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Effect of different levels of palm oil inclusion in diet on growth performance, biochemical parameters and carcass characteristics of slow growing broilers in tropical environment

Kolani Ali Yendou-gname[1], Amoussa Modukpè Romziath[1], Mijiyawa Ahmed[1], Agboka Jacques kossi-messan[1], Pitala wéré[1,2]
[1]Regional Center of Excellence for Avian Sciences, University of Lomé, Lomé, Togo
[2]Higher School of Agronomy, University of Lomé, Lomé, Togo

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ABSTRACT

The study aimed to evaluate the growth performance, biochemical parameters and carcass characteristics of slow-growing Dutch blue broilers in a tropical environment over a period of 14 weeks. A total of 240, 14 – day old Dutch blue broilers were randomly assigned to four treatment groups (T0, T1, T2 and T3) and were fed diets containing 0%, 1%, 2% and 3% palm oil, respectively. Data were collected on feed intake, body weight, biochemical parameters, organs and carcass weight. The collected data were analyzed using GraphPad Prism version 8.0 software. The results showed that the feed intake of the broilers increased as the level of palm oil incorporation increased. The average daily gain was higher in groups T2 and T3 compared to the other groups. Feed conversion ratio was positively impacted by the inclusion of 1% and 2% palm oil in the diet. An increase in total cholesterol levels was observed as the level of palm oil inclusion increased, while the lowest concentrations of total protein and triglycerides were found in the group fed the control diet. With regards to carcass characteristics, the yields of breast meat, drumstick, and carcass increased as the level of palm oil inclusion in the diet increased. However, there was no significant effect on thigh yield ($P > 0.05$). The relative weight of the liver decreased significantly with of palm oil levels, while the relative weights of the spleen and heart remained similar ($P > 0.05$). The inclusion of 1% and 2% palm oil in the broiler feed improves feed efficiency, growth performance, and carcass yield.

Corresponding Author:

Kolani Ali Yendou-Gname
Regional Center of Excellence for Avian Sciences, University of Lomé
01 BP 1515, Lomé – Togo
Email: chonchonkolani@gmail.com

1. INTRODUCTION

Poultry feed is one of the most crucial aspects of poultry production. With feeds providing the essential nutrients accounting for over 70% of the total cost of poultry production. Energy sources, which make up 40-70% of poultry feed, are the largest in terms of quantity and are often the most expensive (Kırkpınar & Açıkgöz, 2018). In tropical regions, the intensification of poultry production is facing various challenges, including the high cost of energy-providing raw materials, especially maize. The competition for energy sources by industries for biofuel and human food is also making it scarce and expensive for use in broiler production (Ahiwe et al., 2018). Energy is vital in broiler chicken diets as it is used for metabolic processes, bird health, growth, and meat production, and is also a key factor regulating feed intake and feed conversion. To address this issue, it is necessary to find local and effective alternatives to maintain an adequate energy level without affecting production performance. In this context, oils and fats have been used as energy substitutes in broiler diets, replacing cereal grains with highly concentrated energy sources like fats and oils that are rich in fatty acids and vitamins (Benzertiha et al., 2019; Jimenez-Moya et al., 2021; Kim et al., 2020). The oil also enhances the absorption of fat-soluble vitamins, improves feed palatability, reduces feed dustiness, and slows down the passage rate of feed in the gut, providing more time for nutrient absorption (Saminathan et al., 2020). Attia et al. (2020) observed an improvement in feed efficiency, carcass yield, and a decrease in abdominal fat in broilers fed a diet of different oil sources. The dietary lipids can also alter blood triglyceride and lipoprotein levels (Ghasemi et al., 2016; Hakim et al., 2021; Rafiei-Tari et al., 2021).

Palm oil is rich in energy and widely available in Africa. It consists mainly of triglycerides (95% - 99%) and minor amounts of compounds like vitamin E, carotenoids, phytosterols, tocopherols, tocotrienols, squalene, and phenolic compounds (Gonzalez-Diaz & García-Núñez, 2021). Due to its nutritional composition, palm oil can be used as a substitute for a portion of maize in poultry feed, making it an attractive raw material. While previous research has investigated the effects of palm oil inclusion in broiler diets, most of these studies were conducted in temperate climates and with fast-growing broiler strains (Obua, 2001). There is limited data on the use of palm oil as an energy source to improve the growth performance of slow-growing broilers in tropical environments, which are becoming increasingly popular due to their improved welfare and meat quality. The present study aimed to evaluate the impact of different levels of palm oil on the growth performance, biochemical, and carcass characteristics of Dutch Blue broilers in the tropical region.

