



Impact of dietary supplementation of *Carica papaya* essential oil on the blood chemistry of broiler chickens

Alagbe John Olujimi^{a*}, Daniel Nnadozie Anorue^b, Shittu Muritala Daniel^c, Emiola I.A^d

- a. Department of Animal Nutrition and Biochemistry, Sumitra Research Institute, Gujarat, India
- b. Department of Animal Science, University of Abuja, Nigeria
- c. Department of Animal Production and Health, Ladoko Akintola University of Technology, Ogbomosho, Oyo State, Nigeria.
- d. Department of Animal Biotechnology, Ladoko Akintola University of Technology, Ogbomosho, Oyo State, Nigeria.

Abstract: This study was designed to investigate how adding *Carica papaya* essential oil to the feed affects the blood chemistry of broiler chickens. An 8-week trial, involving 400 one-day-old mixed-sex Ross 307 chicks, was designed. The chicks were divided into 4 groups, each of which contained 100 birds, and 5 replicates, each containing 20 birds. Treatments T1, T2, T3, and T4 received a basal diet with 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 fed to chicks. The results demonstrated that the therapies had no discernible ($P>0.05$) effect on white blood cells, hemoglobin, red blood cells, or packed cell volume, lymphocytes, monocytes, eosinophils, and neutrophils values in the start and end phases. *Carica papaya* essential oil had no discernible effect ($P>0.05$) on the levels of total protein, albumin, globulin, creatinine, aspartate transaminase, or alanine phosphatase, except cholesterol levels, which were greater ($P<0.05$) in T1 than in other treatments in both the start and end phases. All findings, however, fall within the ideal ranges for healthy birds, indicating no signs of infection, inflammation, or metabolic disease. It is concluded that *Carica papaya* essential oil has several bioactive components with therapeutic value and can be used up to 300 mg/kg per kilogram of birds without having any negative effects on the birds' blood profiles.

Keywords: *Carica papaya*, essential oil, hematology, serum, broilers, food safety.

1. Introduction

There is increasing legislative pressure, according to [Kritas and Morrison \(2004\)](#), to phase out the routine use of relatively tiny doses of antibiotics in animal feed. The European Union already prohibited the use of antibiotic growth promoters as of January 2006 due to concerns regarding the possible spread of antibiotic resistance to human illnesses, drug residues in food-grade animal products, and the environment ([Adewale et al., 2021](#)). 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 ([Singh et al., 2021](#)).

Using essential oils, especially those from *Carica papaya*, is one option for antibiotic alternatives. According to [Kaur et al. \(2019\)](#) and [Aruoma et al. \(2006\)](#), the papaya (*Carica papaya* Linn) is a dicotyledonous, flowering plant that is a member of the Caricaceae family. Tropical America is the plant's original habitat, but it has since expanded to other parts of the world ([Alagbe, 2021a](#); [Miranda-Osorio et al., 2016](#)). The secondary metabolites found in papaya oils are many and have a variety of functions, including antibacterial, antioxidant, anti-inflammatory, anti-protozoal, and immune-modulatory ([Agubosi & James, 2022](#); [Owoyele et al., 2008](#); [Sharma et al., 2022](#)). Additionally, it contains a lot of oleic acid and triacylglycerols, which are beneficial for animal health ([Aravind et al., 2013](#); [Saliassi et al., 2018](#)). The leaves, roots, stem bark, seeds, and other parts of the plant have been utilized in the past to treat a range of illnesses, including malaria, typhoid, gastrointestinal issues, and sexually transmitted diseases ([García-Solís et al., 2009](#); [Hadi et al., 2022](#)).

[Received] 03 Oct 2023; Accepted 07 Dec 2023; Published (online) 10 Dec 2023]

Finesse Publishing stays neutral about jurisdictional claims published maps



Attribution 4.0 International (CC BY 4.0)

Corresponding email: dralagbe@outlook.com (Alagbe, J.O)

DOI: [10.61363/meqmwj94](https://doi.org/10.61363/meqmwj94)

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 ([Oluwafemi et al., 2021](#); [Puangsri et al., 2005](#)). According to in vitro research by [Nayak et al. \(2012\)](#), papaya essential oils can also suppress the growth of Gram-positive and Gram-negative bacteria. According to [Somanah et al. \(2016\)](#), papaya seeds include arginine, histidine, isoleucine, leucine, threonine, proline, and valine among other amino acids.

