



EFFECTS OF COCONUT OIL (*COCOS NUCIFERA*), AVOCADO OIL (*PERSEA AMERICANA*), MELON SEED OIL (*CITRULLUS COLOCYNTHIS* L.) ON GROWTH PERFORMANCE, BLOOD, BIOCHEMICAL, HAEMATOLOGICAL PARAMETERS, AND TOTAL MICROBIAL LOADS OF NOILER BIRDS

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ABSTRACT

This study was carried out to examine the comparative effects of coconut oil (CO), avocado oil (AO), and melon seed oil (MSO) on the growth performance, blood, biochemical, hematological parameters, and total microbial loads of Noiler birds. A total of 120 Noiler birds with an average weight of 50.3 ± 0.13 g were randomized into four treatment groups with 3 replications (10 per pen) for six weeks of fattening. Weekly body weight gain and daily feed intake of the birds were recorded for six weeks, after which average weight gain and feed conversion ratios were calculated. At the end of the feeding trials, blood samples were collected for biochemical and hematological parameter assessments, and the digesta from the colon and ileum were collected for their intestinal total microbial load analysis. The average weight gains and feed conversion ratios (FCR) of the birds supplemented with CO (1229.40 ± 15.00) and MSO (1232.66 ± 43.18) were observed to be significantly higher ($P < 0.05$), compared to the birds supplemented with AO (1110.73 ± 18.29) and the birds fed feed only

(1034.79 ± 2.04) having the least weight gained. The biochemical parameters of the birds across the treatment were not significantly different ($P > 0.05$). White blood cells, packed cell volume, red blood cells and lymphocytes were significantly higher in the CO group compared to the birds supplemented with the avocado oil and melon seed oil. There was no significant difference ($P > 0.05$) in the weight of the spleen, bursa and gall bladder among the birds. The *Lactobacillus* spp. in the colon of birds supplemented with coconut oil (6.43 ± 0.56) and melon oil (6.25 ± 0.65) were significantly higher. It can be concluded that coconut oil and melon seed oil have the potential to serve as growth promoters for chicken production.

Key words: comparative study; digesta; growth; haematology; intestinal microbes

INTRODUCTION

The poultry industry can produce very high-quality

proteins for human nutrition as well as a source of income for the community in many countries, hence poultry production has a very important role in economic development of any country [44]. Noiler chicken is a dual purpose breed of chicken developed by Amo Farm Sieberer Hatchery Limited for small holders to address the challenges of food insecurity and financial dependency among the rural populace, especially women. Noiler was bred to survive on low quality feedstuffs to provide good quality meat and egg [37].

Antimicrobials are sometimes given to food animals at low doses in order to promote faster growth [7]. The mechanism of action of the antimicrobial growth promoter is not fully understood but the potential of the intestinal microbiota in increasing feed efficiency has been shown [8, 19]. However, repeated use of these drugs in small doses in food animals, such as for the purposes of growth promotion, feed proficiency enhancement, and prophylaxis has been identified as a significant contributing factor to increasing antimicrobial resistance [12, 46]. Because of this, many countries have already taken action to reduce the use of antibiotics in food-producing animals [47, 48].

Following this action, alternative substances and strategies for animal growth promotion and disease prevention are being investigated, among which phytogenic and natural products have received attention since they have acquired more acceptability among consumers as natural additives [18, 45].

Fats especially from plant-based sources have shown positive alterations in the gut microbiota in both *in vivo* and *in vitro* studies [26]. Coconut oil is a highly saturated oil (about 90 %), and 60 % of its total fatty acid composition are medium chain length of 6 to 12 carbon atoms [10], which are absorbed directly into the portal circulation without re-esterification in intestinal cells [22]. This is in contrast to the longer-chain saturated fatty acids which are more typically found in animal fats; medium-chain fatty acids (MCFA) are more easily metabolized [41]. Recent data from a human trial suggest that coconut oil, at least in daily doses of 30 ml, may not have the same dyslipidemic properties and proinflammatory properties as other saturated fats [6]. In addition, virgin coconut oil contains high concentrations of polyphenols and may therefore have antioxidant, as well as anti-inflammatory effects, as demonstrated in some animal models [15].

