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Effect of dietary supplementation of essential oils on hematological and biochemical parameters of Narmadanidhi birds

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Abstract
The current study was conducted to investigate the hematological and biochemical parameters of Narmadanidhi birds supplemented with thyme oil, cinnamon oil, and clove oil at dosage rates of 150 and 300 ppm of the basal diet. A total of 210 day old Narmadanidhi chicks were divided into 7 groups (T_1, T_2, T_3, T_4, T_5, T_6 and T_7) with 6 replicates of 5 chicks in each for a 98-day feeding trial. The haematological parameters (Hb, TEC, TLC and PCV) and biochemical parameters (glucose, cholesterol, total protein, albumin, globulin, SGPT and SGOT) were analyzed. The haematological parameters like Hb and TEC were significantly (p<0.05) changed in treatment groups whereas no significant (p<0.05) change observed in TLC and PCV. The biochemical parameter like glucose, cholesterol, total protein, albumin, globulin, SGOT and SGPT were found significantly (p<0.05) changed in treatment groups. Based on the results of this study, it could be concluded that essential oils at a level 150 and 300 ppm of basal diet no detrimental impact on hematological and biochemical parameters of Kadaknath birds.

Keywords: Narmadanidhi, thyme oil, cinnamon oil, clove oil, haematological and biochemical parameters

Introduction
The European Union has prohibited the use of antibiotics as growth promoters for livestock species since 2006 (Castanon, 2007) [1]. In December 2016, the US Food and Drug Administration (FDA) imposed restrictions on the use of growth promoters and antibiotics in animal diets. Following the removal of antibiotic growth promoters, the poultry industry has had to deal with rising mortality and culling (Zhao *et al*., 2007) [2]. Therefore, in order to ensure the sustainability of poultry farming, the cost of possible substitutes for antimicrobial growth promoters are essential (Yang *et al*., 2018) [3]. Consequently, essential oils (Attia *et al*., 2017) [4] and medium-chain fatty acids (Boyen *et al*., 2008) [5] have been proposed as alternatives to antibiotics and growth promoters.

Essential oils are oily, volatile, or aromatic liquids extracted from flowers, seeds, herbs, leaves, fruits, roots, and bark (Brenes and Roura, 2010) [6]. Essential oils, as widely reported in the literature, increase body weight gain (Yang *et al*., 2018) [3], feed intake (Valiollahi *et al*., 2014) [7], feed conversion ratio (Yang *et al*., 2018) [3], nutrient digestibility and absorption (Boyen *et al*., 2008) [5], dressing percentage (Mahmoodi *et al*., 2014) [8], serum cholesterol and abdominal fat (Mukhtar *et al*., 2013) [9].

Essential oils' positive effects have been linked to antioxidant (Silva *et al*., 2012) [10], antibacterial (Du *et al*., 2016) [11], and immunological activities (Hosseini *et al*., 2016) [12]. Furthermore, essential oils promote gut ecology and imitate digestive enzyme activity (Jang *et al*., 2007) [13]. The Thyme oil, Cinnamon oil and Clove oil, for example, have showed promise in improving poultry performance, gut environment, and immunity (Attia *et al*., 2017) [4].

The advancement of the feed additive business and the manufacture of encapsulated, heat-stable essential oils can preserve them from oxidative degradation and increase their overall quality (Attia *et al.*, 2017) [4]. Digestibility and metabolic profiles indicate how animals respond to feed additives (Mokhtari *et al.*, 2018) [14]. In this regard, we evaluated the replacement of antibiotics with essential oils as broiler growth enhancers in terms of haematological and biochemical parameters.

Materials and Methods

Place of the experiment

The present study was conducted on Kadaknath chickens at the Department of Livestock Production Management, College of Veterinary Science & Animal Husbandry, Rewa (M.P.). Kadaknath birds were raised for a total of 98 days. The location is at latitude 24ºN, longitude 81ºE, and elevation 450 above mean sea level. It is within India's Eastern Plateau and Hills Agro-climatic Zone. The climate of the area is tropical, with an average annual rainfall of 1128mm. Temperatures can reach 45ºC in summer and as low as 4ºC in winter. The soil is a mix of red and black, with a homogeneous topography.

Management of birds

All birds were maintained in deep litter system under isomanagerial conditions. Readymade broiler feed purchased from market was offered to birds during research period. The birds were routinely vaccinated against Marek's Disease (MD), Gumboro (IBD) and Newcastle Disease (ND) etc.

Ethical approval

The birds were handled humanely throughout the study, and the experimental design and protocol for using the birds in research were approved by the Institutional Ethical Committee.