Previous studies demonstrated that essential oils have a wide range of possible advantages, all of which aim to improve livestock performance ([Alagbe, 2022](#)). However, nothing is known about how papaya seed essentially 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 birds' health. Therefore, this study was designed to investigate how adding *Carica papaya* to the diet affected the blood chemistry of broiler chickens.

2. Materials and Methods

2.1. Experimental location, ethical consent, and extraction of *Carica papaya* essential oil

The study was conducted at the Sumitra Institute's Livestock Unit. The research was conducted according to 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 a fine powder to reduce their surface area. The 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. 200 grams of pulverized papaya seeds were soaked in the round-bottom flask (RBF) with 500 mL of 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 the boiling point. Water vapor produced passes through the condenser to the separatory funnel, where a layer of water and oil is formed. The tube was gradually released, and the essential oil was collected in a beaker.

2.2. Experimental birds' management, diet, and design

For the experiment, 400 mixed-sex Ross 307 broiler chicks at one day old were purchased from a hatchery in India and split up into four groups (5 repetitions, each with 20 birds), using a random design. Chicks were kept in semi-closed pens in a battery cage that measured (150cm, 90cm, 80cm) (length, breadth, 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.

3. Experimental set-up

These were the experimental groups:

An essential oil-free standard feed control group: Group 1

Supplemental group for *Carica papaya* oil: 100 milligrams, 200 milligrams, and 300 mg per kilogram of basic feed in groups 2, 3, and 4, respectively.

3.1. 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), mass range (10 to 1.050 m/z), dynamic range (106), scanning speed (up to 6,250 u/s), mass axis stability, electric current (100 to 300 eV), filament (EI double filament), ion temperature (106 to 350 °C) and uncoated proprietary inert collision energy source (60 eV).), detector (triaxial HED-EM with lifetime EM and dynamic scaling aperture), collision cell (linear six-pole), collision cell fuel (nitrogen and helium quenching gases to reduce metastable helium), mass gap (10 to 1,050 m/z), dynamic range (106), scan rate (up to 6,250 u/s), mass axis stability, electron energy (100 to 300 eV), filament (EI double filament), ion temperature (106 to 350 °C), uncoated specific inert collision energy (selectable up to 60eV), detector (triaxial HED-EM with lifetime EM and dynamic zoom aperture), collision cell (linear six-pole), collision cell gas (nitrogen and helium quenching gas is used to reduce metastable helium),



3.2. Blood collection

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). White blood cell, packed cell volume, hemoglobin, and red blood cell parameters were extracted using the electrical resistance approach. Serum biochemical analyses were carried out using a Pictus 700 automatic analyzer (model F1209-06A, Hungary) with the following technical specifications: photometric module, measuring module (25 μ L flow cell volume), 15 mm square cuvette, Minimum aspiration volume: 200 μ L, and analysis mode.

3.3. 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. The operating temperature range (6 $^{\circ}$ C to 41 $^{\circ}$ C), wavelength range (900–1700 rpm), and wavelength accuracy (0.05 nm) are the equipment's technical details.

4. Statistical analysis

The General Linear Model technique of Application of Methodology to the Social Sciences (23rd Edition) to do a one-way analysis of variance on statistical data gathered on blood profile. Significant variations were observed at ($P < 0.05$).

Table 1: Ingredients and gross composition of the trial diet (% DM)

Ingredients	Starting diet (0- 28d)	Growing 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		
C.P	23.11	19.73
C.F	4.23	5.13
E.E	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 (%)		
C.P	23.48	21.90
C.F	4.00	4.40
E.E	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; C.P: ham protein; C.F: ham life; Ca: calcium; P: phosphorus.

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

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 -terpinol acetate (3.06 %), carvone (2.75 %), and γ -terpene (2.07 %). While geranyl acetate, benzyl acetate, 2-methyl propyl acetate, oxacyclohexadec-2-one, cis-methyl dihydro jasmonate, n-hexyl salicylate, and geraniol values are: 1.41 %, 1.22 %, 0.96 %, 0.86 %, 1.33 %, 0.96 %, and 1.04 %, respectively. Limonene, α -pinene, α -terpineol, myrcene, linalool, α -terpinyl acetate, carvone, and γ -terpene are groups of terpenoids with a variety range of pharmacological benefits, such as anti-inflammatory, anti-fungal, anti-bacterial, antioxidant, muscle relaxant, sedative, and immune-modulatory roles (Ghosh et al., 2018; Mohammad Abu et al., 2010). They are also responsible for the scent and flavor profiles of *Carica papaya* essential oil and provide therapeutic benefits to the animal's body (Huang et al., 2012). Geranyl acetate, benzyl acetate, 2-methyl propyl acetate, oxacyclohexadec-2-one, cis-methyl dihydro jasmonate, n-hexyl salicylate, geraniol, and veloutone are groups of esters. They are known to have a pleasant, fruity aroma and may be used as artificial flavors (Kumar et al., 2010). Esters contain anti-fibrotic, gastro-protective, anti-diabetic, cardio-protective, antioxidant, immune-stimulatory, and anti-inflammatory properties (Olujimi et al., 2022).

