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Impact of Dietary Supplementation of *Carica papaya* Essential Oil on the Blood Chemistry of Broiler Chickens

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Abstract

The purpose of this study was to look into how adding *Carica papaya* essential oil to the diets affects the blood chemistry of broiler chickens. An 8-week trial involved 400 one-day-old mixed-sex Ross 307 chicks. The birds were divided into 4 groups, each of which contained 100 birds with 5 replicates, each containing 20 birds. Treatments T1, T2, T3, and T4 received a basal diet of 100 mg, 200 mg, and 300 mg/kg, respectively, of *Carica papaya* essential oil in place of T1's basal diet. *Ad libitum* feed and clean water were provided. The findings showed that the treatments had no appreciable impact on pack cell volume, red blood cells, hemoglobin, white blood cells, lymphocytes, monocytes, eosinophils and neutrophils values in the starter and finisher phases. *Carica papaya* essential oil had no discernible effect on the levels of total protein, albumin, globulin, creatinine, aspartate transaminase, or alanine phosphatase, except for cholesterol levels, which were greater in T1 than in other treatments in both the starter and finisher phases. All readings, however, fall within the ideal ranges for healthy birds, indicating no signs of infection, inflammation, or metabolic disease. The research shows that *Carica papaya* essential oil has several bioactive components with therapeutic value and can be used up to 300 mg/kg of diet without having any negative effects on the birds' blood profile or general performance.

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Introduction

There is increasing legislative pressure to phase out the routine use of relatively tiny doses of antibiotics in animal feed [1]. The European Union already prohibited the use of antibiotic growth promoters as of January 2006 due to concerns about drug residues in food-grade animal products and the environment as well as the potential spread of antibiotic resistance to human infections [1, 2]. Alternatives like essential oils have been the subject of research instead. According to the World Health Organization (WHO), one of the top three risks to human health in 2009 was antibiotic resistance [3, 4]. Using essential oils, especially those from *Carica papaya*, is one option for antibiotic alternatives. The papaya (*Carica papaya* Linn) is a dicotyledonous, flowering plant that is a member of the Caricaceae family [5, 6]. Tropical America is the plant's original habitat, but it has since expanded to other parts of the world, including India [7, 8]. The secondary metabolites found in papaya oil are numerous and have a variety of functions, including antibacterial, antioxidant, anti-inflammatory, anti-protozoal, and immune-modulatory activities [9-11]. Additionally, it contains a lot of oleic acid and triacylglycerols, which have been shown to be beneficial for animals' health [12, 13]. The leaves, roots, stem bark, seeds and other parts of the plant have historically been used to cure a variety of conditions, including malaria, typhoid, gastrointestinal issues and sexually transmitted diseases [14, 15].

It is well known that the content and amounts of active chemicals in essential oils from the *Carica papaya* plant vary greatly from region to region, and soil type to climate, among other factors [16, 17]. According to *in vitro* research, papaya essential oils can also suppress the growth of Gram-positive and Gram-negative bacteria [18]. According to Alagbe [19], papaya seeds include arginine, histidine, isoleucine, leucine, threonine, proline and valine among other amino acids. Previous research has demonstrated that essential oils have a wide range of possible advantages, all of which aim to improve livestock performance [20]. However, nothing is known about how papaya seed essential oil affects the blood profile of birds. Since there is a clear correlation between diet and animal health, an examination of the oil's effectiveness will aid in promoting food safety and determining the appropriate level of inclusion without endangering the health of the birds. Therefore, the purpose of this study was to investigate how adding *Carica papaya* to the diet affected the blood chemistry of broiler chickens.

Materials and methods

Experimental location and extraction of *Carica papaya* essential oil

The study was conducted at the Sumitra Institute's Livestock Unit, which is located between 23° 13' N and 72° 41' E. The research was conducted following the guidelines and requirements of procedures that had been authorized by the Research Ethics Council of Gujarat, India's Sumitra Research Institute.

A competent taxonomist from the Faculty of Biological Sciences obtained fresh *Carica papaya* seeds from the Sumitra Teaching and Research farm for thorough identification and authenticity. Collected seeds were air-dried on a flat metallic tray for 18 days to retain the active components in the seeds and pulverized into size to reduce their surface area. Steam distillation technique was employed in the extraction of *Carica papaya* essential oil. The procedure requires an H-shaped Clevenger apparatus, heating mantle, Graham condenser, safety tube, separatory funnel, round bottle flask and beaker. Around 200 grams of pulverized papaya seeds were soaked in a round bottom flask (RBF) with 500 ml water with a heating mantle, and a delivery tube was connected above the RBF with Graham's condenser. The sample was heated to 60°C and maintained at boiling point, water vapors produced passed through the condenser to the separatory funnel where a layer of water and oil was formed. The tube was gradually released and the essential oil was collected in a beaker.

