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# Influence of Graded Levels of Vegetable Oil on the Performance, Health Status, and Body Linear Measurement of Arbor Acre Plus Broilers

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## ABSTRACT

The study evaluated the influence of dietary levels of vegetable oil on the performance, health status, and body linear measurements of Arbor Acre Plus broilers. Three dietary treatments containing 0%, 1% and 2% vegetable oil inclusion was designated as D1, D2 and D3, respectively in the basal diet. The experiment was then mapped out using completely randomised design (CRD) with 4 replications of 10 birds per replicate. Results showed that the total weight, the weight gain and the total feed intake in diets 3 and 2 (2197.48g/bird and 2149.29g/bird, 2155.71g/bird and 2108.00g/bird and 3041.98g/bird and 3141.98g/bird respectively) showed no significant ($P>0.05$) differences but were significantly ($P<0.05$) different from diet one (1) which recorded values of 2015.87g/bird, 1973.43g/bird and 3349.62g/bird. Live weights recorded no significant ($P>0.05$) differences between D3 (2.13kg) and 2 (2.09kg), but were both statistically higher than D1 (2kg). The head in D3 (27.87g/kg BW) was significantly ($P<0.05$) influenced when compared to the value in D2 (24.39g/kg BW), with the lowest value being recorded in D1 (23.97g/kg BW). Also, white blood cell, red blood cell and creatinine recorded in D3 showed significant ($P<0.05$) higher value in comparison to other dietary treatments with values of 5.80 $\times 10^9$/l, 1.88 x $10^6$/l and 25.47Mmol/L, respectively. In terms of body linear measurements, body weight, thigh length, body length, and height at withers were significantly ($P<0.05$) different with D3 recording ($P<0.05$) higher values of 2.20kg, 15.82cm, 25.00cm and 27.39cm, respectively, compared to the other dietary treatments. The average price realised, average price gain and net profit per bird were recorded in D3, with values of ₦3672, ₦1614, and ₦40.36, respectively, which were economically higher when compared to the other diets evaluated in the study. D3 (9.20%) showed a significant ($P>0.05$) better % cost reduction compared to other dietary treatments. It was therefore concluded that the inclusion of vegetable oil at 2% in D3 significantly influenced the performance, health, and body linear

measurements of the broiler chickens without any detrimental effect.

**Keywords:** health, body linear measurement, broilers, vegetable oil, performance

## 1. INTRODUCTION

The primary poultry production industry is typically located in regions characterised by hot and humid climates (Daghir, 2008). Therefore, producers in these regions need to employ various nutritional strategies to manage housing and body temperature of the broiler chickens effectively by mitigating chicken performance and health from the adverse effects of heat stress (Lara & Rostagno, 2013). In many tropical zones, the expense of cooling broiler houses is prohibitively high, prompting a focus on nutritional management instead (Konca *et al*., 2009).

According to Baião and Lara (2005), fat and oil are frequently included in poultry diets to enhance energy density, as they provide 2.25 times more calories than carbohydrates and protein. Diets supplemented with fat improve feed efficiency and profitability in poultry farming. Additionally, oils have been reported to enhance broiler diet palatability, reduce feed dustiness, and slow down the feed passage through the chicken's digestive system (Chwen *et al*., 2013). This allows for better nutrient absorption in the broiler chickens. Dietary fats digestibility majorly depends on their fatty acid composition with diets that contains oils being rich in unsaturated fats which tends to have higher metabolizable energy as a result of the better absorption in the intestines of the chickens compared to those ones with saturated fats (Celebi and Utlu, 2006). During fat digestion, free fatty acids may combine with minerals like calcium (Ca) to form insoluble or soluble soaps, potentially reducing the availability of fatty acids and calcium for absorption (Leeson and Summer, 2005).

Animal oils, such as poultry and fish oil, can serve as an energy source in poultry diets after refining, often replacing vegetable oils. Compared to plant sources, animal oils contain higher levels of saturated and omega-6 fatty acids (Liu *et al*., 2017). However, chicks tend to utilise fatty acids from unsaturated fat sources more efficiently than those from saturated fat sources (Smits *et al*., 2000). Poultry fat provides roughly similar energy content as soybean oil (8220 vs. 8196 kcal/kg) (Firman *et al*., 2008). Nevertheless, some researchers have noted that birds that were fed with diets high in saturated fatty acids can tend to have significantly more abdominal fat. Based on this problem, this study was carried out to determine the influence of graded levels of vegetable oil on broiler performance, health, and body linear measurements.