Avocado is a fruit grown mainly in warm temperate

and subtropical climates throughout the world. The pulp of this fruit contains about 60 % oil, 7 % skin, and approximately 2 % seeds [43]. The lipid content of avocado oil, mainly of monounsaturated fatty acids (MUFA), is associated with cardiovascular system benefits and anti-inflammatory effects [5]. Avocado oil has a high content of monounsaturated fatty acids (69.4 %) and a lower amount of polyunsaturated fatty acids (PUFA) and saturated fatty acids, which were 16.6 % and 14 %, respectively [16]. The presence of compounds with nutritional interest, such as unsaturated fatty acids (MUFA and PUFA), as well as compounds with biological activity, such as tocopherols, tocotrienols, phytosterols, carotenoids, and polyphenols, have made avocado oil of growing interest for research on the possible biological effects of avocado oil, with the aim of preventing and treating diseases through the diets of the population [17].

Citrullus colocynthis has a significant history of medicinal, pharmaceutical, nutraceutical and nutritional use [35]. The oil from melons is rich in fatty acids; the oil contains five main fatty acids: palmitic, stearic, oleic, linoleic and linolenic acids, but the most abundant fatty acid is linoleic; a polyunsaturated fatty acid [13, 14, 20]. Monounsaturated fatty acids of melon seed oil was reported to be 18.2 %, while polyunsaturated fatty acids and saturated fatty acids contributed 53 % and 21.2 % w/w respectively [38, 39]. Research has shown that melon seed oil contains antibacterial, anti-diabetics, and antimicrobial activity [4].

Therefore, this study investigated the effects of coconut oil, avocado oil, and melon seed oil on the growth performance, biochemical, hematological parameters and total microbial loads of Noiler chickens.

MATERIALS AND METHODS

Experimental location

The experiments were carried out at the Poultry Unit of the Teaching and Research Farm, Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Osun State.

Experimental design

A total number of 120 Noiler day old chicks were purchased from a standard and reputable hatchery in Aawe, Oyo state. The birds were transported in a perforated day old chick's carton during the cool weather condition for

proper aeration. Pens were thoroughly cleaned and disinfected against germs and bacteria prior to the arrival of the birds. The birds were grouped using a completely randomized design and allocated to four separate treatments with ten birds per treatment and replicated thrice. The birds were first acclimatized for a week and then the experiments lasted for six weeks.

Experimental diet and feeding

The birds were fed with chick mash from day old to three weeks of age (18 % CP and 2800 kcal); at week four grower mash 17 % CP and 3100 kcal were fed to the birds. The feeds were weighed and supplied to the birds in the morning and remnants were removed in the evening and weighed before fresh feed of known quantity was supplied, this was done in order to determine the feed intake of a birds per day for the efficient calculation of the Feed Conversion Ratio and Average Daily Weight Gain.

Treatment 1 were administered the control experimental diet without supplements.

Treatment 2 were administered the avocado oil supplemented diet at 10 ml.kg⁻¹ of feed.

Treatment 3 were administered the melon oil supplemented diet at 10 ml.kg⁻¹ of feed.

Treatment 4 were administered the coconut oil supplemented diet at 10 ml.kg⁻¹ of feed.

Table 1. Ingredient composition of diets

Ingredients	Chick mash	Growers' mash
Maize	64.9	64.9
Wheat offal	4.0	4.0
Soya bean meal	26.0	14.5
Full fat soya	1.6	13.1
Bone meal	2.5	2.5
Chick premix	0.25	0.25
Salt	0.25	0.25
Methionine	0.3	0.3
Lysine	0.2	0.2

Extraction of oils

Coconut oil

Mature coconuts were purchased from Sabo market, Ile

Ife, Osun state, located in the South West of Nigeria. The coconuts were cut open and the kernel meats (endosperm) were removed and washed clean. The kernel meats were grinded by a bur mill and poured into a bowl. Hot water was added to it and the mixture was sieved to remove the shaft. The milky solution obtained was kept in the refrigerator for a few hours until a cake crust was formed on top of the solution. The cake was then scraped and heated until a clear, transparent liquid was obtained.