Experimental bird management, diet and design

For the experiment, 400 mixed-sex Ross 307 broiler chicks at one day old were employed. The birds were acquired from an established hatchery in India and divided into 4 groups, each with 60 birds (5 repetitions, each with 20 birds), using a random design. These were the experimental groups: An essential oil-free standard feed control group: (group 1) and three supplemental groups for *Carica papaya* oil: 100 mg (group 2), 200 mg (group 3), and 300 mg (group 4) per kilogram of basic feed. Chicks were kept in semi-closed pens in a battery cage that measured (150cm 90cm 80cm) (length breath height) and was 110cm above the ground. It was furnished with aluminum feeders and nipple drinkers. Glucomol® (glucose + paracetamol) (20 grams per

10 liters of water) and water-soluble vitamin (Vitamix®) at 5 grams per 10 liters of water were provided to the birds as soon as they arrived. Diets were created based on [21] nutritional advice for broilers.

Bioactive compounds of *Carica papaya* essential oil

Using an Agilent 7000B triple quadrupole GC/MS instrument, the bioactive components in Carica papaya essential oil were analyzed. It has the following technical specifications: mode (standard), EI (high sensitivity extraction source), ion source material (non-coated proprietary inert source), ion source temperature (106°C to 350°C), filaments (dual filaments for EI), electron energy (100 to 300 eV), mass range (10 to 1050 m/z), dynamic range (106), scan rate (up to 6.250 u/s) and mass axis stabilization, collision cell (linear hexapole), collision cell gas (nitrogen with helium quench gas for reduction of metastable helium), collision energy (selectable up to 60eV), detector (triple axis HED-EM with extended life EM and dynamically ramped iris), total gas flow (up to 80 mL / min GC carrier plus another 5 mL/min of methane for Cl operation plus an additional 1-2 mL/min of N_2) and He for the collision cell gases], pumping system (dual stage turbomolecular pump), pumping system (Agilent mass hunter acquisition, data handling and reporting) and simultaneous MS and GC (can collect 2 GC detector signals while acquiring MS data).

Blood collection and analysis

Blood was drawn from six randomly chosen birds per replication on the 28th and 56th days of the trial for hematological and serum biochemical analysis. While serum indices were taken into sample bottles without an anticoagulant, blood for hematology was taken into bottles containing an anticoagulant (ethylene diamine tetraacetic acid). The OM-2206 auto hematology analyzer was used to perform a hematological study on 2 ml of blood. White blood cell, pack cell volume, hemoglobin and red blood cell

Table 1 Ingredient and gross composition of the trial diet (% dry matter).

Ingredients	Starter's diet (0-28 d)	Grower's diet (29-56 d)
Yellow maize	51.00	55.00
W/O	2.00	5.00
SBM	32.00	30.00
F/M (72 %: imported)	2.00	2.00
GNM	8.00	3.00
Oyster shell	1.50	2.40
Bone meal	3.00	5.00
Lysine	0.20	0.20
Methionine	0.25	0.20
Premix	0.25	0.25
Salt	0.30	0.40
Toxin binder	0.05	0.05
Total	100.00	100.00
Calculated analysis		
CP	23.11	19.73
CF	4.23	5.13
EE	4.55	4.75
Ca	1.58	1.87
P	0.61	0.91
Lysine	1.52	1.67
Methionine plus cysteine	0.93	0.95
Metabolizable energy (Kcal/kg)	3002.7	3168.6
Laboratory analysis (%)		
CP	23.48	21.90
CF	4.00	4.40
EE	4.60	4.51
Ca	1.66	1.81
P	0.79	0.81
Lysine	1.98	1.98
Meth plus cysteine	1.13	1.32
Metabolizable energy (Kcal/kg)	2996.7	3100.3

W/O: wheat offal; SBM: soya bean meal; GNM: groundnut meal; CP: crude protein; EE: ether extract; CF: crude fibre; Ca: calcium; P: phosphorus parameters were produced using the electrical resistance approach. The machine also has the following technical specifications; manual closed and open tube volume at 100 µl each, work station (intel Pentium dual core 2.00 GHz 200 W desktop/tower), (3Gb/s 7200 RPM 16 MB Cache hard drive; 2 GB memory module CD-RW) and (11-inch torch screen with LCD monitor). Serum biochemical analysis was carried out using Pictus 700 automatic analyzer (model F1209-06A, Hungary) with the following technical specifications; photometric module, measuring module (25 µl flow cell volume), 15 mm square cuvette, minimum aspiration volume: 200 µl and analysis mode.