## 2. MATERIALS AND METHODS

**Experimental site**

A feeding trial was carried out at AOL farms, Zaria. Zaria is geographically located at a latitude of 11°15'N and a longitude of 7°60'E at an altitude of 671m above sea level (Google map).

**Sources of vegetable oil**

Vegetable oil was purchased from local market vendors in Samaru market, Zaria. During the period of experimenting, one kilogram (1kg) of vegetable oil was purchased at the rate of two thousand, three hundred Naira (₦2,300).

**Management of experimental birds**

A total of one hundred and twenty (120) marketable Arbor Acre Plus broiler chicks were purchased from Ottarb-Synergy Farms in Ede, Osun State, Nigeria. Each broiler chicks were individually weighed, labelled with a piece of tape attached to its leg bearing a unique identification number, and then randomly distributed into eighteen square feet (18ft$^2$) floor pens. Fresh wood shavings, without sawdust, were spread as bedding material in the pens. Wire partitions were used to separate the pens, ensuring no direct contact between them to minimise the risk of cross-contamination. A continuous lighting program lasting twenty-four hours (24h) was provided for the birds. Both food and water were made available *ad libitum* for consumption.

**Experimental design and diet**

The experimental design for this study was a completely randomised design with three (3) dietary treatments (0%, 1% and 2%) vegetable oil inclusion levels, designated as D1, D2 and D3, respectively. There were 10 broilers per pen and four (4) replicates. A total of 120 broilers were used for the experiment. Broilers were fed with their respective starter and finisher diets for 1-21 and 22-42 days, respectively. NRC (National Research Council) Nutrient Requirements for Poultry (1994) was met for the dietary treatments as presented in Tables 1 and 2.

**Table 1.** Gross composition of experimental starter feed

| Ingredients (%) | D1 | D2 | D3 |
|---|---|---|---|
| **Maize** | 56.00 | 55.00 | 54.00 |
| **Groundnut Cake** | 20.00 | 20.00 | 20.00 |
| **Soybean Meal** | 17.00 | 17.00 | 17.00 |
| **Bone Meal** | 1.90 | 1.90 | 1.90 |
| **Limestone** | 3.15 | 3.15 | 3.15 |
| **Lysine** | 0.15 | 0.15 | 0.15 |
| **Methionine** | 0.20 | 0.20 | 0.20 |
| **Salt** | 0.30 | 0.30 | 0.30 |
| **Premix*** | 0.30 | 0.30 | 0.30 |
| **Vegetable Oil** | 0.00 | 1.00 | 2.00 |
| **Total** | 100.00 | 100.00 | 100.00 |
| **Calculated Analysis** | | | |
| **ME (MJ/kg)** | 12.65 | 12.60 | 12.83 |
| **Crude protein (%)** | 23.24 | 23.15 | 23.06 |
| **Calcium (%)** | 1.82 | 1.82 | 1.82 |
| **Phosphorus (%)** | 0.42 | 0.42 | 0.42 |
| **Lysine (%)** | 1.09 | 1.08 | 1.08 |
| **Methionine (%)** | 0.50 | 0.50 | 0.49 |
| **Fat (%)** | 5.97 | 5.98 | 6.03 |
| **Crude Fibre (%)** | 3.23 | 3.21 | 3.19 |

*Vitamin/Mineral Premix (Bio-mix®) Each 2.5kg supplied: Vit A 10,000,000 iu; Vit $D_3$ 2,000,000 iu; Vit E 23,000mg; Vit $K_3$ 2,000mg; Vit $B_1$ 1,800mg; Vit $B_2$ 5,500mg; Niacin 27,500mg; Pantothenic acid 7,500mg; Vit $B_6$ 3,000mg; Vit $B_{12}$ 15mg; Folic acid 750mg; Biotin 60mg; Choline Chloride 300, 000mg; Cobalt 200mg, Copper 3,000mg; Iodine 1,000mg; Iron 20, 000mg; Manganese 40,000mg; Selenium 200mg; Zinc 30,000mg, Antioxidant 1,250mg.