Avocado oil

Ripe avocado was purchased from Sabo market, Ile-Ife, Osun state, located in the South West of Nigeria. The skin of avocado was peeled off, while the fleshy part was cut into smaller pieces, and blended into a smooth paste. The paste was spread out in a thin layer and sun dried for a period of 28 hours which resulted into dark-brownish green dried crumbs. The oil was exhaustively extracted by Soxhlet extraction according to the method described by S a n t a n a et al. [40].

Melon seed oil

The oil from the melon seeds were extracted by the continuous extraction in Soxhlet apparatus (chemglass) for 8 hours using petroleum ether (60—80 °C boiling range) as a solvent according to the method described by AOAC [2]. At the end of the extraction, the extraction solvent was evaporated in a rotary evaporator [37].

Data collection and analyses

The birds were weighed weekly and at the end of the experiment, the feed conversion ratios were calculated to measure the efficiency with which the bodies of the live-stock converted animal feed into the desired output. It was calculated as: average feed intake per daily weight gain. Blood samples (six per treatment) were collected by severing the jugular vein of the neck, the blood was collected directly into both blank and EDTA sample bottles. The sample inside the plain sample bottle was centrifuged at 3000 rpm for 10 minutes after which the serum was separated into clean bottles. The digesta from the colon and ileum were collected for microbiological analysis according to the method of O l u t i o l a et al. [36] and all organs were weighed. The immune organ index was calculated using the formula, immune organ weight (mg)/live weight (g).

Packed Cell Volume (PCV)

Microcapillary tubes were filled with uncoagulated blood and the end was sealed with plasticine. The tubes were centrifuged in a micro hematocrit centrifuge. The plasma at the top of the capillary tube could be used for determining the plasma protein and fibrinogen and for assessing plasma colour and turbidity. The level of the settled blood cells was read by placing the tube on the hematocrit graphic reader.

Erythrocyte counts

The red blood cell count per million was done using blood containing anticoagulants by the haemocytometer method. A red cell pipette was used to draw blood up to 0.5 mark and was dropped on a glass slide, smeared and was covered with a cover slip. This was viewed under the microscope. The erythrocytes in the five lower squares were counted. The volume counted was calculated using the formula below:

$$\text{RBC} = \frac{\text{Total number of cell count} \times \text{dilution factor}}{0.02 \text{ mm}^3}$$

White blood cell count

The total white blood cells were counted under the microscope using the haemocytometer. A white blood cell pipette was used to draw blood to 0.5 mark and diluted to 1.2 mark with the aid of a white cell diluting fluid. The leucocytes in the four lower squares were counted. The number of cells counted was calculated using the formula below:

$$\text{WBC} = \frac{\text{Total number of cell count} \times \text{dilution factor}}{0.4 \text{ mm}^3} [32]$$

Microbial analysis of crop and ileum samples

Bacterial detection was carried out on samples recovered from the crop and ileum. The double fold dilution method was conducted for each sample and thereafter pour-plated using several media. The media which include nutrient agar and de Man Rogosa and Sharpe agar (MRS) were assessed to determine the total heterotrophic bacteria count and *Lactobacillus* spp. respectively [36].

Biochemical parameters

To determine the biochemical parameters, blood samples were collected into plain sample bottles and allowed to clot and centrifuged for 15 minutes at 2200–2500 rpm

to separate the sera. The sera samples were used for the biochemical parameters determination of total protein, albumin, total cholesterol, HDL, LDL and triglyceride, according to the enzymatic colorimetric method described by Schmidt, Schmidt [42] using a commercial diagnostic reagent kits (Randox Laboratories Ltd., UK). The globulin was calculated by subtracting the albumin value from the total protein.

