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Application of factorial design and response surface methodology on growth rate of broiler chickens served with fluted pumpkin leaves extract

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ABSTRACT

Livestock industry in Nigeria is ridden with myriad of problems, which have resulted to a gross shortage of meat and other animal products. The growth rate of agriculture sector in Nigeria is still below the potentials of the natural and human resources due to high cost of agricultural inputs. To increase protein intake in Nigeria, there is urgent need to increase broiler production at household and commercial holdings. This research was conducted to assess the weight gained by the broiler chickens served fluted pumpkin leaves extract and also to examine the possible combination of number of weeks and quantity of fluted pumpkin leaves extract that can result in maximum weight of the broiler chickens. The data were collected as a secondary data from the Federal College of Animal Health and Production Technology (I.A.R & T), Ibadan. An 8-weeks experiment was conducted to assess the weight gained by the broiler chickens served with fluted pumpkin leaves extract (FPLE). Forty day old Anak 2000 broiler chicks were randomly distributed to 5 treatments which contained 0, 30, 60, 90 and 120 ml of FPLE per litre of water for A, B, C, D and E, respectively, in a completely randomized design. Each treatment was replicated four times with two birds per replicate. The birds were fed with the same starter and finisher diets. The feed and water were served. Factorial design was used to study the main and interaction effects of number of weeks and quantity of FPLE on the weight of broiler chickens. Response surface model was fitted and subjected to canonical analysis to the characterization of the nature of its turning point and to capture the combination of number of weeks and quantity of FPLE that brings maximum weight of the broiler chickens. The results showed that the average body weight gained was significant (P<0.05). It was least in control compared to the birds served with 30-120 ml of FPLE. Factorial Design revealed that birds served with FPLE gained more weight than those in control. The birds served 120 ml of FPLE per litre of water for 8 weeks had the best performance in terms of weight gain. The use of FPLE in broiler chickens production is most effective from five weeks of age. The fitted Response Surface Model indicated that number of weeks and quantity of FPLE together with their mutual interaction significantly (P<0.05) determined the weight of broiler chickens. The maximum weight was achieved when number of week was ten with 100ml of FPLE. Number of weeks, FPLE and their mutual interaction play a key role in obtaining maximum weight of broiler chickens. These factors should be put into consideration in making of feed for broiler chickens.

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Introduction

Livestock industry in Nigeria is ridden with myriad of problems, which have resulted to a gross shortage of meat and other animal products (Nworgu, 2002). The growth rate of agriculture sector in Nigeria is still below the potentials of the natural and human resources due to high cost of agricultural inputs, poor funding of agriculture, inadequate functional infrastructural facilities, inconsistencies of government agricultural policies, inadequate private section participation, poor mechanized farming and little or no adoption of some simple agricultural technologies developed by scientists (Nworgu 2006). In spite of her numerous human and natural resources, Nigeria still remains among the least consumers of animal protein in Africa. The protein intake of an average Nigerian is about 53.8g with only 6.0-8.4g/head/day of animal origin, Egbunike(1997). CBN(1993) revealed that North America, Western and Eastern European countries consume 66, 39 and 33g of animal protein per head per day respectively; while an average Nigerian consumes 7.5g/head/day. To increase protein intake in Nigeria, there is urgent need to increase broiler production at household and commercial holdings. The per capital consumption of broiler meat in Nigeria was below 2.0kg, Ikpi and Akinwunmi (1981) as against 12.0kg to 15.5kg between 1985 and 1990 in South Africa, Viljoem (1997). Presently, Nigeria food security is in doubt. Food insecurity is a critical variable for understanding the nutritional status of low-income populations in the world.

