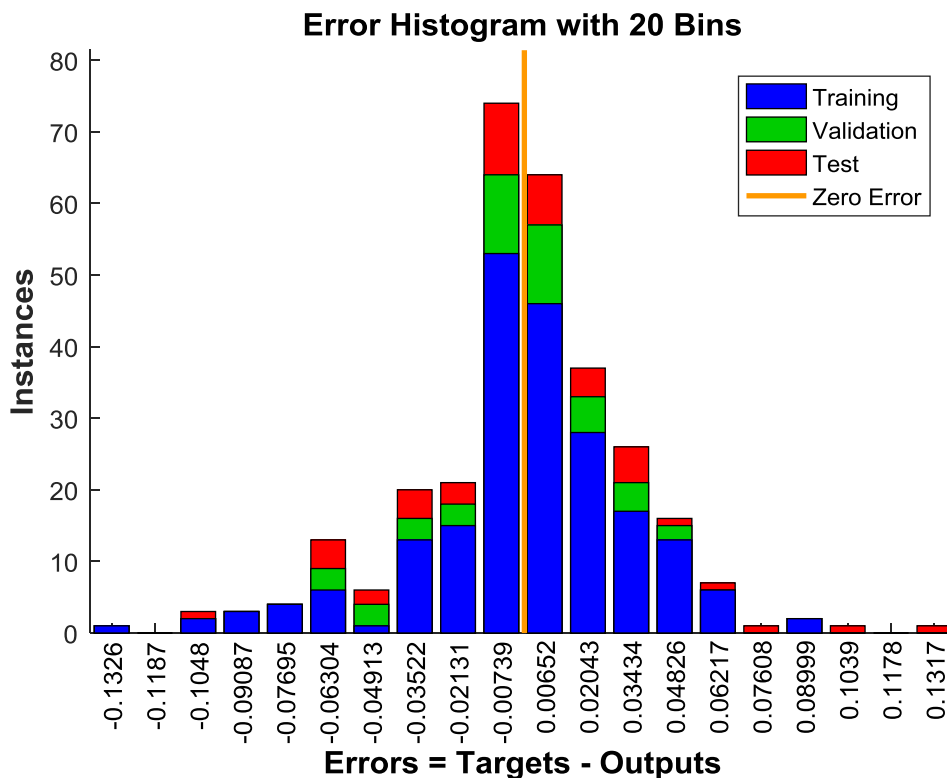


Figure 1. Error Histogram of Overall Network

3.4 Performance Analysis of ANN

Forty five samples in the design were first tested at random for prediction using the network mode and confirmation tests were performed for testing significance of the model. The training process of the network with 13 epochs and 6 validation checks is presented in Figure 2. Graphical presentation of the neural network is presented in figure 3 where at 7th epoch of the learning process, the network has shown its best performance of validation with minimum error of 0.00076795.