Chemical analysis of diet

Perkin Elmer's near-infrared (Model DA 7250, England), which examines samples in 60 seconds, was used to analyze the trial diet. Operating temperature range (6°C to 41°C), wavelength range (900–1700 rpm) and wavelength accuracy (0.05 nm) are the equipment's technical details.

Statistical analysis

The General Linear Model technique of the Statistical Package of Social Sciences (version 23) was used to do a one-way analysis of variance on statistical data gathered on blood profiles. The same statistical software Duncan's new multiple range test was used to differentiate the means. At (P< 0.05), significant differences were found.

Results

Major bioactive compounds of *Carica papaya* essential oil

Table 2 represents the major bioactive compounds of *Carica papaya* essential oil including their retention time and peak areas. The most abundant compounds include; limonene (11.26%), α-pinene (10.71%), α-terpineol (8.05%), myrcene (5.66%), linalool (4.32%), α-terpinyl acetate (3.06 %), carvone

Table 2 Major bioactive compounds of *Carica papaya* essential oil using gas chromatography and mass spectrometry.

Compounds	Time of reaction (minutes)	Concentration (%)	Molecular weight (g/mole)	Molecular formula
Myrcene	7.113	5.66	136	$C_{10}H_{16}$
α-pinene	8.662	10.71	136	$C_{10}H_{16}$
α-terpineol	8.990	8.05	154	$C_{10}H_{15}O$
Limonene	10.461	11.26	136	$C_{10}H_{16}$
Linalool	11.228	4.32	154	$C_{10}H_{15}O$
Carvone	12.006	2.75	150	$C_{10}H_{14}O$
Geranyl acetate	12.114	1.41	196	$C_{13}H_{24}O$
α-terpinyl acetate	12.556	3.06	196	$C_{12}H_{20}O_3$
Benzyl acetate	13.209	1.22	150	$C_9H_{10}O_2$
2-methyl propyl acetate	13.421	0.96	234	$C_{15}H_{22}O_2$
Oxacyclohexadec-2-one	13.566	0.80	238	$C_{15}H_{22}O_2$
Cis-methyl dihydrojasmonate	15.190	1.33	226	$C_{13}H_{22}O_3$
n-Hexyl salicylate	15.612	0.96	222	$C_{13}H_{18}O_2$
Geraniol	17.008	1.40	154	$C_{10}H_{18}O$
γ-terpene	17.241	2.07	136	$C_{10}H_{16}$
Veloutone	17.882	1.54	196	$C_{13}H_{24}O$

Table 3 Hematological results of broilers fed diets supplemented with *Carica papaya* essential oil (0 – 28 d).

Constituents	Group 1	Group 2	Group 3	Group 4
Pack cell volume (%)	30.90 ± 0.60	33.06 ± 1.80	31.92 ± 2.00	30.96 ± 0.97
Haemoglobin (g/dL)	9.50 ± 0.29	9.33 ± 0.66	9.90 ± 1.20	9.65 ± 1.10
Red blood cell (×10^{12}/L)	2.25 ± 0.25	2.26 ± 0.25	2.26 ± 0.25	2.26 ± 0.25
White blood cell (×10^9/L)	10.56 ± 0.50	10.02 ± 0.00	10.80 ± 0.22	10.88 ± 0.31
Lymphocytes (%)	71.63 ± 2.50	70.42 ± 1.89	70.80 ± 1.00	71.36 ± 1.33
Monocytes (%)	1.92 ± 1.00	1.88 ± 0.30	1.86 ± 0.35	2.00 ± 0.50
Basophils (%)	0.92 ± 0.12	0.86 ± 0.10	1.00 ± 0.13	0.90 ± 0.00
Eosinophils (%)	1.00 ± 0.10	1.00 ± 0.15	1.50 ± 0.39	1.20 ± 0.22
Neutrophils (%)	0.30 ± 0.01	0.29 ± 0.00	0.35 ± 0.01	0.31 ± 0.01