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Poultry production is regarded as a means of sustainable livelihood and a way of achieving a certain level of economic independence. Idufuako and Madubuike (1984) reported that poultry meat and eggs offer considerable potentials for bridging the protein gap in view of the fact that high yielding exotic poultry are easily adaptable to our environment and the technology of production is relatively simple with returns on investment appreciably high. High cost of feed in poultry industry in Nigeria is the major problem of farmers. Nworgu, (2006) asserts that feed accounts for 70-80% of the total production cost of poultry in Nigeria. Oluyemi (1984) and Kekeocha (1985) noted that feed cost was over 70% for broiler production, while Nworgu and Egbunike (1999) reported that feed utilization accounted for 60 – 70% of the total cost of broiler production. One of the ways of improving the standard of living of the poultry farmers is to increase their profit margin through the application of simple, affordable, easily available and sustainable technology such as the use of fluted pumpkin leaves extract (FPLE) in broiler nutrition and production.

Adedapo et al. (2002) used fluted pumpkin and sorghum bicolor extracts as potent haematinics in domestic rabbits and concluded that the rabbits served these extracts had the highest values of packed cell volume, haemoglobin, red and white blood cells and faster responds to therapy. In Nigeria, animals lose weight during the dry season, hence, farmers' net profit is reduced and cost of animal protein per unit is very high for the populace. The use of fluted pumpkin leaf extract in broiler production is not common in Nigeria. Hence, this study will assess the growth rate, nutritive value, profit and benefit cost ratio of broiler chicken served fluted pumpkin leaves extracts.

The problem of undernourishment is worst in African countries where 32% (One out of every three Africans) of the population was under-nourished during 1983-1985 period compared to 22% in far East, 14% in Latin America and 11% in near East, FAO (1990). This problem still remains the same presently in Nigeria. The WHO (2002) noted that at least 50% of all deaths among the under-age are attributed to malnutrition, while lucky survivors cannot run away from the stark realities of poor health and overall indigent lifestyle.

Blood parameters have been shown to be major indices of physiological, pathological and nutritive status of an organism and changes in the constituent compounds of blood when compared to normal values could be used to interpret the metabolic stage of an animal as well as quality of feed. It is against these backgrounds that this study was conducted to determine the nutritive value of Telfairia Occidentalis leaves extract and evaluate its effects on the weight gain, feed and water intake of broiler chickens served this extract at four days interval during the late dry season (December 2003 – February 2004) as birds lose weight during this period of the year due to positive heat load.

Preparation of Fluted Pumpkin leaves Extract

One kilogramme of freshly cut fluted pumpkin leafs with leaf stalks were washed, drained, chopped and pounded in a mortar with pestle. This was then squeezed and filtered with a sieve to obtain the homogenous extract of the fluted pumpkin leafs (FPL). The homogenous FPLE was prepared at four days interval and served the animals fresh according to the treatments.

Source of Data Collection:

The collection of data is as important as the statistical inference drawn from the analysis. The data were collected as a secondary data from the Federal College of Animal Health and Production Technology (I.A.R & T.), Ibadan. Oyo State. Nigeria.

Methodology

The data were collected as a secondary data from the Federal College of Animal Health and Production Technology (I.A.R & T.), Ibadan. Oyo State. Nigeria. An 8-weeks experiment was conducted to assess the weight gained by the broiler chickens served with fluted pumpkin leaves extract (FPLE). Forty day old Anak 2000 broiler chicks were randomly distributed to 5 treatments which contained 0, 30, 60, 90 and 120 ml of FPLE per litre of water for A, B, C, D and E, respectively, in a completely randomized design. Each treatment was replicated four times with two birds per replicate. The birds were fed with the same starter and finisher diets. The feed and water were served. Factorial design was used to study the main and interaction effects of number of weeks and quantity of FPLE on the weight of broiler chickens. Response surface model was fitted and subjected to canonical analysis to the characterization of the nature of its turning point and to capture the combination of number of weeks and quantity of FPLE that brings maximum weight of the broiler chickens.

Factorial Design Analysis

Factorial design is widely used in experiments involving two or more factors, where it is necessary to study the joint effect of the factors on a response. If all factors in the experiment are fixed, we can easily formulate and test hypotheses about the main effects and interactions using the ANOVA.