**Table 2.** Gross composition of experimental finisher feed

| Ingredients (%) | D1 | D2 | D3 |
|---|---|---|---|
| **Maize** | 57.45 | 56.50 | 55.45 |
| **Wheat Bran** | 3.60 | 3.60 | 3.60 |
| **Groundnut Cake** | 18.50 | 18.50 | 18.50 |
| **Soybean Meal** | 14.50 | 14.50 | 14.50 |
| **Bone Meal** | 1.50 | 1.50 | 1.50 |
| **Limestone** | 2.50 | 2.50 | 2.50 |
| **Lysine** | 0.15 | 0.15 | 0.15 |
| **Methionine** | 0.20 | 0.20 | 0.20 |
| **Salt** | 0.30 | 0.30 | 0.30 |
| **Premix*** | 0.30 | 0.30 | 0.30 |
| **Vegetable Oil** | 0.00 | 1.00 | 2.00 |
| **Total** | 100.00 | 100.00 | 100.00 |
| **Calculated Analysis** | | | |
| **ME (MJ/kg)** | 12.60 | 12.60 | 12.81 |
| **Crude protein (%)** | 20.19 | 20.06 | 20.01 |
| **Calcium (%)** | 1.45 | 1.45 | 1.45 |

| | | | |
|---|---|---|---|
| **Phosphorus (%)** | 0.36 | 0.36 | 0.36 |
| **Lysine (%)** | 1.03 | 1.03 | 1.02 |
| **Methionine (%)** | 0.49 | 0.49 | 0.48 |
| **Fat (%)** | 5.95 | 6.00 | 6.15 |
| **Crude Fibre (%)** | 3.38 | 3.36 | 3.34 |

*Vitamin/Mineral Premix (Bio-mix®) Each 2.5kg supplied: Vit A 10,000,000 iu; Vit $D_3$ 2,000,000 iu; Vit E 23,000mg; Vit $K_3$ 2,000mg; Vit $B_1$ 1,800mg; Vit $B_2$ 5,500mg; Niacin 27,500mg; Pantothenic acid 7,500mg; Vit $B_6$ 3,000mg; Vit $B_{12}$ 15mg; Folic acid 750mg; Biotin 60mg; Choline Chloride 300, 000mg; Cobalt 200mg, Copper 3,000mg; Iodine 1,000mg; Iron 20, 000mg; Manganese 40,000mg; Selenium 200mg; Zinc 30,000mg, Antioxidant 1,250mg.

**Birds Slaughtering and Blood Collection**

Before collecting blood samples in the early morning, the birds were fasted for 12 hours, from 8 PM to 8 AM. Four birds per treatment group were randomly chosen to assess carcass and relative organ characteristics, haematological parameters, and serum parameters. Following the guidelines from the World Poultry Association, the birds were stunned before being slaughtered. They were then bled by cutting the jugular vein and carotid artery, with blood samples collected during the slaughtering process after the experimental period. Blood samples for haematological analyses were collected in ethylenediaminetetraacetic acid (EDTA) bottles, while those intended for serum biochemical indices were collected in anticoagulant-free test tubes.

**Carcass analysis**

At the end of day 42, four birds were selected based on average of the final weight from each treatment group for slaughtering and carcass analysis. The slaughtered birds were dipped in a water bath at 65°C for 30 seconds before defeathering was carried out following the method described by Akanbi (2019). Subsequently, the birds were defeathered, weighed, and eviscerated. The eviscerated weight was determined by removing the offal and internal organs. The weights of carcass parts and organs were recorded and expressed as a percentage of the live body weight.

**Body linear measurements**

The body weights of the individual birds and body linear traits were recorded early in the morning before feeding on a weekly basis by careful and humane handling of the birds. Body weight (BDW) was measured in grams (g) using a digital weighing scale. The body linear traits taken in cm using tailor's tape include:

1. Shank Length: from the hock joint to the base of the third toe.
2. Breast Width: the distance between the base of the left wing and the right wing.
3. Body Length: the distance that runs along the base of the neck and the tip of the tail
4. Thigh Length: the distance between the hock joint and the pelvic joint.
5. Height at Withers: The distance between the ground to the withers.

**The economics of production**

The financial impact and net revenue resulting from incorporating vegetable oil into the birds' diet were assessed. Expenses such as drugs, vaccines, and litter were consistent across all treatments. Profit per bird for each treatment was calculated by factoring in the cost of day-old chicks, the expense of the experimental diet, feed consumption costs, average weight gain, drug and vaccine expenses, and the average price obtained per bird, following the method outlined by Adegbenro *et al*. (2017).