T1: standard feed with no papaya essential oils; T2: standard feed plus 100 mg/kg papaya essential oil; T3: standard feed plus 200 mg/kg papaya essential oil; T4: standard feed plus 300 mg/kg *Carica papaya* essential oil

(2.75%) and γ-terpene (2.07 %). While geranyl acetate, benzyl acetate, 2-methyl propyl acetate, oxacyclohexadec-2-one, cis-methyl dihydrojasmonate, n-hexyl salicylate, geraniol and veloutone values are 1.41%, 1.22%, 0.96%, 0.86%, 1.33%, 0.96%, 1.04% and 1.54%, respectively. Limonene, α-pinene, α-terpineol, myrcene, linalool, α-terpinyl acetate, carvone and γ-terpene are members of terpenoids with a variety range of pharmacological benefits such as anti-inflammatory, anti-fungal, anti-bacterial, antioxidants, muscle relaxants, sedative and immune-modulatory roles [22, 23]. They are also responsible for the scent and flavor profiles of *Carica papaya* essential oil and also provide therapeutic benefits to the animal's body [24]. Geranyl acetate, benzyl acetate, 2-methyl propyl acetate, oxacyclohexadec-2-one, cis-methyl dihydrojasmonate, n-hexyl salicylate, geraniol and veloutone are members of esters. They are known to have a pleasant, fruity aroma and may be used as artificial flavors [25]. Esters contain anti-fibrotic, gastro-protective, anti-diabetic, cardio-protective, antioxidant, immune-stimulatory and anti-inflammatory properties [26].

Hematological analysis of broiler chicks

Hematological results of broiler chicks fed diets supplemented with *Carica papaya* essential oil (0-28 d) and (29-56 d) is displayed in Table 3 and Table 4 correspondingly. In the starter phase, pack cell volume, hemoglobin, red blood cell, white blood cell, lymphocytes, monocytes, basophils, eosinophils and neutrophil levels varied from 30.90 – 33.06%, 9.33 – 9.65 g/dL, 2.25 – 2.26 ($\times 10^{12}$/L), 10.02 – 10.88 ($\times 10^{9}$/L), 70.42 – 71.63%, 1.88 – 2.00%, 0.86 – 0.92%, 1.00 – 1.50% and 0.29 - 0.35%, sequentially. However, all values were not significantly (P>0.05) influenced by the groups. In the finisher phase (Table 4), PCV, red blood cell, Hb, RBC, WBC, lymphocytes, monocytes, basophils, eosinophils and neutrophil levels varied between 33.06 - 39.42%, 3.10 - 3.11 ($\times 10^{12}$/L), 10.50 - 10.67 g/dL, 11.30 - 11.40 ($\times 10^{9}$/L), 73.10 - 73.18%, 2.10 - 2.18 %, 0.86 - 0.87%, 1.50 - 1.51% and 0.55 - 0.57%, respectively. Dietary supplementation of *Carica papaya* essential oil did not affect the parameters (P>0.05).

Serum biochemical analysis

Serum biochemical results of chicks fed diets supplemented with *Carica papaya* essential oil at the starter phase (0-28 days) and finisher phase (29-56 days) are presented in Table 5 and Table 6, respectively. In the starter phase, total protein (Tp), globulin (Glo), albumin (Alb), creatinine (Crt), triglycerides (Try), alanine phosphatase (ALP) and aspartic transferase (AST) values were not influenced

Table 4 Hematological results of broilers fed diets supplemented with *Carica papaya* essential oil (29 – 56 d).

Constituents	Group 1	Group 2	Group 3	Group 4
Pack cell volume (%)	33.90 ± 2.00	33.06 ± 2.00	34.92 ± 2.11	33.96 ± 2.02
Hemoglobin (g/dL)	10.50 ± 0.60	10.67 ± 0.65	10.60 ± 0.67	10.65 ± 0.60
Red blood cell ($\times 10^{12}$/L)	3.11 ± 0.32	3.10 ± 0.29	3.11 ± 0.32	3.11 ± 0.32
White blood cell ($\times 10^{9}$/L)	11.30 ± 0.70	11.40 ± 0.70	11.40 ± 0.70	11.40 ± 0.70
Lymphocytes (%)	73.18 ± 2.50	73.10 ± 2.50	73.11 ± 2.50	73.16 ± 2.50
Monocytes (%)	2.10 ± 0.50	2.18 ± 0.50	2.16 ± 0.55	2.15 ± 0.66
Basophils (%)	0.86 ± 0.02	0.87 ± 0.02	0.87 ± 0.02	0.87 ± 0.02
Eosinophils (%)	1.51 ± 0.38	1.50 ± 0.38	1.50 ± 0.39	1.50 ± 0.39
Neutrophils (%)	0.55 ±0.00	0.55 ± 0.00	0.57 ± 0.01	0.55 ± 0.01