The model for the three-factor analysis used in this paper is given as;

$$Y_{ijkl} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + (\tau\beta\gamma)_{ijk} + \epsilon_{ijkl} \quad \ldots\ldots\ldots 1$$

$$\begin{cases} i = 1,2,3,\ldots,a \\ j = 1,2,3,\ldots,b \\ k = 1,2,3,\ldots,c \\ l = 1,2,3,\ldots,n \end{cases}$$

Response Surface Methodology

As an important aspect in the statistical design of experiments, the Response Surface Methodology (RSM) is a collection of mathematical and statistical techniques useful for the modeling and analysis of problems in which a response of interest is influenced by several variables and the objective is to optimize this response, Montgomery (2005).

A first - order model with 2 independent variables can be expressed as

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon \ldots\ldots\ldots 11$$

If there is a curvature in the response surface, then a higher degree polynomial should be used. The approximating function with 2 variables called a second-order model is given as:

$$y = \beta_0 + \sum_{j=1}^{q} \beta_j x_j + \sum_{i=1}^{q} \beta_{jj} x_j^2 + \sum \sum_{i<j} \beta_{ij} x_i x_j + \epsilon \ldots\ldots\ldots 12$$

$$= \beta_0 + x'_i \beta + x'_i \beta x_i + \epsilon_{ij} \ldots\ldots\ldots 13$$

where $x_i = (x_{1i}, x_{2i}, \cdots, x_{iq})$,

$$\beta = (\beta_1, \beta_2, \cdots, \beta_q) \ldots\ldots\ldots 14$$

Data Analysis And Discussion Of Results

The result obtained on the three - factor analysis is given in the table below:

Decision:

From Table 1: we observed that the main effects of Treatment and weeks are highly significant at $(p < 0.05)$. The Treatment and weeks interaction is also highly significant; thus there is strong interaction between treatment and week.

$$R^2_{Adj} = 1 - \frac{SS_E/df}{SS_{Total}/df} = 1 - \frac{64.879/280}{82443.565/319}$$

$$= 1 - \frac{0.232}{258.444} = 1 - 0.00089 = 0.999$$

The adjusted R^2 also indicates that, there is high significant effect between the effects and interaction. The model is a good fit with 99% adjusted R squared. It is also seen from Table1 that there exist no evidence of lack of fit, which implies that the design is a good fit.

The response surface model was also fitted to obtain possible combination of number of weeks and pumpkin that can produce optimum weight of the bird in poultry keeping.

The fitted model is given as:

$$Y = 4.02 + 0.102X_1 + 0.014X_2 - 0.0049X_1^2 - 0.008X_2^2 + 0.00001X_1X_2$$

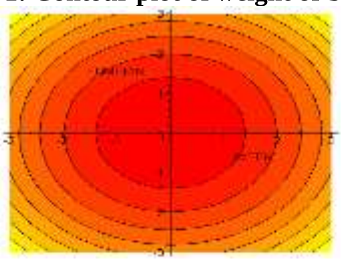
where: x_1 = week and x_2 = Fluted pumpkin - Treatment. The analysis of variance for second order response surface model indicates that, there are significant interactions between the weeks of growing birds and the Fluted pumpkin. The small *p* - values for linear and square terms also point out that their contribution is significant to the model. Small *p* - values for the interactions and the squared terms suggest that there is curvature in the response surface, as shown in the table 2.

Lack of fit test for fitted Second-Order Response Surface Model

The analysis of variance result in table 3 showed that there is significant evidence of lack of fit (p-value = 0.002) at $\alpha = 5\%$. The main effects were significant at 0.05 significant level. The interaction of number of week and pumpkin significantly contributed to the weight of bird at $\alpha = 0.05$, as shown in table 1.