Statistical analysis

The statistical software program SAS was used to analyze the data obtained from the experiment. The data were subjected to analysis of variance (ANOVA), while the means were separated using the Duncan Multiple Range Test.

RESULTS

The growth performance indices of Noiler birds supplemented with different oils are shown in Table 2. The Noiler birds fed with coconut oil and melon oil supplements showed final body weights which were significantly higher ($P < 0.05$) compared to the birds on the avocado oil supplemented diet. Birds supplemented with the three natural oil had significantly lower feed conversion ratios (FCR) compared with the control birds.

The biochemical parameters of Noiler chicken presented in Table 3 showed that there were no significant differences ($P > 0.05$) in the serum parameters of the birds in all of the treatment groups. There were significant increases ($P < 0.05$) in red blood cell, haemoglobin and packed cell volume (PCV) of animals supplemented with coconut oil, when compared with other groups of experimental birds (Table 4). The birds fed the coconut oil supplemented diet had significantly higher WBC (18691.7 ± 238.19) and lymphocyte (68.83 ± 0.95) compared to animals fed the avocado oil and melon oil supplemented diet. Animals in the control group showed higher heterophils values (31.83 ± 2.39), followed by animals in the avocado oil group (28.83 ± 3.05), melon oil group (25.67 ± 0.56), and coconut oil group (24.33 ± 1.09). However, there were no significant differences in platelet, monocyte, eosinophil, and basophil count across all of the treatments.

The organ parameters presented in Table 5 showed that there were significant differences ($P < 0.05$) in: the weights of the heart, liver, gizzard, right kidney, left kidney, large

Table 2. Growth performance of Noiler chickens fed different oil supplemented feeds

Parameters	T1	T2	T3	T4
Initial weight [g]	50.42 ± 0.15	50.37 ± 0.09	50.39 ± 0.07	50.35 ± 0.13
Final weight [g]	1085.14 ± 1.83 ^b	1161.21 ± 18.08 ^b	1283.03 ± 43.10 ^a	1279.76 ± 14.98 ^a
Weight gain [g]	1034.79 ± 2.04 ^b	1110.73 ± 18.29 ^b	1232.66 ± 43.18 ^a	1229.40 ± 15.00 ^a
Feed intake [g]	2173.20 ± 35.76 ^b	2063.78 ± 3.62 ^c	2315.23 ± 7.38 ^a	2291.57 ± 4.56 ^a
FCR	2.10 ± 0.03 ^a	1.86 ± 0.03 ^b	1.83 ± 0.07 ^b	1.86 ± 0.02 ^b

^{a, b, c}—means with different superscript in the same row are significantly different at P < 0.05; T1—birds on control diet; T2—birds supplemented with avocado oil; T3—birds supplemented with melon oil; T4—birds supplemented with coconut oil; FCR—feed conversion ratio

Table 3. Serum biochemical parameters of Noiler chickens fed different supplemented feeds

Parameter	T1	T2	T3	T4
Total protein [g.dl ⁻¹]	7.03 ± 0.28	7.07 ± 0.08	7.57 ± 0.45	7.13 ± 0.18
Albumin [g.dl ⁻¹]	2.47 ± 0.31	2.40 ± 0.15	2.58 ± 0.37	2.42 ± 0.21
Globulin [g.dl ⁻¹]	4.87 ± 0.08	4.67 ± 0.11	4.98 ± 0.23	4.72 ± 0.05
A/G ratio	0.47 ± 0.07	0.50 ± 0.05	0.48 ± 0.08	0.48 ± 0.05
Total cholesterol [mg.dl ⁻¹]	192.00 ± 7.26	199.3 ± 3.70	203.17 ± 9.22	194.17 ± 3.54
Trig [mg.dl ⁻¹]	78.67 ± 8.11	71.83 ± 3.71	85.50 ± 7.93	78.19 ± 6.81
HDL [mg.dl ⁻¹]	103.3 ± 2.42	96.67 ± 2.01	102.17 ± 3.55	98.33 ± 3.33
LDL [mg.dl ⁻¹]	72.93 ± 6.42	88.27 ± 2.24	83.90 ± 5.11	80.20 ± 3.11