T1: standard feed with no papaya essential oils; T2: standard feed plus 100 mg/kg papaya essential oil; T3: standard feed plus 200 mg/kg papaya essential oil; T4: standard feed plus 300 mg/kg *Carica papaya* essential oil

Table 5 Serum biochemical results of chicks fed diets supplemented with *Carica papaya* essential oil (0 – 28 d).

Constituents	Group 1	Group 2	Group 3	Group 4
Total protein (g/dL)	6.23 ± 0.06	6.35 ± 0.07	6.30 ± 0.04	6.26 ± 0.03
Globulin (g/dL)	2.36 ± 0.17	2.45 ± 0.22	2.42 ± 0.19	2.46 ± 0.17
Albumin (g/dL)	3.87 ± 0.26	3.90 ± 0.30	3.88 ± 0.24	3.28 ± 0.25
Creatinine (mg/dL)	1.33 ± 0.12	1.25 ± 0.10	1.28 ± 0.10	1.30 ± 0.11
Cholesterol (mg/dL)	143 ± 12.0^{a}	135 ± 9.33^{b}	132 ± 9.50^{b}	130 ± 9.88^{b}
Triglycerides (mg/dL)	90.10 ± 8.80	88.10 ± 7.31	88.75 ± 7.50	88.60 ± 7.12
AST (U/L)	110 ± 37.22	102 ± 35.18	106 ± 35.00	102 ± 36.02
ALP (U/L)	27.96 ± 6.77	26.28 ± 5.80	25.92 ± 5.10	25.16 ± 5.52

^{a,b} Means with different superscripts along the row are significantly (P<0.05) different; SEM: standard error of the mean; T1: standard feed with no papaya essential oils; T2: standard feed plus 100 mg/kg papaya essential oil; T3: standard feed plus 200 mg/kg papaya essential oil; T4: standard feed plus 300 mg/kg *Carica papaya* essential oil.

Table 6 Serum biochemical results of chicks fed diets supplemented with *Carica papaya* essential oil (29 – 56 d).

Constituents	Group 1	Group 2	Group 3	Group 4
Total protein (g/dL)	7.08 ± 0.40	7.28 ± 0.51	7.28 ± 0.50	7.27 ± 0.48
Globulin (g/dL)	3.02 ± 0.10	3.10 ± 0.12	3.08 ± 0.16	3.05 ± 0.18
Albumin (g/dL)	4.06 ± 0.06	4.18 ± 0.08	4.20 ± 0.10	4.22 ± 0.12
Creatinine (mg/dL)	0.96 ± 0.00	0.93 ± 0.00	0.90 ± 0.00	0.92 ± 0.00
Cholesterol (mg/dL)	151.2 ± 13.88^{a}	143.1 ± 13.92^{b}	141.8 ± 14.02^{b}	140.1± 14.0^{b}
Triglycerides (mg/dL)	97.06 ± 4.88	95.22 ± 3.10	96.31 ± 3.80	96.02 ± 4.71
AST (U/L)	123.5 ± 39.60	123.7 ± 39.00	123.1 ± 38.86	123.0 ± 39.00
ALP (U/L)	38.88 ± 6.33	37.06 ± 5.72	37.96 ± 6.07	38.00 ± 6.18

^{a,b} Means with different superscripts along the row are significantly (*P*<0.05) different; SEM: standard error of the mean; T1: standard feed with no papaya essential oils; T2: standard feed plus 100 mg/kg *Carica papaya* essential oil; T3: standard feed plus 200 mg/kg *Carica papaya* essential oil; T4: standard feed plus 300 mg/kg *Carica papaya* essential oil