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

Compounds	Retention Time (minutes)	Percentage concentration	Molecular weight (gram/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 ₉ H 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

4.2. Hematological results of broiler chicks fed diets supplemented with *Carica papaya* essential oil (0-56 d)

Hematological results of broiler chicks fed with *Carica papaya* essential oil (0-28 d) and (29-56 d) have been presented in Tables 3 and 4, respectively. In the starting phase, pack hemoglobin, lymphocytes, monocytes, red blood cells, white blood cells, and cell volume, 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. In the end 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 ($P>0.05$).

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.

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
Haemoglobin (g/dL)	10.50 ± 0.60	10.67 ± 0.65	10.60 ± 0.67	10.65 ± 0.60
Red blood cell (×10 ¹² /L)	3.11 ± 0.32	3.10 ± 0.29	3.11 ± 0.32	3.11 ± 0.32
White blood cell (×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.

4.3. Serum biochemical results of broilers fed diets supplemented with *Carica papaya* essential oil (0-56 days)

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 Tables 4 and 5, 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 ($P>0.05$) by the treatments except for higher cholesterol levels ($P<0.05$) 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 among the group ($P>0.05$). Conversely, cholesterol levels were affected by the dietary supplementation of *Carica papaya* essential oil ($P<0.05$).

Table 4: 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

beans with different superscripts along a 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.

Table 5: 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

beans with different superscripts along a 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.

5. Discussion

Blood parameters are used to determine an animal's health state ([Livingston et al., 2019](#)). In this experiment, hematological parameters determined in both the start and end phases were within the established ranges for healthy birds ([Joshua et al., 2022](#); [Livingston et al., 2019](#)), indicating the absence of inflammation, infection, malnutrition, and deterioration in animal physiology. Normal PCV, Hb, and RBC levels suggested that the birds were not anemic, allowing for an efficient supply of oxygen and nutrient utilization ([Adewale et al., 2021](#); [Alagbe et al., 2023](#)). Essential oils are reported to promote growth performance and blood indices of birds ([Oluwafemi et al., 2021](#); [Shittu et al., 2022](#)). This study showed that the presence of limonene and α -pinene, the most prominent bioactive compounds in *Carica papaya* essential oil, did not negatively affect the system in any way for birds and were also within the tolerable level to enhance their overall health ([Olafadehan et al., 2020b](#)). Haemoglobin is responsible for the movement of carbon dioxide from the tissues to the lungs, and oxygen returns from the lungs to the tissues ([Livingston et al., 2019](#)). According to [Bílková et al. \(2017\)](#), states that white blood count is at a good level in birds. A low RBC rate may indicate bone marrow damage, hemorrhagic infections, vitamin B12 deficiency, metabolic disorders, chronic inflammation, iron deficiency, and gastrointestinal infections, amongst others ([Alagbe, 2022](#)).

WBCs are cells of the immune system that are involved in protecting the body against both infectious diseases and pathogens ([Livingston et al., 2019](#)). Neutrophils are involved in the destruction of bacteria and release chemicals that kill or inhibit the growth of pathogens ([Alagbe, 2021a](#)). Monocytes change into macrophages in



the tissues, where it cleans up cells by phagocytosis ([Obikaonu et al., 2012](#); [Zomrawi et al., 2012](#)). Basophils defend the body from allergens, pathogens, and parasites ([Adeyemi et al., 2000](#); [Alagbe et al., 2023](#)). It also releases histamine and heparin to improve blood flow and prevent blood clots ([Steel & Torrie, 1981](#)). Lymphocytes are saddled with the production of antibodies to prevent diseases ([Sobayo et al., 2013](#); [Thrall, 2007](#)).