T1—birds fed feed only; T2—birds supplemented with avocado oil; T3—birds supplemented with melon oil; T4—birds supplemented with coconut oil; A/G Ratio—albumin/globulin ratio; Trig—triglyceride; HDL—high density lipoprotein; LDL—low density lipoprotein

Table 4. Haematological parameters of Noiler chickens fed different supplemented feeds

Parameter	T1	T2	T3	T4
PCV [%]	31.67 ± 2.30 ^b	31.33 ± 2.53 ^b	33.33 ± 0.21 ^b	37.00 ± 1.03 ^a
Hb [g.dl ⁻¹]	10.40 ± 0.69 ^b	10.42 ± 0.85 ^b	10.92 ± 0.10 ^b	12.33 ± 0.33 ^a
RBC [10 ¹² .l ⁻¹]	3.36 ± 0.11 ^{ab}	3.16 ± 0.25 ^b	3.49 ± 0.04 ^{ab}	3.67 ± 0.05 ^a
WBC [10 ⁹ .l ⁻¹]	16.43 ± 0.80 ^b	17.51 ± 0.54 ^{ab}	17.32 ± 0.23 ^{ab}	18.69 ± 0.24 ^a
Platelet [10 ⁹ .l ⁻¹]	143.00 ± 129.79	137.00 ± 94.90	157.833 ± 74.09	138.167 ± 141.83
Lymphocyte [%]	61.7 ± 2.46 ^b	63.67 ± 3.06 ^{ab}	67.17 ± 0.60 ^{ab}	68.83 ± 0.95 ^a
Heterophils [%]	31.83 ± 2.39 ^a	28.83 ± 3.05 ^{ab}	25.67 ± 0.56 ^{ab}	24.33 ± 1.09 ^b
H/L ratio	0.51	0.45	0.38	0.35
Monocyte [%]	2.83 ± 0.31	3.17 ± 0.48	3.33 ± 0.44	3.00 ± 0.52
Eosinophils [%]	4.67 ± 0.56	4.17 ± 0.91	3.83 ± 0.87	3.83 ± 0.54
Basophil [%]	0.17 ± 0.17	0.17 ± 0.17	0.00 ± 0.00	0.00 ± 0.00

^{a, b, c}—means with different superscript in the same row are significantly different at P < 0.05; T1—birds fed feed only; T2—birds supplemented with avocado oil; T3—birds supplemented with melon oil; T4—birds supplemented with coconut oil; H/L ratio—heterophil/lymphocyte ratio; Hb—haemoglobin; RBC—red blood cell