Ration

The birds were fed on formulated broiler rations until the end of the experiment. The diet was formulated to meet the nutritional requirements as recommended by the NRC. Thyme oil, cinnamon oil, and clove oil were purchased locally in Jabalpur, Madhya Pradesh, India.

Experimental birds

A total of 210 day old Kadaknath chicks were divided into 7 experimental groups (one control and six treatments groups) with 6 replicates of 5 chicks in each for a 98-day feeding trial (from 1 to 98 day of age).

Experimental design

T_1 = Control group: Birds were fed with standard broiler ration as basal diet
T_2 = Basal diet + Thyme Oil @ 150 ppm
T_3 = Basal diet + Thyme Oil @ 300 ppm
T_4 = Basal diet + Cinnamon Oil @150 ppm
T_5 = Basal diet + Cinnamon Oil @ 300 ppm
T_6 = Basal diet + Clove Oil @ 150 ppm
T_7 = Basal diet + Clove Oil @ 300 ppm

Blood sampling

Blood samples (2.0 ml/bird) were collected at the end of experiment to estimate haematological parameters: Haemoglobin, Total Erythrocyte Count (TEC), Total Leukocyte count (TLC), Packed cell volume (PCV). Serum was separated at 2000 rpm for 15 minutes to estimate the biochemical parameters (Glucose, Serum protein, Serum globulin, Serum albumin, Cholesterol, SGPT and SGOT) using standard kit.

Haematological and biochemical studies

Estimations of hematological parameters were done by standard procedures described by Jain (1986) [15]. The serum biochemical parameters like Serum glucose, total sprotein, albumin, Cholesterol, Alanine aminotransferase (ALT) or Serum glutamic pyruvic transaminase (SGPT) and Aspartate aminotransferase (AST) or Serum glutamic oxaloacetic transaminase (SGOT) were analysed on autoanalyzer using commercially available standard kits (Erba).

Statistical analysis

All data pertain to various haematological and biochemical parameters were analyzed statistically by running ANOVAs using SPSS 20 software. Significant mean differences between the treatments were determined at a 5% significance level ($p<0.05$) using Duncan's Multiple Range Test (Duncan, 1955) [16]. All data have been presented as mean ± SE.

Results and Discussion

Haematology parameters of Narmadanidhi birds

The data representing the haematological parameters in terms of haemoglobin, total erythrocyte counts, packed cell volume and total leucocyte counts of Narmadanidhi birds fed diets supplemented with 150 and 300 ppm of Thyme oil, Cinnamon oil and Clove oil on 98th day of feeding trial are shown in Table 1.

Table 1: Haematogical parameters (Mean ± SE) of Narmadanidhi birds supplemented with different essential oils

Parameter	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Hb (g/dl)	8.21 ± 0.02^{bc}	8.42 ± 0.04^{cd}	8.48 ± 0.04^{cd}	8.05 ± 0.21^{b}	8.60 ± 0.07^{d}	7.40 ± 0.09^{a}	7.92 ± 0.08^{b}
TEC (million/µ)	3.75 ± 0.04^{a}	3.92 ± 0.01^{b}	3.92 ± 0.01^{b}	3.91 ± 0.02^{b}	3.92 ± 0.03^{b}	3.96 ± 0.01^{b}	3.96 ± 0.01^{b}
PCV (%)	32.50 ± 0.39^{a}	31.91 ± 0.49^{a}	31.92 ± 0.48^{a}	32.33 ± 0.35^{a}	31.58 ± 0.37^{a}	31.91 ± 0.43^{a}	31.75 ± 0.44^{a}
TLC (10^3/ µl)	25.66 ± 0.81^{a}	25.83 ± 0.98^{a}	25.81 ± 0.97^{a}	26.00 ± 0.80^{a}	27.66 ± 0.38^{a}	26.66 ± 0.85^{a}	26.33 ± 1.03^{a}

Means (±SE) bearing different superscript (a, b, c, d) differ significantly ($p<0.05$) within a row.
T_1 (control): basal diet, T_2: basal diet + Thyme oil @ 150 ppm, T_3: basal diet + Thyme oil 300 @ ppm, T_4: basal diet + Cinnamon oil @ 150 ppm, T_5: basal diet + Cinnamon oil @ 300 ppm, T_6: basal diet + Clove oil @ 150 ppm and T_7: basal diet + Clove oil @ 300 ppm