(*P*>0.05) by the treatments except for cholesterol levels, which were higher (*P*<0.05) in diet 1 than in other groups. In the finisher phase, total protein, globulin, albumin, creatinine, triglycerides, alanine transaminase, ALP and cholesterol levels ranged from 7.08 - 7.28 g/dL, 3.02 - 3.10 g/dL, 4.06 - 4.22 g/dL, 0.90 - 0.96 mg/dL, 140.1 - 151.2 mg/dL, 95.22 - 97.06 mg/dL, 37.06 - 38.88 (U/L) 123.0 - 123.5 (U/L) and 140.1 - 151.2 mg/dL, respectively. Tp, Glo, Alb, Crt, triglycerides, ALP and AST values were significantly (*P*>0.05) different among the group. Conversely, cholesterol levels were affected by the dietary supplementation of *Carica papaya* essential oil (*P*<0.05).

Discussion

Blood parameters are used to determine an animal's health state [27]. In this experiment, hematological parameters determined in both starter and finisher phase were within the established ranges for healthy birds [28, 29], indicating the absence of inflammation, infection, malnutrition, and deterioration in animal physiology. Normal PCV, Hb and RBC levels suggest that the birds were not anemic giving room for an efficient supply of oxygen and nutrient utilization [30, 31]. Essential oils are reported to promote growth performance and blood indices of birds [32, 33]. This study shows that the presence of limonene and α-pinene, which are the most prominent bioactive compounds in *Carica papaya* essential oil did not have any deleterious effect on the system of birds and is also within the tolerable level to enhance their regular overall health [34]. Hemoglobin is responsible for the movement of oxygen from the lungs to the tissues and for conveying carbon dioxide from tissues back to the lungs [35]. White blood cell count was within the optimum ranges for birds [36]. A low RBC rate may indicate bone marrow damage, hemorrhagic infections, vitamin B12 deficiency, metabolic disorders, chronic inflammation, iron deficiency, gastro-intestinal infections amongst others [37]. WBCs are cells of the immune system that are involved in protecting the body against both infectious diseases and pathogens [32]. Neutrophils are involved in the destruction of bacteria and release chemicals that kill or inhibit the growth of pathogens [38]. Monocytes change into macrophages in the tissues where they clean up cells by phagocytosis [39, 40]. Basophils defend the body from allergens, pathogens and parasites [41, 42]. It also releases histamine and herpatin to improve blood flow and prevent blood clots [43]. Lymphocytes are saddled with the production of antibodies to prevent diseases [44, 45].

The results on serum indices in both starter and finishers phases revealed that readings were within the normal range for healthy chickens reported by [46]. Total protein measurements can reflect nutritional status, kidney and liver disease, or any other health condition [47, 48]. The outcome of this experiment suggests that the nutritional requirements of the experimental birds were met and the supplementation of *Carica papaya* essential oil was within the permissible range for birds. Albumin is synthesized in the liver, carries substances (hormones, vitamins and enzymes) throughout the body and maintains oncotic pressure in the blood [49, 50]. Low albumin levels in the serum might be a result of inflammations, infections, or liver diseases [51, 52]. Globulins give an insight into the nutritional status and immune function of birds [53, 54]. Creatinine is a waste product from the normal breakdown of muscle tissues [55]. High levels of creatinine in the blood suggest renal failure [36]. AST can be found in the liver, brain, pancreas, heart, kidneys, lungs and skeletal muscles of animals [29, 31]. Very elevated AST levels can indicate hepatitis, cirrhosis, heart problems, pancreatitis, or toxicity [44, 52]. ALP is an enzyme found throughout the body but it is mostly found in the liver, bones, kidney and digestive systems [36, 55]. Elevated ALP levels suggest an obstruction of the liver and blockage of bile ducts while low levels indicate malnutrition, magnesium and zinc deficiency [56, 57]. Cholesterol levels were higher in diet 1 relative to the other treatments, this suggests that *Carica papaya* essential oil can avert the dangers of excessive fats in the meat of birds, modulating the fatty acid profile as well as improving the shelf life of products, this will prevent cardiovascular diseases and promote food safety among consumers.

Conclusions

In conclusion, *Carica papaya* essential oils contain several bioactive compounds with pharmacological benefits, such as hepato-protective, antioxidant, antibacterial, antifungal, antimicrobial, anti-inflammatory, immuno-stimulatory, hepato-protective and antioxidant properties amongst others. It can be supplemented up to 300 mg/kg in the diets of broilers without compromising their body physiology and health status.

Conflict of interest

The authors declare no conflict of interest.

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