The results on serum indices in both the starting and growing phases revealed that findings were within the normal range for healthy chickens reported by Jain (1993). Total protein measurements can reflect nutritional status, kidney and liver disease, or any other health condition ([Alagbe, 2021b](#); [Bounous & Stedman, 2000](#)). 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 ([Banerjee, 1998](#)). Low albumin levels in the serum might be a result of inflammation, infection, or liver diseases ([Café et al., 2012](#); [Nworgu et al., 2007](#)). Globulins give an insight into the nutritional status and immune function of birds ([Islam et al., 2004](#); [Jain, 1986](#)). Creatinine is a waste product from the normal breakdown of muscle tissues ([Alagbe, 2021b](#)). High levels of creatinine in the blood suggest renal failure. AST can be found in the liver, brain, pancreas, heart, kidneys, lungs, and skeletal muscles of animals ([Olafadehan et al., 2020a](#)). Extremely high AST levels may be a sign of cardiac issues, cirrhosis, hepatitis, pancreatitis, or toxicity ([Oluwafemi et al., 2021](#)). ALP is an enzyme found throughout the body, but it is mostly found in the liver, bones, kidneys, and digestive systems ([Shittu et al., 2022](#)). Elevated ALP levels suggest an obstruction of the liver and blockage of the bile ducts, while low levels indicate malnutrition, magnesium, and zinc deficiency ([Alagbe, 2021b](#)). 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.

6. Conclusion

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

CRedit authorship contribution statement

Alagbe John Olujimi, Daniel Nnadozie Anorue, Experiment and analyze data, Shittu Muritala Daniel, Emiola I.A, Data analysis, writing-original draft, editing, proofreading.

Funding

This work was not financially supported by any funding agency.

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgments

The author(s) acknowledge that they did not receive any financial support from any funding agency, whether public, private, or non-profit. The study was conducted independently without external funding.

References

- Adewale, A., Alagbe, J., & Adeoye, A. O. (2021). Dietary supplementation of Rauvolfia vomitoria root extract as a phyto-genic feed additive in growing rabbit diets: Haematology and serum biochemical indices. *International Journal of Orange Technologies*, 3(3), 1-12.
- Adeyemi, O., Fasina, O., & Balogun, M. (2000). Utilization of full-fat Jatropha seed in broiler diet: effect on haematological parameters and blood chemistry. Proc. 25th Annual Conference Nig Soc Anim. Prod (NSAP),