Haemoglobin

The oxygen-carrying protein in red blood cells is called hemoglobin. The blood's oxygen content is directly indicated by hemoglobin levels. Dehydration, chronic obstructive pulmonary disease, and other conditions are associated with elevated hemoglobin levels, while anemia, liver disease, and blood loss are associated with decreased hemoglobin levels. The most important factors in determining anemia and erythrocyte distribution are hemoglobin levels. A bird's general health is influenced by the quantity of red blood cells in its blood (Imaseun and Ijen, 2017) [17]. The average haemoglobin concentrations in this study were 8.21±0.02,

8.42±0.04, 8.48±0.04, 8.05±0.21, 8.60 ±0.07 7.40±0.09 and 7.92±0.08b g/dl in T_1, T_2, T_3, T_4, T_5, T_6 and T_7 groups respectively in Narmadanidhi birds. There was significantly ($p<0.05$) higher haemoglobin concentration observed in the T_1, T_2, T_3, T_4, T_5 and T_7 as compared to T_6 group.

Total erythrocyte counts

Erythrocyte/RBC transports oxygen to animal tissues for oxidation, which releases energy and removes carbon dioxide (CO_2) from the tissues. Iron is required for the synthesis of hemoglobin and myoglobin (El-bashier *et al*., 2012) [18]. The average values of total erythrocyte counts (TEC) in this study were 3.75±0.04, 3.92±0.01, 3.92±0.01b, 3.91±0.02, 3.92 ±0.03, 3.96 ±0.01 and 3.96 ±0.01 million/µl in T_1, T_2, T_3, T_4, T_5, T_6 and T_7 groups respectively in Narmadanidhi birds. There was significantly ($p<0.05$) higher total erythrocyte counts observed in the T_2, T_3, T_4, T_5, T_6 and T_7 as compared to T_1 group compared to other groups.

Packed cell volume

The packed cell volume (PCV) is a measurement of the percentage of red blood cells in your blood. PCV plays a role in the delivery of oxygen and nutrients from the bloodstream to certain cells or tissues. Low PCV levels indicate anemia, which can cause fatigue, weakness, and organ failure. High PCV levels indicate dehydration and require rapid treatment to restore fluid balance. High PCV levels could indicate polycythemia, which increases the risk of blood clots and stroke (Goodwin *et al*., 1992) [19]. The average values of PCV in this study were 32.50±0.39, 31.91±0.49, 31.92±0.48, 32.33±0.35 31.58 ±0.37, 31.91±0.43 and 31.75±0.44% in T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups respectively in Narmadanidhi birds. There was no significant ($p<0.05$) difference observed in PCV values among the T_1, T_2, T_3, T_4, T_5, T_6 and T_7 groups.

Total leucocyte counts

Leucocytes/White blood cells (WBCs), give the immune system antibodies and shield the body from outside invaders. According to Soetan and Oyewol (2009) [20], animals with high WBCs can produce antibodies and show a significant degree of disease resistance. Birds with more WBC can create antibodies during phagocytosis and show increased disease resistance, whereas birds with lower WBC are more likely to become ill (Soetan and Oyewol, 2009) [20]. The average values of total leucocyte counts (TLC) in this study were 25.66±0.81, 25.83±0.98, 25.81±0.97, 26.00±0.80, 27.66±0.38, 26.66±0.85 and 26.33±1.03x10^3/µl in T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups respectively in Narmadanidhi birds. There was no significant ($p<0.05$) difference observed in TEC values among the T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups.

Al-Kassie (2009) [21] shown that supplementing broiler meals with oil extract derived from thyme and cinnamon resulted in significantly ($p<0.05$) increased RBC, WBC, Hb, and PCV values than the control groups. Shunthwal and Sheoran (2017) [22] reported a substantial ($p<0.05$) rise in WBC counts in the 10% flaxseed group. Mushtaque *et al*. (2012) [23] reported comparable results after feeding broilers with a combination of phytogenic feed additives. Tiago *et al*. (2019) [24] supplemented eucalyptus oil with water and discovered no significant ($p<0.05$) difference in haematological measures such as total erythrocytes and hemoglobin. The Islam *et al*. (2020) [25] who observed that there was no significant ($p>0.05$) change in hematological parameters (RBC, WBC, Hb and PCV) between the treatments by supplementing Aloe vera and Amla through water. Eler *et al*. (2019) [26] detected enhanced TEC in broilers after feeding with oregano essential oil and 10% flaxseed.