**Data analysis**

One-Way Analysis of Variance (ANOVA) using SPSS version 23 was used to analysed the data collected from the experiment. Significant treatment means were compared using New Duncan's Multiple Range Test of the same package.

## 3. RESULTS & DISCUSSION

The results of the performance characteristics of broilers fed diets containing varying levels of vegetable oil are shown in Table 3. Significant differences ($P<0.05$) were recorded in all parameters except for initial body weight. Final body weight, total weight gain, and total feed intake indicated that D3 and 2 (2197.48g/bird and 2149.29g/bird, 2155.71g/bird and 2108.00g/bird, and 3041.98g/bird and

3141.98g/bird, respectively) showed no significant differences (P>0.05) but were significantly different (P<0.05) from D1, which recorded values of 2015.87g/bird, 1973.43g/bird, and 3349.62g/bird, respectively. Consistent with our findings, Shahryar *et al*. (2011) reported that the addition of poultry fat and canola oil at 3% in the broiler diet resulted in a higher weight gain in broiler chickens and an improved feed conversion ratio (FCR). This result may have arisen from the high content of metabolizable energy contained in the oil and the absorption of their unsaturated fatty acids which they contained which leads to the reduction in feed consumption of the birds while maintaining their energy intake. Similarly, Khatun *et al*. (2018) study reported that broilers that were fed diets containing sunflower oil showed greater weight gain and improved FCR compared to those fed palm oil. Zhang *et al*. (2011) reported that broilers fed a diet containing soybean oil had higher weight gain and better FCR than those fed poultry fat and tallow oil. However, Polycarpo *et al*. (2014) observed no effect of chicken tallow and soybean oil on feed intake, weight gain, and FCR in broilers. Meng *et al*. (2004) found similar weight gain, feed intake. In addition, D3 showed significant (P<0.05) better FCR (1.41), when compared to D2 (1.49) and D1 (1.70). Mortalities were significantly (P<0.05) lower in D3 which recorded no mortality compared to D1 and D2, which recorded mortalities of 2.50% and 5.00%, respectively. This could be as a result of the birds' ability to utilise vegetable oil for energy production and heat during digestion, enabling them to adapt to the cold weather during the experimental period.

**Table 3:** Performance characteristics of broiler-fed diet containing graded levels of vegetable oil inclusion

| Parameters | D1 | D2 | D3 | SEM (±) | P Value |
|---|---|---|---|---|---|
| **Initial Body Weight (g/bird)** | 41.44 | 41.29 | 41.77 | 1.27 | 0.96 |
| **Final Body Weight (g/bird)** | $2015.87^{b}$ | $2149.29^{a}$ | $2197.48^{a}$ | 102.86 | 0.02 |
| **Total Weight Gain (g/bird)** | $1973.43^{b}$ | $2108.00^{a}$ | $2155.71^{a}$ | 100.38 | 0.01 |
| **Total Feed Intake (g/bird)** | $3349.62^{b}$ | $3141.98^{a}$ | $3041.98^{a}$ | 163.56 | 0.01 |
| **Average Daily Weight Gain (g/bird)** | $46.99^{b}$ | $50.19^{a}$ | $51.33^{a}$ | 2.26 | 0.01 |
| **Average Daily Feed Intake (g/bird)** | $79.75^{b}$ | $74.81^{a}$ | $72.43^{a}$ | 4.85 | 0.01 |
| **Feed Conversion Ratio** | $1.70^{c}$ | $1.49^{b}$ | $1.41^{a}$ | 0.10 | 0.04 |
| **Mortality (%)** | $2.50^{b}$ | $5.00^{c}$ | $0.00^{a}$ | 2.17 | 0.01 |

$^{abc}$ means along the same row with different superscripts shows significantly different (P<0.05) SEM: Standard Error of the Mean