- Agubosi, O., & James, A. (2022). Influence of dietary inclusion of Sunflower (*Helianthus annuus*) oil on growth performance and oxidative status of broiler chicks. *Central Asian Journal of Medical and Natural Science*, 3(1), 187-195.
- Alagbe, J. (2021a). Dietary supplementation of rauwolfia vomitoria root extract as a phyto-genic feed additive in growing rabbit diets: growth performance and caecal microbial population. *Concept in Dairy and Veterinary Sciences*, 4(2), 2021.
- Alagbe, J. (2021b). *Prosopis africana* stem bark as an alternative to antibiotic feed additives in broiler chicks diets: Performance and carcass characteristics. *Journal of Multidimensional Research and Reviews*, 2(1), 64-77.
- Alagbe, J. (2022). Use of medicinal plants as a panacea to poultry production and food security: A review. *Gospodarka I Innowacje*, 22(2022), 1-12.
- Alagbe, J. O., Agubosi, O. C., & Oluwafemi, R. A. (2023). Histopathology of broiler chickens fed diets supplemented with *Prosopis africana* (African mesquite) essential oil. *Brazilian Journal of Science*, 2(9), 49-59.
- Aravind, G., Bhowmik, D., Duraivel, S., & Harish, G. (2013). Traditional and medicinal uses of *Carica papaya*. *Journal of medicinal plants studies*, 1(1), 7-15.
- Aruoma, O. I., Colognato, R., Fontana, I., Gartlon, J., Migliore, L., Koike, K., Coecke, S., Lamy, E., Mersch-Sundermann, V., & Laurenza, I. (2006). Molecular effects of fermented papaya preparation on oxidative damage, MAP Kinase activation and modulation of the benzo [a] pyrene mediated genotoxicity. *Biofactors*, 26(2), 147-159.
- Banerjee, G. (1998). A Textbook of Animal Husbandry, 8thEdn. *Kalyani Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India*, 40.
- Bounous, D., & Stedman, N. (2000). Normal avian hematology: chicken and turkey. *Schalm's veterinary hematology*, 1147-1154.
- Café, M. B., Rinaldi, F. P., Morais, H. R., Nascimento, M., Mundim, A. V., & Marchini, C. F. P. (2012). Biochemical blood parameters of broilers at different ages under thermoneutral environment. *Worlds Poultry Science Journal*, 5(9), 143-146.
- García-Solís, P., Yahia, E. M., Morales-Tlalpan, V., & Díaz-Muñoz, M. (2009). Screening of antiproliferative effect of aqueous extracts of plant foods consumed in Mexico on the breast cancer cell line MCF-7. *International journal of food sciences and nutrition*, 60(sup6), 32-46.
- Ghosh, P., Das, P., Das, C., Mahapatra, S., & Chatterjee, S. (2018). Morphological characteristics and Phyto-pharmacological detailing of *Hatishur* (*Heliotropium indicum* Linn.): A concise review. *Journal of Pharmacognosy and Phytochemistry*, 7(5), 1900-1907.
- Hadi, A., Singh, S., Ali, S., & Mehdi, M. (2022). Traditional uses of medicinal plants by indigenous tribes of Ladakh union territory. *Res J Agril Sci*, 13, 68-77.
- Huang, L., Chen, S., & Yang, M. (2012). *Euphorbia hirta* (Feiyangcao): A review on its ethnopharmacology, phytochemistry and pharmacology. *Journal of Medicinal Plants Research*, 6(39), 5176-5185.
- Islam, M., Lucky, N., Islam, M., Ahad, A., Das, B., Rahman, M., & Siddiui, M. (2004). Haematological parameters of Fayoumi, Assil and local chickens reared in Sylhet region in Bangladesh. *Int. J. Poult. Sci*, 3(2), 144-147.
- Jain, N. C. (1986). *Schalm's veterinary hematology*.
- Joshua, B. I., Luka, H. S., Elisha, I. L., Nyam, L. S., Suleiman, I., Gambo, R. A., Audu, S., Saidu, A. J., Dominic, U. A., & Dorcas, B. (2022). Haematological and serum biochemical parameters of broilers slaughtered at Bukuru live bird market of Jos South Local Government Plateau State Nigeria. *Acta Scientific Veterinary Sciences (ISSN: 2582-3183)*, 4(6).
- Kaur, M., Talniya, N. C., Sahrawat, S., Kumar, A., & Stashenko, E. E. (2019). Ethnomedicinal uses, phytochemistry and pharmacology of *Carica papaya* plant: A compendious review. *Mini-Reviews in Organic Chemistry*, 16(5), 463-480.
- Kritas, S., & Morrison, R. (2004). Can probiotics substitute for subtherapeutic antibiotics? A field evaluation in a large pig nursery. Proceedings of the 18th IPVS Congress; Hamburg, Germany,
- Kumar, S., Malhotra, R., & Kumar, D. (2010). *Euphorbia hirta*: Its chemistry, traditional and medicinal uses, and pharmacological activities. *Pharmacognosy reviews*, 4(7), 58.
- Livingston, M. L., Landon, C., Barnes, H., & Brake, J. (2019). White striping and wooden breast myopathies of broiler breast muscle is affected by time-limited feeding, genetic background, and egg storage. *Poultry Science*, 98(1), 217-226.