2. METHOD

2.1 Ethical approval

The research was conducted adhering closely to the guidelines outlined in the "Guide for the Care and Use of Experimental Animals" (008/2021/BC-BPA/FDS-UL) provided by the University of Lome, Togo.

2.2 Study areas

The study was conducted at the Regional Center of Excellence in Avian Sciences (CERSA), located at the Agricultural Experimentation Station of the University of Lomé (SEAL). The site is characterized by a tropical climate, with average annual temperatures ranging from 25°C to 32°C and an average annual humidity level of 75%. The area experiences two alternating rainy seasons and dry seasons.

2.3 Experimental design

A total of 240 unsexed commercial Dutch Blue broiler chicks, with an initial body weight of 57.27g ± 2.07, were used in the study. The birds were reared in deep litter pens for a 2 weeks adaptation period before the start of the trial. Then, they were randomly allotted to four dietary treatments, each with four replicates of 15 birds for 14 weeks. The four experimental diets were isocaloric and isoproteic : T0 (control) had no added fat, while T1, T2, and T3 contained 1%, 2%, and 3% palm oil, respectively. The birds were fed a starter diet from week 3 to 6 and a finisher diet from week 7 to 16. The ingredients and composition of the diets are presented in Table 1. The birds had *ad libitum* access to water and feed and were subjected to the same prophylactic treatments.

Table 1. Gross composition of experimental diets (%)

Feed stuffs	starter (3 – 6 week)				Finisher (7– 16 week)			
	T0	T1	T2	T3	T0	T1	T2	T3
White maize	55	51.5	48	44.5	63	59.5	56	52.5
Wheat bran	4	7	10	13	2.5	5.5	8.5	11.5
Fish meal	8	8	8	8	5	5	5	5
Roasted soya seed	23.5	23	22.5	22	25	24.5	24	23.5
Lysine	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Methionine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Oyster Shell	2	2	2	2	2	2	2	2
Broiler concentrate[1]	7	7	7	7	2	2	2	2

Palm oil	0	1	2	3	0	1	2	3
				Calculated components[2]				
ME (kcal/kg)	2990	2993	2996	2998	3108	3111	3114	3117
CP (%)	21.29	21.23	21.18	21.12	19.70	19.64	19.59	19.53
CF (%)	8.16	9.03	9.90	10.77	8.25	9.12	9.99	10.86
Lys (%)	1.15	1.14	1.14	1.13	1.06	1.06	1.05	1.05
Met (%)	0.39	0.38	0.38	0.38	0.36	0.36	0.35	0.35
Met + Cys (%)	0.59	0.59	0.59	0.59	0.56	0.56	0.56	0.56
Ca (%)	1.72	1.71	1.70	1.70	1.20	1.19	1.18	1.18
P (%)	0.54	0.56	0.58	0.60	0.47	0.50	0.52	0.54
CF	4.33	4.44	4.55	4.66	4.58	4.69	4.80	4.92

T0 : 0% ; T1 : 1% ; T2 : 2% ; T3 : 3% ; ME : Metabolism Energy ; CP : Crude Protein ; CF : Crude Fat ; Lys : Lysine ; Met : Methionine ; Cys : Cystine

[1]Composition of broiler concentrate: crude protein(%),30; lysine(%), 2.5; methionine(%), 2.5 methionine + cysteine(%), 2.3; Calcim (%), 8.5; Phosphor (%), 1.3; metabolism energy (kcal/kg), 1800. Mineral and vitamin complex: provided per kilogram of diet: Transretinyl acetate, 60 mg; cholecalciferol, 1.5 mg; a-tocopherol acetate, 400 mg; bisulphate menadione complex, 40 mg; thiamine mononitrate, 30 mg; riboflavin, 120 mg; nicotinic acid,200 mg; Pyridoxine, 100 mg; Cyanocobalamin, 0.4 mg; folic acid, 20 mg; d-biotin, 2 mg; choline chloride, 7,000 mg; iron, 36 mg; iodine, 1.6 mg; manganese, 48 mg; zinc, 56 mg; copper, 12 mg; selenium, 0.32 mg.

[2]Components of experimental diets were calculated values according to west Africa food composition database (stadlmayr, 2012).

2.4 Body weight and feed conversion ratio evaluation

The birds were weighed at the beginning and weekly intervals thereafter to calculate the body weight gain (BWG). Feed were daily weighed before given in order to determine the birds feed intake (FI). Feed conversion ratio (FCR) was calculated from the body weight Gain and feed intake weekly.