Table 5. Weight of organs of Noiler chickens fed different supplemented feeds

Parameter	T1	T2	T3	T4
Gizzard [g]	–	27.36 ± 1.65 ^b	28.03 ± 2.01 ^a	28.75 ± 2.49 ^a
Heart [g]	2.99 ± 0.25 ^b	3.58 ± 0.19 ^b	3.69 ± 0.32 ^a	3.73 ± 0.31 ^a
Liver [g]	11.17 ± 1.55 ^b	16.97 ± 1.69 ^a	14.59 ± 0.94 ^{ab}	16.97 ± 1.34 ^a
Spleen [g]	1.62 ± 0.14	1.74 ± 0.11	1.85 ± 0.13	1.88 ± 0.12
Bursa [g]	1.66 ± 0.07	1.72 ± 0.26	2.32 ± 0.33	0.94 ± 0.11
IOI (Spleen) [mg.g ⁻¹]	1.68 ± 0.16	1.33 ± 0.03	1.50 ± 0.15	1.32 ± 0.13
IOI (Bursa) [mg.g ⁻¹]	1.60 ± 0.10	1.47 ± 0.48	1.31 ± 0.08	1.51 ± 0.06
Right kidney [g]	2.11 ± 0.28 ^b	2.79 ± 0.18 ^a	2.58 ± 0.10 ^{ab}	2.55 ± 0.24 ^a
Left kidney [g]	1.98 ± 0.22 ^b	2.89 ± 0.23 ^a	2.87 ± 0.18 ^a	2.74 ± 0.20 ^a
Right lung [g]	1.78 ± 0.12 ^b	2.12 ± 0.13 ^{ab}	2.37 ± 0.09 ^a	2.18 ± 0.14 ^a
Left lung [g]	1.78 ± 0.14 ^b	2.29 ± 0.07 ^{ab}	2.83 ± 0.26 ^a	2.75 ± 0.25 ^a
Large intestine [g]	4.15 ± 0.16 ^a	1.65 ± 0.06 ^c	3.79 ± 0.56 ^{ab}	3.01 ± 0.43 ^{bc}
Small intestine [g]	29.88 ± 4.17 ^b	43.51 ± 4.27 ^a	34.75 ± 2.63 ^{ab}	36.82 ± 2.59 ^{ab}
Large intestine [cm]	8.08 ± 0.94 ^a	5.93 ± 0.29 ^b	7.83 ± 0.59 ^a	6.27 ± 0.63 ^a
Small intestine [cm]	109.95 ± 5.09 ^c	122.70 ± 4.89 ^{bc}	139.83 ± 6.41 ^a	127.57 ± 4.52 ^a
Gall bladder [g]	1.52 ± 0.20	1.26 ± 0.13	1.45 ± 0.08	1.31 ± 0.11

^{a, b, c}— means with different superscript in the same row are significantly different at P < 0.05;

T1—birds fed feed only; T2—birds supplemented with avocado oil; T3—birds supplemented with melon oil;

T4—birds supplemented with coconut oil

Table 6. Microbial loads of Noiler chickens fed different supplemented feeds

Parameter	T1	T2	T3	T4
Colon				
THB [CFU.ml ⁻¹]	5.73 ± 0.55	5.11 ± 0.29	4.65 ± 0.19	4.84 ± 0.19
LSC [CFU.ml ⁻¹]	4.66 ± 0.13 ^b	5.69 ± 0.50 ^{ab}	6.25 ± 0.65 ^a	6.43 ± 0.56 ^a
Ileum				
THB [CFU.ml ⁻¹]	5.73 ± 0.55	5.16 ± 0.15	5.32 ± 0.32	5.21 ± 0.42
LSC [CFU.ml ⁻¹]	4.66 ± 0.13	4.88 ± 0.08	5.63 ± 0.52	5.58 ± 0.56

^{a, b, c}—means with different superscript in the same row are significantly different at P < 0.05; T1—birds fed feed only;

T2—birds supplemented avocado oil diet; T3—birds supplemented melon oil diet; T4—birds supplemented coconut oil diet;

THB—total heterotrophic bacteria; LSC—*Lactobacillus* spp. count

intestine, small intestine, right lung, and the left lung; also the length of the large intestine, and small intestine. However, there was no significant difference ($P < 0.05$) in the weights of spleen, bursa, and gall bladder.

Table 6 shows the intestinal microbial loads collected from the colon and ileum of Noiler birds. In the colon of

birds supplemented with natural oil diets, Table 6 showed that there was no significant difference ($P > 0.05$) in the total heterotrophic bacteria, while there was a significant difference ($P < 0.05$) in the *Lactobacillus* spp. count across the treatment which was seen to be higher compared in oil supplemented birds compared to the control birds.

DISCUSSION

In recent years, attention has been focused on the dietetic and health effects of fat. This study was conducted to evaluate the efficacy of the utilization of coconut, melon seed and avocado oils as natural feed additives on dual purpose Noiler chickens. The improved feed intake and weight gain noticed in birds supplemented with coconut and melon seed oil could be due to dietary fat reduced passage rate of the digesta through the gastrointestinal tract, allowing for better nutrient absorption and utilization [24]. The addition of fat to the diet, besides supplying energy, improved the absorption of fat-soluble vitamins, diminishes the pulverulence, and increased the palatability of the rations [38]. The improvement in growth performance could be due to an increase in the efficiency of nutrients utilization; especially crude protein or antibacterial properties of medium-chain fatty acids (MCFA) [11, 49]. The carcass and organ weights of this study agrees with the reports of Tuleun, Igba [46] that the organ weights of broilers are the results of their live weight, since the surface area determines the amount of feathers and visceral organs required.