**Table 4:** Carcass and organ traits measurement of broiler-fed diets containing graded levels of vegetable oil inclusion

| Parameters | D1 | D2 | D3 | SEM (±) | P Value |
|---|---|---|---|---|---|
| **Live Weight (kg)** | $2.00^{b}$ | $2.09^{a}$ | $2.13^{a}$ | 0.10 | 0.03 |
| **Dress Weight (%)** | 91.06 | 90.41 | 89.17 | 1.36 | 0.83 |
| **Eviscerated Weight (%)** | 74.27 | 74.54 | 76.44 | 1.88 | 0.06 |
| **Head (g/kg BW)** | $23.97^{c}$ | $24.39^{b}$ | $27.87^{a}$ | 1.16 | 0.04 |
| **Drumstick (g/kg BW)** | 91.97 | 102.06 | 92.78 | 5.55 | 0.62 |
| **Thigh (g/kg BW)** | 104.57 | 109.65 | 105.65 | 5.08 | 0.10 |
| **Wing (g/kg BW)** | 73.60 | 74.92 | 77.71 | 2.30 | 0.28 |
| **Back (g/kg BW)** | 149.45 | 154.60 | 152.66 | 7.26 | 0.73 |
| **Breast (g/kg BW)** | 208.91 | 213.49 | 229.85 | 11.96 | 0.04 |
| **Shank (g/kg BW)** | $36.60^{c}$ | $39.82^{a}$ | $39.30^{b}$ | 1.92 | 0.01 |
| **Neck (g/kg BW)** | 36.00 | 36.50 | 37.08 | 2.94 | 0.87 |
| **Liver (g/kg BW)** | 22.04 | 19.49 | 22.12 | 1.35 | 0.35 |
| **Spleen (g/kg BW)** | 1.27 | 0.91 | 0.90 | 0.15 | 0.66 |
| **Heart (g/kg BW)** | 4.64 | 4.84 | 4.93 | 0.44 | 0.63 |
| **Gizzard (g/kg BW)** | 19.11 | 21.74 | 21.71 | 1.45 | 0.72 |
| **Proventriculus (g/kg BW)** | 4.92 | 4.90 | 4.84 | 0.45 | 0.12 |
| **Pancreas (g/kg BW)** | 2.38 | 2.34 | 2.47 | 0.33 | 0.07 |
| **Belly Fat (g/kg BW)** | 13.42 | 12.53 | 12.33 | 1.62 | 0.31 |
| **Lung (g/kg BW)** | 5.31 | 5.45 | 5.88 | 0.26 | 0.77 |

$^{abc}$ means along the same row with different superscripts shows significantly different (P<0.05) SEM: Standard Error of the Mean

Table 4 presents the carcass and organ characteristics of broiler chickens fed diets containing graded levels of vegetable oil. Significant differences (P<0.05) were observed in live weight, head weight, and shank weight. Live weight showed no significant differences (P>0.05) between D3 (2.13kg) and D2 (2.09kg) were both statistically higher than D1 (2kg). The head weight of broilers in D3 (27.87g/kg BW) was significantly (P<0.05) influenced compared to D2 (24.39g/kg BW) and D1 (23.97g/kg BW). In the same way, shank weight varied significantly (P<0.05) among the dietary treatments as D2 (39.82 g/kg BW) recorded the highest statistical value compared to D3 (39.30g/kg BW) and D1 (36.60g/kg BW). These differences could have been as a result of the high energy content in the vegetable oil whih has translated to an increased heat production by the animals by meeting their energy requirements more efficiently. Shahryar (2011) found that adding poultry fat and canola oil to the broiler diet resulted in lower gizzard weight and higher abdominal fat, while breast yield, thigh yield, and liver weight were not affected by the oil sources. Polycarpo *et al*. (2014) reported that different fat sources (chicken tallow and soybean oil) had similar effects on carcass yield, drumstick yield, and breast yield in broiler diets. Similarly, Neto *et al*. (2011) found that soybean oil and poultry fat in broiler diets had similar effects on carcass, breast, and thigh yield. Khatun *et al*. (2018) observed that the use of palm oil, sunflower oil, and their combination in broiler diets had similar effects on breast muscle pH, cooking loss, and breast meat colour. Liver weight was higher in birds fed a fish oil-based diet, possibly due to the higher content of free fatty acids in fish oil, leading to liver oxidation and an increase in size.