2.5 Carcass characteristics and organs relative weight evaluation

At the end of experiment, 8 birds from each treatment group were weighed, slaughtered and 5 ml of blood were collected for analysis. After slaughter, plucking, evisceration, and cleaning, the carcasses were chilled at 4°C for 6 hours. Hot carcass weight of birds was obtained by removing the skin, head, feathers, lungs, toes with feet and gastrointestinal tract. Internal organs, i.e., liver, heart, spleen and gizzard were immediately weighed post-slaughter. Chicken carcass including thigh, drumstick and breast were collected and weighed.

2.6 Biochemical parameters evaluation

The collected blood samples were immediately placed in non-heparinized tubes and centrifuged at 3000 rpm for 10 minutes using a Shimadzu electric centrifuge (Tokyo, Japan) to separate the serum. The serum was then analyzed to determine the concentrations of various blood parameters, such as total cholesterol, triglycerides, and total protein, using a Technicon RA automated biochemistry analyzer (Technicon Instruments Corporation, Tarrytown, New York, USA).

2.7 Statistical analysis

Data were compiled by using Microsoft Excel 2013 and all values were presented as the Mean ± SEM. Normality of data distribution was confirmed using Shapiro-Wilk test. One-way Analysis of Variance (ANOVA) was performed to determine significant differences between groups using GraphPad Prism 5 software (California, USA). Average weekly Feed intake, weight gain and feed conversion ratio were analyzed over the trial period. On the other hand, the comparison of carcass yield and biochemical parameters between different treatments was carried out at the end of the experiment. Post-hoc comparisons between groups were conducted using Tukey's, Kruskall-Wallis, or Duncan's test at a significance level of $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Research results

3.1.1 Effect of palm oil on prouction parmaters

Average weekly Feed intake, body weight gain, and feed conversion ratio are presented in Table 2.

Table 2. Average Weekly Feed intake (AWFI), Average Weekly Body weight Gain (AWBG) and Feed Conversion Ratio (FCR) of broilers fed different levels of palm oil

Parameters	T0	T1	T2	T3	P-value

AWFI (g/bird/week)	496.8±31.22[b]	501.8±28.35[b]	538.2±29.04[b]	573.4±41.11[a]	0.009
AWBG (g/bird/week)	83.9±5.92[b]	71.7±6.42[b]	95.1±6.66[a]	89.3±6.02[ab]	0.002
FCR	5.2±0.24[a]	4.6±0.20[b]	4.8±0.23[b]	5.9±0.32[a]	0.002

[a,b,c] Within a row, data sharing no common letter are significantly different (p<0.05)
T0 : 0% ; T1 : 1% ; T2 : 2% ; T3 : 3%

Feed intake was influenced significantly with the different level of palm oil. The results showed the level of palm oil significantly influenced that feed intake. Our study found that there was an increase in feed intake with increasing levels of palm oil inclusion, particularly at a 3% inclusion level ($P < 0.05$). This is supported by the findings of Leeson and Summers (2009); Saminathan et al. (2020), who observed that the incorporation of lipids in poultry diets improves feed palatability and reduces pulverization. This reduction is linked to the ability of lipids to act as binders, thereby limiting the fragmentation of feed particles. Lipid inclusion in the form of oil and fats in poultry feed is essential as an excellent energy source. In addition, energy, palm oil is a rich source of fatty acids and fat-soluble vitamins. Thus, its inclusion in the diet of broilers supports their performance by providing essential nutrient requirements. Our results are consistent with Ebdi & Nobakht (2017), who reported that supplementation of canola oil in broiler diets improves feed intake. The lowest feed conversion ratio was observed in broilers fed with 1% and 2% palm oil (Table 2). In poultry production, the benefits of using oils in diets include a reduction in feed dust and an improvement in the hydrolysis and absorption of lipoproteins that provide fatty acids. As a result, oils enhance nutrient absorption and utilization (Nobakht et al., 2011; Oketch et al., 2023; Ravindran et al., 2016), leading to a more efficient use of nutrients from the diet. Previous studies have shown that supplementing broiler diets with vegetable oils such as palm oil and soybean oil has a positive impact on growth performance (Sampath et al., 2020; Zhao & Kim, 2017), which is in agreement with our findings.

Figure 1 shows the body weight of broilers fed different levels of palm oil according to age.