The non-significant levels of serum parameters of the experimental birds were in agreement with Nandakumaran et al. [30] who found no difference when coconut oil was fed to rats. Khaw et al. [23] however found a non-significant increase in LDL but a significant increase in HDL values while Lim [25] reported a significant increase in the serum levels of both HDL and LDL cholesterol in humans consuming coconut oil for over two weeks. Nevinn, Rajamohan [31]; Arunima, Rajamohan [3] reported that the supplementation of virgin coconut oil beneficially modulated hepatic lipid metabolism in rats and coconut oil, in particular, lowered total cholesterol, lipoproteins, and phospholipids. The reason for this was that the coconut oil consisted predominantly of medium chain fatty acid that was metabolized rapidly in the liver to energy and did not participate in the biosynthesis and transport of cholesterol. Moreover, Murray et al. [28] reported that the increased concentration of HDL-C protected against the development of atherosclerosis in rodents and humans possibly as a result of enhanced reverse cholesterol transport (RCT), i.e. transfer of cholesterol from the arterial wall to the liver, followed by excretion into the bile, thus, reducing the plasma cholesterol levels. Oluba et al. [33, 34] reported that melon oil with a rich content of polyunsaturated fatty acids produced

a significant reduction ($P < 0.05$) in the serum total, free and esterified cholesterol and triglyceride concentrations in rats. Broilers supplemented with avocado non-saponifiable fatty had HDL-C fraction increased significantly ($P < 0.05$) with a decrease in LDL-C [9].

The increase in haematological parameters of Noiler chickens supplemented with coconut oil was in agreement with Akinjayeju, Adedolu [1] who reported an increase in haematological parameters of coconut oil supplemented rats. This result was however in contrast to the findings of Nandakumaran et al. [30] and with El-Abasy et al. [11] that reported that oral coconut oil administration to pregnant rats and rabbits did not have any effect on the hematological parameters.

The heterophil to lymphocyte ratio (H/L) is a widely established measure of stress particularly in the medical and veterinary literature [27]. Increases in heterophil to lymphocyte ratios (H/L) caused by heterophilia have been reported to be an indicator of chronic stress [9]. The heterophil/lymphocyte ratio was lowest in birds supplemented with coconut oil. This ability of coconut oil to reduce stress in chickens may be due to the presence of phenolic compounds, such as caffeic acid, p-coumaric acid, ferulic acid and catechin which improved its antioxidant capacity and the ability to fight diseases associated with oxidative stress [21]. Coconut oil also may enhance the immune system activity through several fatty acids, which are a potent immune stimulant [11].

The intestine provides the primary supply of nutrients: the sooner it achieves its functional capacity, the sooner the young birds can utilize dietary nutrients, efficiently grow at their genetic potential and resist infectious and metabolic diseases [26]. The fats from plant-based sources such as nuts, or vegetable oils have shown positive alterations in the gut microbiota biodiversity both in *in vivo* and *in vitro* studies [29]. The increase in lactobacillus count could be due to the antimicrobial effects of natural oil, as suggested by Erhan, Bolukbasi [13] who reported that citrus peel oil supplementation increased lactobacilli counts in the jejunum of broiler chickens. It is well documented that the mode of action of *Lactobacillus* consists in competitive exclusion against harmful bacteria in the gut, in favor of beneficial microbial populations, leading to improvement in nutrients utilization of feed and this could have been responsible for the weight advantage of coconut oil over the control birds [50].

CONCLUSIONS

It can be concluded that supplementing the feed of chickens, especially with coconut oil, has beneficial effects on the growth and stress response of Noiler birds and has no deleterious effect on the serum cholesterol.

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