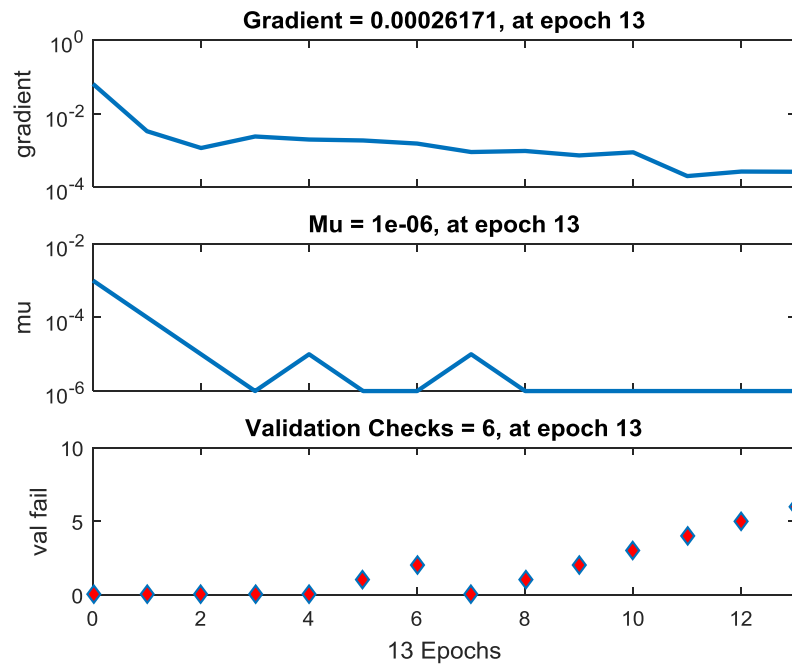


Figure 2. Training State Plot

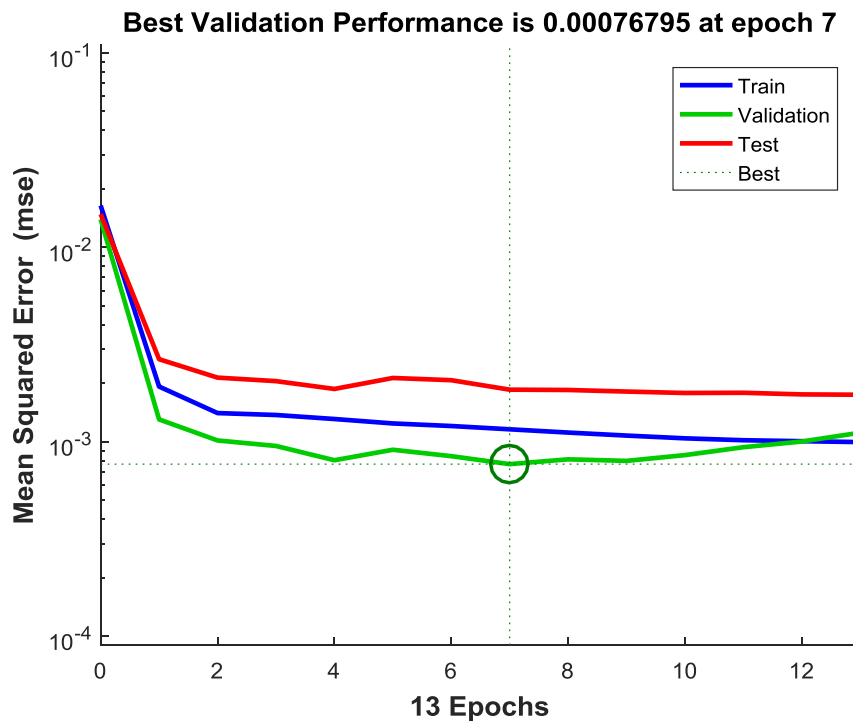


Figure 3. Neural Network training performance plot.

Regression plots for mean square error for trained (Figure 4a), validated (Figure 4b), test (Figure 4c) values and overall (Figure 4d) regression plot is shown in Figure 4. The R^2 values of for all train, test, validated and overall experiment ascertained the model validity. The high values of coefficients of correlation (R^2) indicates that the data is reliable and adequate to describe the relationship between feather weights and body weights.