- Miranda-Osorio, P. H., Castell-Rodríguez, A. E., Vargas-Mancilla, J., Tovilla-Zárate, C. A., Ble-Castillo, J. L., Aguilar-Domínguez, D. E., Juárez-Rojop, I. E., & Díaz-Zagoya, J. C. (2016). Protective action of *Carica papaya* on β -cells in streptozotocin-induced diabetic rats. *International Journal of Environmental Research and Public Health*, 13(5), 446.
- Mohammad Abu, B., Zakaria Zuraini, Z. Z., Sreenivasan Sasidharan, S. S., Lachimanan Yoga Latha, L. Y. L., & Santhanam Amutha, S. A. (2010). Assessment of *Euphorbia hirta* L. leaf, flower, stem and root extracts for their antibacterial and antifungal activity and brine shrimp lethality.
- Nayak, B. S., Ramdeen, R., Adogwa, A., Ramsubhag, A., & Marshall, J. R. (2012). Wound-healing potential of an ethanol extract of *Carica papaya* (Caricaceae) seeds. *International Wound Journal*, 9(6), 650-655.
- Nworgu, F., Ogungbenro, S., & Solesi, K. (2007). Performance and some blood chemistry indices of broiler chicken served fluted pumpkin (*Telfaria occidentalis*) leaves extract supplement.
- Obikaonu, H., Okoli, I., Opara, M., Okoro, V., Ogbuwu, I., Etuk, E., & Udedibie, A. (2012). Haematological and serum biochemical indices of starter broilers fed leaf meal of neem (*Azadirachta indica*).
- Olafadehan, O., Oluwafemi, R., & Alagbe, J. (2020a). Carcass quality, nutrient retention and caeca microbial population of broiler chicks administered Rolfe (*Daniellia oliveri*) leaf extract as an antibiotic alternative. *Journal of Drug Discovery*, 14(33), 146-154.
- Olafadehan, O., Oluwafemi, R., & Alagbe, J. (2020b). Performance, haemato-biochemical parameters of broiler chicks administered Rolfe (*Daniellia oliveri*) leaf extract as an antibiotic alternative. *Drug Discovery*, 14(33), 135-145.
- Olujimi, A. J., Mohammad, R. S., Daniel, S. M., & Christiana, O. O. (2022). Effect of *Trichilia monadelpha* stem bark extract on the fatty acid composition of rabbit's thigh meat. *Journal of Environmental Issues and Climate Change*, 1(1), 61-68.
- Oluwafemi, R., Uankhoba, I., & Alagbe, J. (2021). Effects of turmeric oil as a dietary supplements on the growth performance and carcass characteristics of broiler chickens. *International Journal on Orange Technologies*, 3(4), 54-62.
- Owoyele, B. V., Adebukola, O. M., Funmilayo, A. A., & Soladoye, A. O. (2008). Anti-inflammatory activities of ethanolic extract of *Carica papaya* leaves. *Inflammopharmacology*, 16(4), 168-173.
- Puangstri, T., Abdulkarim, S., & Ghazali, H. (2005). Properties of *Carica papaya* L.(papaya) seed oil following extractions using solvent and aqueous enzymatic methods. *Journal of Food Lipids*, 12(1), 62-76.
- Saliasi, I., Llodra, J. C., Bravo, M., Tramini, P., Dussart, C., Viennot, S., & Carrouel, F. (2018). Effect of a toothpaste/mouthwash containing *Carica papaya* leaf extract on interdental gingival bleeding: A randomized controlled trial. *International Journal of Environmental Research and Public Health*, 15(12), 2660.
- Sharma, S., John, A. O., Xing, L., Ram, S., & Amita, K. (2022). Comparative analysis of ethanolic *Juniperus thurifera* leaf, stem bark and root extract using gas chromatography and mass spectroemetry. *International Journal of Agriculture and Animal Production*, 2(6), 18-27.
- Shittu, M., Alagbe, J. O., Ojebiyi, O. O., Ojediran, T. K., & Rafiu, T. A. (2022). Growth performance and haematological and serum biochemical parameters of broiler chickens given varied concentrations of *Polyalthia longifolia* leaf extract in place of conventional antibiotics. *Animal Science and Genetics*, 18(2).
- Singh, A., Alagbe, J., Sharma, S., Oluwafemi, R., & Agubosi, O. (2021). Effect of dietary supplementation of melon (*Citrullus lanatus*) seed oil on the growth performance and antioxidant status of growing rabbits. *Indonesian Journal of Innovation and Applied Sciences (IJIAS)*, 1(2), 134-143.
- Sobayo, R., Adeyemi, O., Oso, A., Fafiolu, A., Daramola, J., Sodipe, G., Ogunade, I., & Odetola, O. (2013). Haematological, serum and carcass characteristics of broiler chicken fed graded levels of *Garcinia kola* (Bitter kola) used as phytobiotic. *Nigerian Journal of Animal Production*, 40(1), 48-56.
- Somanah, J., Ramsaha, S., Verma, S., Kumar, A., Sharma, P., Singh, R. K., Aruoma, O. I., Bourdon, E., & Baborun, T. (2016). Fermented papaya preparation modulates the progression of N-methyl-N-nitrosourea induced hepatocellular carcinoma in Balb/c mice. *Life Sciences*, 151, 330-338.
- Steel, R. G. D., & Torrie, J. H. (1981). *Principles and procedures of statistics, a biometrical approach*.
- Thrall, M. A. (2007). *Hematologia e bioquímica clínica veterinária*. Editora Roca.
- Zomrawi, W., Atti, K. A., Dousa, B., & Mahala, A. (2012). The effect of ginger root powder (*Zingiber officinale*) supplementation on broiler chicks performance, blood and serum constituents.