**Table 5:** Haematology and serum biochemical indices of broiler-fed diets containing graded levels of vegetable oil inclusion

| Parameters | D1 | D2 | D3 | SEM (±) | P Value |
|---|---|---|---|---|---|
| **Packed Cell Volume (%)** | 25.83 | 28.33 | 28.67 | 0.87 | 0.47 |
| **Haemoglobin (g/dl)** | 8.64 | 9.44 | 9.58 | 0.49 | 0.09 |
| **White Blood Cell (x10$^9$/l)** | 3.05$^b$ | 5.87$^a$ | 5.80$^a$ | 0.49 | 0.01 |
| **Red Blood Cell (x10$^6$/l)** | 1.50$^c$ | 1.75$^b$ | 1.88$^a$ | 0.56 | 0.01 |
| **Mean Cell Haemoglobin Conc. (g/dl)** | 32.07 | 32.87 | 32.91 | 0.13 | 0.77 |
| **Mean Cell Haemoglobin (pg)** | 62.66$^a$ | 53.98$^{ab}$ | 52.39$^b$ | 8.48 | 0.01 |
| **Total Cholesterol (mmol/L)** | 2.23 | 3.25 | 2.37 | 0.25 | 0.04 |
| **Triglyceride (mmol/L)** | 0.79 | 0.78 | 0.67 | 0.08 | 0.41 |
| **Creatine (Mmol/L)** | 10.06$^c$ | 20.11$^b$ | 25.47$^a$ | 3.11 | 0.04 |
| **Total Protein (g/L)** | 44.07 | 44.02 | 46.71 | 4.14 | 0.13 |
| **Aspartate aminotransferase (μ/L)** | 186.13 | 176.45 | 174.82 | 5.62 | 0.29 |
| **Alanine Aminotransferase (μ/L)** | 38.75 | 38.43 | 38.59 | 0.82 | 0.97 |

$^{abc}$ means along the same row with different superscripts shows significantly different (P<0.05) SEM: Standard Error of the Mean

The haematological and serum biochemical indices is presented in Table 5. D3 showed significant (P<0.05) higher values compared to the D1 and D2 in WBC, RBC, and creatinine levels measuring 5.80 x 10^9/l, 1.88 x 10^6/l, and 25.47 mmol/L, respectively. This result is supported by (Sadeghi *et al*., 2014) who indicated that n-3 fatty acids enhanced chicks' antibody response to RBC compared to birds without fatty acids. The inclusion of flaxseed oil in the diet as reported by (Swanson *et al*., 2012) has also been shown to improve immune response probably due to its effect on the long-chain n-3 PUFA and eicosanoid levels (Swanson *et al*., 2012).

However, D1 showed a significant (P<0.05) higher MCH (62.66 pg) when in comparison to D2 (53.98 pg). D3 and D2 were statistically the same. This implies that the birds were able to utilise the feed without experiencing stress or anaemia, facilitating proper digestion. This finding is in contrast with a Abdulqadir *et al*.'s (2014) study, which found no influence of different levels of dietary frying olein oil on haematology in broilers. In a survey carried out by Namayandeh *et al*. (2013) on the dietary inclusion of olive oil, our findings are consistent with their previous report, indicating that birds and rats fed an oil-rich diet exhibited lower serum triglyceride levels and significantly higher levels of serum HDL and creatinine. Variations in serum lipid content between studies may be a result of genetic, sex, and dietary factors.

**Table 6:** Body linear measurements of broiler-fed diet containing graded levels of vegetable oil inclusion

| Parameters | D1 | D2 | D3 | SEM (±) | P Value |
|---|---|---|---|---|---|
| **Body Weight (kg)** | 2.03$^b$ | 2.15$^a$ | 2.20$^a$ | 0.32 | 0.02 |
| **Breast Width (cm)** | 17.25 | 17.26 | 18.10 | 0.20 | 0.37 |
| **Shank Length (cm)** | 8.78 | 8.25 | 8.67 | 0.06 | 0.09 |

| | | | | | |
|---|---|---|---|---|---|
| **Thigh Length (cm)** | $14.27^{b}$ | $14.46^{b}$ | $15.82^{a}$ | 0.10 | 0.03 |
| **Body Length (cm)** | $24.06^{b}$ | $24.67^{a}$ | $25.00^{a}$ | 0.12 | 0.03 |
| **Height at Withers (cm)** | $25.73^{b}$ | $25.93^{b}$ | $27.39^{a}$ | 0.13 | 0.01 |

$^{abc}$ means along the same row with different superscripts shows significantly different (P<0.05) SEM: Standard Error of the Mean

Table 6 shows the body linear measurements of the broiler birds. The table showed significant (P<0.05) differences in D3 which recorded values of 2.20 kg for body weight, 15.82 cm for thigh length, 25.00 cm for body length, and 27.39 cm for height at withers. However, the values in D3 and D2 were statistically similar (P>0.05) for body length, suggesting the birds' ability to efficiently utilise the vegetable oil-containing diet to develop more body parts.