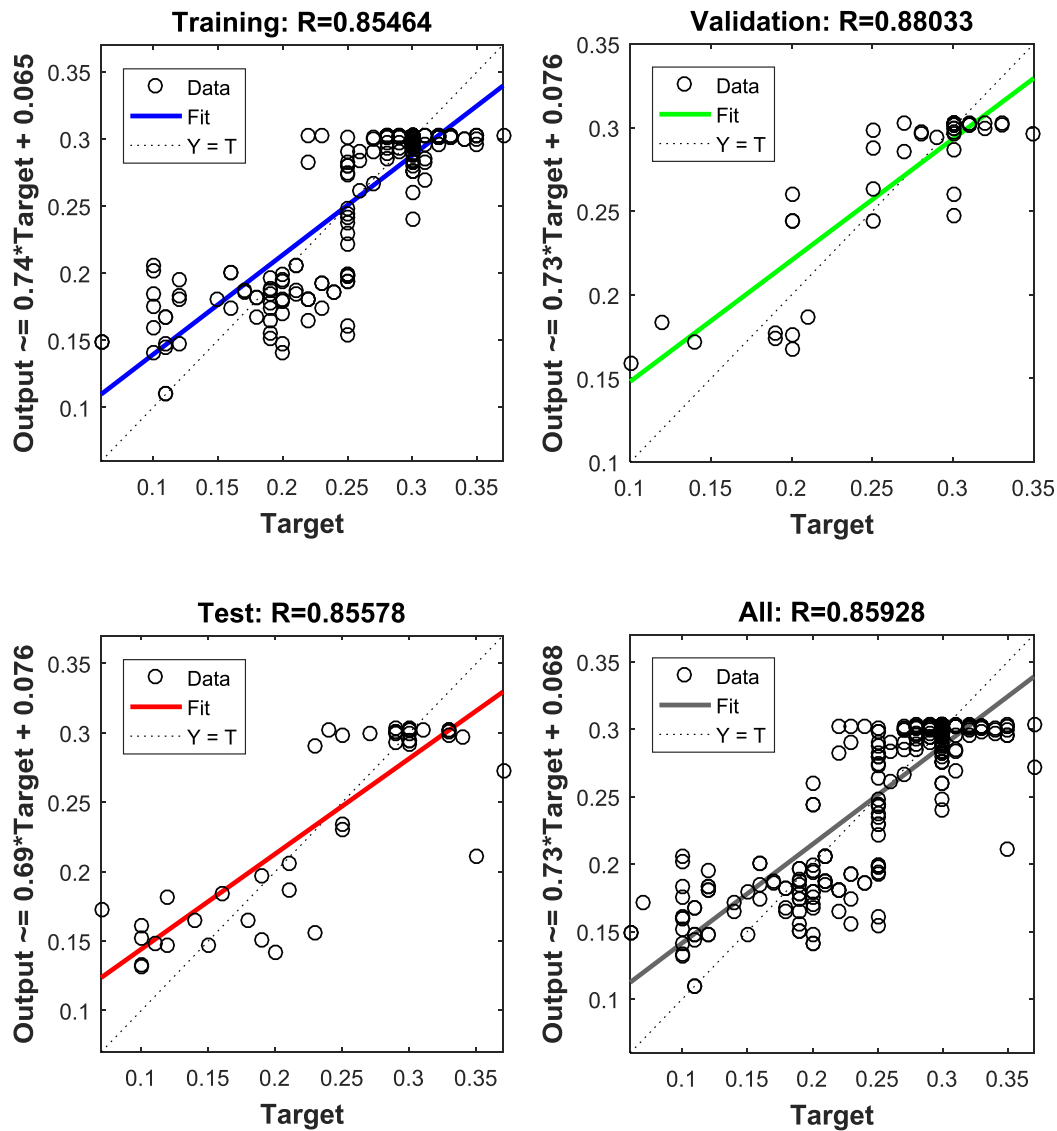


Figure 4. Correlation Coefficients for the Network

3.5 Model Validation

Model validation is an important component of a credibility test for any model developed. Model validation involves comparing the observed values with the predicted results [11]. Graphs of predicted versus real data are one of the forms of data visualization. Ideally, all points on the graph should be close to each other. Statistical analysis revealed the MSE and Coefficient of correlation as 0.0007679 and 0.88033. Model output graph presented in Figure 5 shows the trend and reflects closeness of the experimental data with the ANN predicted values.

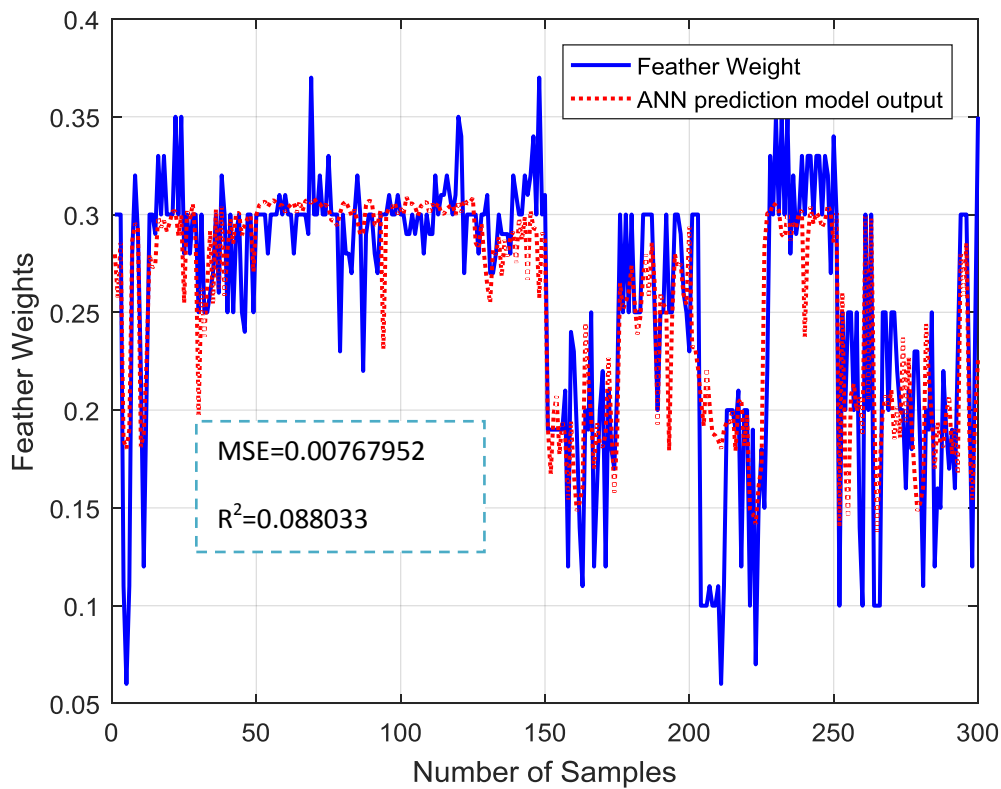


Figure 5. Predicted versus Measured Feather Weight graph

Model Simulink Equation

$$Y = (a_2 - r)k_o + y_{mx},$$

Where, Y = output, r = y1_step1.ymin, k_o = y1_step1.gain, y_{mx} = y1_step1.xoffset.