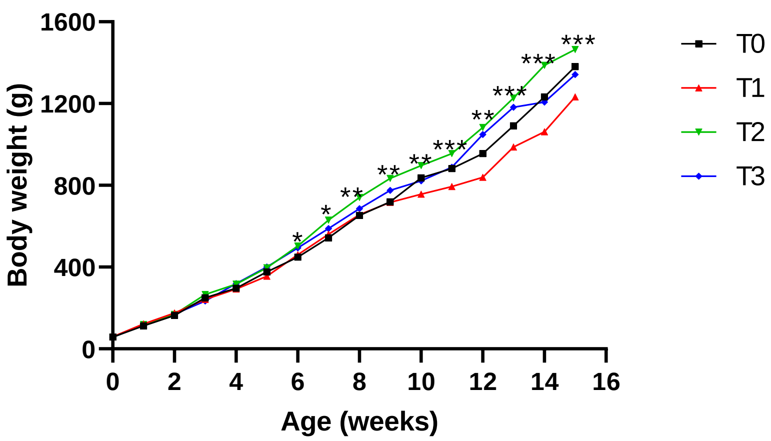

Fig 1. Growth curve of broilers fed different levels of palm oil during the experiment
T0 : 0% ; T1 : 1% ; T2 : 2% ; T3 : 3%

The data showed that there was no difference ($P > 0.05$) among the treatments at the beginning of the experiment (0 to 5 weeks). However, from the 6th week, broilers in group T2 showed a greater growth rate than that of the other treatment groups until the end of the rearing period. Our results showed that a 2% inclusion of palm oil in the diet improved the growth performance of birds. This can be attributed to the positive impact of this combination of fat sources on reducing the passage rate of digesta through the gastrointestinal tract, leading to improved nutrient absorption (Baião & Lara, 2005; Latshaw, 2008; Poorghasemi et al., 2013; Saminathan et al., 2020). In treated subjects, these nutrients were utilized to synthesize a large amount of protein (Bigot et al., 2003) and adipose tissue. These proteins, produced in large quantities, are responsible for muscle mass (Allanonto, 2011), leading to weight gain in broilers fed with 2% and 3% palm oil (table 2) and resulting in a higher average carcass weight ($P < 0.05$). Kana et al. (2012) reported that the inclusion of palm oil in feed has a positive effect on weight gain.

3.1.2 Effect of palm oil on organs yield characteristics of broilers

The organ yield characteristics of broilers fed different levels of palm oil are presented in Table 3.

Table 3. Organs yield characteristics of broilers fed different levels of palm oil

Parameters	T0	T1	T2	T3	P-Value
Heart yield (%)	0.47±0.02	0.46±0.02	0.4473±0.01	0.46±0.01	0.8485
Gizzard yield (%)	2.36±0.08^{a}	2.35±0.01^{a}	2.021±0.04^{b}	2.07±0.02^{b}	<0.0001
Liver yield (%)	2.14±0.07^{ab}	2.42±0.08^{a}	1.812±0.05^{c}	1.98±0.04^{bc}	<0.0001
Spleen yield (%)	0.16±0.01	0.13±0.01	0.14±0.01	0.17±0.01	0.6453

^{a,b,c} Within a row, data sharing no common letter are significantly different (p<0.05)

T0 : 0% ; T1 : 1% ; T2 : 2% ; T3 : 3%

The data showed that the heart and spleen yields did not differ among broilers receiving different levels of palm oil in their diets (P > 0.05). However, there was a progressive reduction in the gizzard and liver yields as the level of palm oil in the diet increased.

From a physiological perspective, the liver is vital organ as it plays a key role in lipid metabolism. When carbohydrates are replaced by lipids, fatty acid synthesis in the liver decreases, which might explain the reduction in the relative weight of the liver in broilers that are fed diets containing palm oil. According to Jalaludeen et al. (2022), diets high in carbohydrates stimulate hepatic lipogenesis, leading to the synthesis of SFAs, MUFAs, and PUFAs, with the latter primarily coming from dietary fat in ducks. The relative weight of the gizzard also decreased significantly as the level of palm oil increased, a finding that is supported by Bobadoye et al. (2006).

3.1.3 Effect of palm oil on carcass characteristics of broilers

The results of the effect of different palm oil levels on carcass yields are presented in Table 4.