In Table 7, the production economics of broiler chickens fed diets containing graded levels of vegetable oil are presented. All factors, such as the cost of day-old chicks, vaccines and drugs, labour, and other expenses, were consistent across all diets. D3 showed higher values of ₦3672, ₦1614, and ₦40.36 for average price realised, average price gain, and net profit per bird, respectively when compared to the D1 and D2. The percentage cost reduction revealed that D3 (9.20%) was significantly and economically better than D1 and D2 which implies that there is benefit in using 2% vegetable oil in broiler chicken diet which broiler farmers can use to achieve cost savings and higher net profits.

**Table 7:** Economy of production of broiler-fed diet containing graded levels of vegetable oil inclusion

| Parameters | D1 | D2 | D3 | SEM (±) | P Value |
|---|---|---|---|---|---|
| **Cost of Day-Old Chicks (₦)** | 300.00 | 300.00 | 300.00 | - | - |
| **Cost of Experimental Diet (₦)** | 453.02 | 467.23 | 484.37 | - | - |
| **Total Feed Consumed (kg/bird)** | $3.35^{b}$ | $3.14^{a}$ | $3.04^{a}$ | 0.62 | 0.01 |
| **Total Weight Gain (kg)** | $1.97^{b}$ | $2.11^{a}$ | $2.16^{a}$ | 0.27 | 0.01 |
| **Cost of Vaccines and Drugs (₦)** | 90.00 | 90.00 | 90.00 | - | - |
| **Cost of Feed Consumed (₦)** | 1517.62 | 1467.10 | 1472.48 | 106.20 | 0.44 |
| **Cost of Labour (₦)** | 250.00 | 250.00 | 250.00 | - | - |
| **Other Costs (₦)** | 245.00 | 245.00 | 245.00 | - | - |
| **Total Cost of Production (₦)** | 2102.62 | 2052.10 | 2057.48 | 127.59 | 0.46 |
| **Average Price Realised (₦1700/kg)** | 3349.00 | 3587.00 | 3672.00 | 264.38 | 0.77 |
| **Average Price Gained (₦)** | 1246.38 | 1534.90 | 1614.52 | 69.29 | 0.35 |
| **Net Profit per Bird (₦)** | 31.16 | 38.37 | 40.36 | 3.85 | 0.57 |
| **%Cost Reduction** | $0.00^{c}$ | $7.21^{b}$ | $9.20^{a}$ | 0.03 | 0.01 |

$^{abc}$ means along the same row with different superscripts shows significantly different (P<0.05) SEM: Standard Error of the Mean

## 4. CONCLUSION

This study found that the incorporation of 2% vegetable oil has significantly influence and improve the performance, health, and body linear measurements of broiler chickens without any deleterious effects. Also, the cost reduction associated with using 2% vegetable oil is economically favourable for broiler production in tropical regions.

### Authors' Contributions

All authors contributed to the conception and design of the experiment. Olawale Mojeed Akanbi analysed the collected data and wrote the manuscript. Olawale Mojeed Akanbi was the principal author who was responsible for managing all activities of the experiment, and worked in the execution of the trial and was also involved in data collection and interpretation. Adeola Endurance Talabi, Hiqmah Busayo Lawal and Olanrewaju Ahmed Binuyo helped with the field trial. Olufemi Gooday Allen and Isaiah Akinwumin Ajewole were responsible for the data analysis. All authors read and approved the final manuscript.

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**Conflict of interest**

The authors declare that there are no conflicts of interests.

**Ethical approval**

In this article, the animal regulations are followed as per the ethical committee guidelines of Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria; the authors observed the influence of graded levels of vegetable oil on the performance, health status, and body linear measurement of Arbor Acre Plus Broilers. The animal ethical guidelines are followed in the study for observation, identification & experimentation.

**Informed consent**

Not applicable.

**Data availability**

All data associated with this study will be available based on the reasonable request to corresponding author.

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