3.5 Sensitivity Analysis Test by using ANN developed

Results of sensitivity analysis for specifying training and learning neural network was executed via MATLAB software. The sensitivity coefficients ranged from 0.04 kg to 0.6kg with each variable kept constant. This indicates that if there is a 5% increase of weights of a sensitivity coefficient of say 0.11kg, the change that this could cause would be negligible. Hence it would be concluded that the sensitivity of the developed model to change amongst the independent variables that are contained in the developed prediction model is negligible and therefore not significant as shown in the Figure 6.

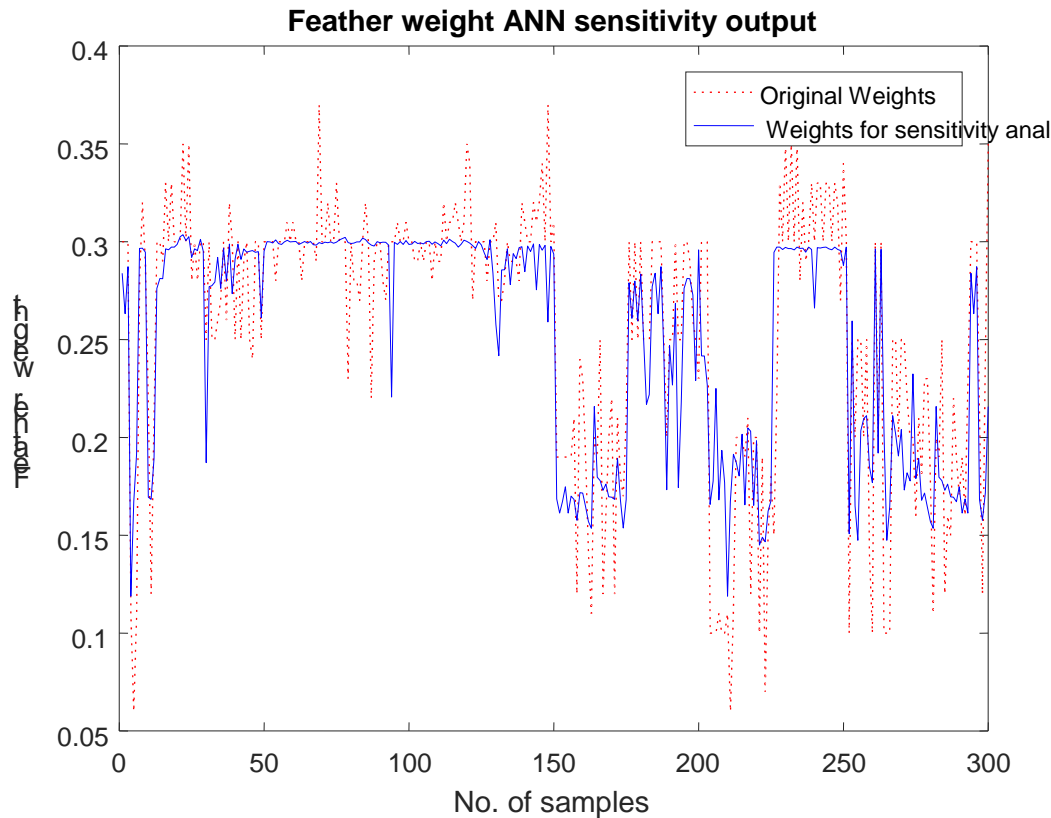


Figure 6. Feather Weight Sensitivity Output

4 CONCLUSIONS

The average weights obtained from day old chickens to week 7 and carcass were 0.05kg, 0.1397kg, 0.2978kg, 0.467kg, 0.625kg, 0.833kg, 1.082kg, and 1.353kg. All body weights increased as week progressed. Average feather weight was 0.272kg. The model was developed using Artificial Neural Network in MATLAB software and it showed a good agreement between the predicted and measured results as indicated by the coefficient of correlation (R^2) value; 0.85928 while the sensitivity coefficient for all the independent parameters validated ranged from 0.04 to 0.06kg. The value of MSE of 0.000115980 showed that there is good accuracy for long term prediction.

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