Table 4. Carcass characteristics of broilers fed different levels of palm oil

Parameters	T0	T1	T2	T3	P-Value
Carcass weight (g)	1089±28.99^{b}	930.9±27.87^{c}	1265±6.71^{a}	1209±14.41^{ab}	<0.0001
Carcass yield (%)	64.01±0.32^{b}	69.34±1.20^{a}	67.30±0.41^{a}	66.57±0.22^{a}	<0.0001
Breast weight (g)	214.5±7.37^{b}	211.9±9.26^{b}	257.1±6.96^{a}	254.4±2.71^{a}	0.0001
Breast yield (%)	12.69±0.39^{b}	15.78±0.60^{a}	13.60±0.21^{ab}	14.06±0.24^{a}	0.0001
Thigh weight (g)	347.8±8.19^{a}	286.4±9.75^{b}	360.4±16.47^{a}	386.7±11.60^{a}	<0.0001
Thigh yield (%)	20.49±0.15	21.31±0.43	19.03±0.77	21.25±0.52	0.5859
Drumstick weight (g)	172.2±3.90^{b}	140.6±4.22^{b}	196.5±2.60^{a}	222.3±11.43^{a}	<0.0001
Drumstick yield (%)	10.16±0.12^{b}	10.48±0.19^{ab}	10.46±0.15^{ab}	12.34±0.72^{a}	0.0204

^{a,b,c} Within a row, data sharing no common letter are significantly different (p<0.05)

T0 : 0% ; T1 : 1% ; T2 : 2% ; T3 : 3%

The broilers fed 2% and 3% palm oil had the highest carcass weight. Similar results were obtained for the weights of breast, thigh, and drumstick. The broilers that consumed 1% palm oil had the lowest weight, however, they had the highest carcass yield. The thigh yield was not significantly different (P > 0.05) among the broilers fed different levels of palm oil. The carcass and breast yield were higher in broilers fed palm oil. The drumstick yield being high in the group that received 3% palm oil.

Our experiment showed that carcass, breast, and drumstick yields increased with the addition of palm oil to broiler diets. This suggests an accumulation of protein in different parts of the carcass with the inclusion of palm oil. This result is in agreement with the findings of Mendes et al. (2004), but differs from that reported by Bobadoye *et al.* (2009). The best feed efficiency was observed with diets containing 1% and 2% oil, which showed the highest weight gain and better feed conversion ratio compared to other treatments. The high feed conversion ratio observed in groups T0 and T3 contradicts the results of (Rahman et al. (2010), who reported improvements in feed conversion with 4% palm oil in fast-growing broilers. The discrepancy in results is likely due to differences in broiler strain and palm oil dietary compositions.

3.1.4 Effect of palm oil on blood parameters

The results of the serum analysis of cholesterol, triglycerides, and total protein are presented in Table 5. The biochemical parameters were affected significantly by the experimental dietaries.

Table 5. Serum concentration of cholesterol, triglycerides and total protein of broilers fed different levels of palm oil

Parameters	T0	T1	T2	T3	P-value
Total protein (g/dL)	30.40±0.44^{b}	30.77±1.16^{b}	33.63±0.86^{a}	34.40±0.42^{a}	0.0009

Total Cholesterol (mg/dL)	1.03±0.01[c]	1.71±0.28[bc]	2.36±0.39[b]	3.98±0.47[a]	<0.0001
Triglycerides (mg/dL)	0.27±0.01[c]	0.32±0.01[b]	0.33±0.02[b]	0.37±0.02[a]	<0.0001

[a,b,c] Within a row, data sharing no common letter are significantly different ($p<0.05$)
T0 : 0% ; T1 : 1% ; T2 : 2% ; T3 : 3%

The cholesterol concentration increased as the level of palm oil incorporation increased. T2 and T3 groups had the highest total protein concentration compared to the other treatments. Triglyceride levels were lower in the control group but higher in broilers fed palm oil.

The biochemical profile is an important indicator of the physiological status of animals. Adding fat to the broiler diet can alter blood triglyceride, cholesterol, and total protein concentrations. In particular, palm oil is rich in saturated fatty acids and its inclusion in the diet constitute additionnal source of fatty acids. As a result, the amount of saturated fatty acids in the diet will increase with increasing levels of palm oil. The inclusion of high levels of saturated fatty acids in diets raises blood triglyceride levels in broilers (Crespo & Esteve-Garcia, 2003; Rafiei-Tari et al., 2021). As saturated fatty acids are hypercholesterolemic, they raise total cholesterol levels (Mensink & Katan, 1992). This explains the increase in cholesterol levels in broilers fed diets with added palm oil. These results are similar to those obtained by Tari et al. (2019), who reported that cholesterol levels were highest in chickens fed palm oil and lowest in those fed olive oil. Our findings agree with previous reports that showed palm oil resulted in a significant increase in serum triglycerides, cholesterol, and VLDL (Adeyemi et al., 2016).

4. CONCLUSION

This study indicates that incorporating 1% and 2% palm oil in the diet of broilers in tropical regions may enhance their growth performance. In light of these findings, it is imperative for researchers to thoroughly examine the profitability of using palm oil as an alternative energy source for slow-growing broilers in tropical climates.

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