Since the response surface is explained by the second-order model, it is necessary to analyze the optimum setting. The graphical visualization is very helpful in understanding the second-order response surface. Specifically, contour plots can help characterize the shape of the surface and locate the optimum response approximately. We graphed the contour plot of weight of birds as shown in Figure 1 below:

Fig. 1: Contour plot of weight of birds



Since the response surface is not a plane, it is more complicated to determine the optimum value. But each of the main factors is related to the weight of the birds at their high level. At this point, we need a more efficient procedure to find the optimum conditions for the model. As a result, we performed canonical analysis of the second order response surface model to determine and characterize the nature of its stationary or turning point.

Canonical Analysis of the Fitted Second Order Response Surface Model

This is done to determine and characterize the nature of its stationary or turning point.

The turning point or stationary point is given as,

$$X^* = -\frac{1}{2}(B^{-1})b = \begin{Bmatrix} 10.41 \\ 0.875 \end{Bmatrix}$$

where $B = \begin{Bmatrix} -0.0049 & 0.0000 \\ 0.0000 & -0.008 \end{Bmatrix}$ and $b = \begin{Bmatrix} 0.102 \\ 0.014 \end{Bmatrix}$, $B^{-1} = \begin{Bmatrix} -204.0816 & 0 \\ 0.0000 & -125 \end{Bmatrix}$

The matrixes were obtained from the fitted model. At the turning point, number of week = 10 and pumpkin = 100ml

Nature of the turning Point of the Fitted Second Order Response Surface Model

The nature of the turning point was obtained by determining the Eigen-values (λ_1, λ_2) of the characteristic equation below

$$|B - \lambda I| = \left| \left\{ \begin{pmatrix} -0.0049 & 0.0000 \\ 0.0000 & -0.008 \end{pmatrix} \right\} - \lambda \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \right| = 0$$

$\lambda_1 = -0.0049$ and $\lambda_2 = -0.008$

Both λ_1 and λ_2 are negative. This implied that the turning point of the model was a maximum point. The constructed canonical form of the fitted model is

$$Y = 4.557 - 0.0049\mathbf{w_1^2} - 0.008\mathbf{w_2^2}$$

where w_1 and w_2 are the transformed (x_1 and x_2) independent variables respectively in the response surface polynomial model. Solving the model gives number of weeks to be ten and pumpkin to be one (100ml).

Thus, we concluded that ten weeks of feeding fowl with one (100ml) pumpkin resulted in achieving optimum weight of the fowl.

Conclusions

Number of weeks, FPLE and their mutual interaction play a key role in obtaining maximum weight of broiler chickens. These factors should be put into consideration in making feed for the broiler chickens.

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Table 1: Analysis of Variance of effect of Fluted Pumpkin Leaves Extract on weight of Broiler Chickens

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	82378.686	39	2112.274	9104.63	.000
Intercept	272704.074	1	272704.074	1175448.60	.000
Treatment	1437.004	4	359.251	1548.50	.000
Week	78263.15	7	11180.449	48191.59	.000
Trt & week	2678.55	28	95.662	412.34	.000
Error	64.879	280	.232		
Lack of Fit	.000	0			
Pure Error	64.879	280	.232		
Corrected Total	82443.565	319			

R Squared = .999 (Adjusted R Squared = .999)

Table 2: The fitted Second Order Surface Response Model

Model	*Coefficient*	*p-value*
Constant	*4.02*	*.014*
Week	*0.102*	*.006*
Pumpkin	*0.014*	*.028*
*week *pumpkin*	*0.00001*	*.005*
*week *week*	*-0.0049*	*.018*
pumpkin pumpkin*	*-0.008*	*.040*

Table 3: Analysis of Variance for lack of fit for first Order Response Surface Model

Variation	Mean Square	p-value
Residual	36.06	
Lack of fit	22.35	0.002
Pure Error	13.71	

Table 4: Summary for the fitted Second-Order Surface Response Model

Model	*R-square*	*Adjusted R- square*	*P-value*
Number of week, pumpkin, Number of week pumpkin*	*0.956*	*0.8352*	*0.008*