Tabari *et al*. (2018) [27] reported substantial improvements in Hb, WBC, and PCV levels in broiler hens fed clove aqueous extract. The benefit could be linked to better food intake and digestion. The active component of clove oil (Ugeonol) is considered a digestion stimulating factor (Cabuk *et al*., 2003) [28], in addition to its antibacterial properties, which may have resulted in increased feed utilization efficiency. Tariq *et al*. (2014) [29] discovered that a combination of 0.5% Aloe vera (*Aloe barbadensis*), 0.5% Clove (*Syzigium aromaticum*), and 0.25% Aloe vera and 0.25% Clove had no effect on total erythrocyte count, total leukocyte count, haemoglobin concentration and packed cell volume.

Haque *et al*. (2010) [30] found that organic acid supplementation in broiler chicken diets had no significant ($p<0.05$) effect on haemoglobin concentration, TEC, TLC and PCV. Hernandez *et al*. (2006) [31] demonstrated that including organic acids in broiler chicken feeds had no influence on haemoglobin. Rathore (2013) [32] found no significant ($p<0.05$) difference in hemoglobin and PCV across treatment groups after feeding *Mentha arvensis*. Additionally, all of the values fell within the usual physiological range. Toghyani *et al*. (2010) [33] discovered no deleterious effects of thyme on TEC, TLC, hemoglobin content, hematocrit percentage.

Table 2: Biochemical parameters (Mean ± SE) of Narmadanidhi birds supplemented with different essential oils

Parameter	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Glucose (mg/dl)	161.17±0.85^a	167.52±1.05^b	167.48 ±1.05^b	162.17±0.71^a	167.74±1.27^b	166.67±1.07^b	166.39±1.17^b
Cholesterol (mg/dl)	139.69±1.13^a	154.79±0.68^c	156.79±0.68^c	148.24 ±1.93^b	152.67±2.24^{bc}	150.35±2.43^{bc}	148.91±2.73^b
Total Protein (g/dl)	4.54 ±0.04^a	4.67 ±0.04^{bc}	4.69 ±0.04^{bc}	4.61 ±0.04^{ab}	4.83 ±0.02^d	4.80 ±0.04^{cd}	4.71±0.02^{bcd}
Albumin (g/dl)	2.68 ±0.02^a	2.73 ±0.02^b	2.76 ±0.02^b	2.72±0.02^{ab}	2.85 ±0.01^d	2.83±0.02^{cd}	2.78±0.01^{bc}
Globulin (g/dl)	1.77±0.01^a	1.83±0.01^{bc}	1.84±0.01^{bc}	1.80±0.01^{ab}	1.88±0.01^d	1.87±0.01^{cd}	1.84±0.01^{bc}
SGPT (IU/L)	9.42±0.55^b	10.54±0.46^{bc}	10.72±0.56^{bc}	5.97±0.29^a	11.55±0.55^c	10.33±0.49^{bc}	10.19 ±0.42^{bc}
SGOT (IU/L)	163.26±1.62^a	169.90±2.07^{bc}	172.50±2.16^{bc}	237.53±6.77^d	184.19±2.25^c	178.69±2.45^{bc}	164.09 ±1.90^a

Means (±SE) bearing different superscript (a,b,c,d) differ significantly ($p<0.05$) within a row.

T_1 (control): basal diet, **T_2**: basal diet + Thyme oil @ 150 ppm, **T_3**: basal diet + Thyme oil 300 @ ppm, **T_4**: basal diet + Cinnamon oil @ 150 ppm, **T_5**: basal diet + Cinnamon oil @ 300 ppm, **T_6**: basal diet + Clove oil @ 150 ppm and **T_7**: basal diet + Clove oil @ 300 ppm

Biochemical parameters of Narmadanidhi birds

Serum glucose

Glucose is the principal energy source for the majority of cells in the body, including the brain and other cells. Carbohydrates are composed of glucose. Glucose levels in the blood are important because they can indicate health concerns (Lehninger *et al*., 2017) [34]. The average glucose concentrations (mg/dl) in this study were 161.17±0.85, 167.52 ±1.05, 167.48±1.05, 162.17±0.71, 167.74±1.27, 166.67±1.07 and 166.39±1.17 mg/dl in T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups respectively in Narmadanidhi birds. There was significantly ($p<0.05$) higher serum glucose concentrations observed in the T_2, T_3, T_5, T_6, and T_7 groups as compared to other T_1 and T_4 groups.

Tabari *et al*. (2018) [27] reported that broiler chicks fed with clove aqueous extract had significantly lower serum glucose levels (p<0.05) than the control group. Sabu and Kuttan (2002) [35] discovered that an aqueous extract of clove (*Eugenia caryophyllus*) exhibits antihyperglycemic properties in rats without altering basal plasma glucose levels. This effect could be related to polyphenol-rich clove extract, which increases glucose uptake by muscle cells. Mohammadi *et al*. (2014) [36] observed that dietary supplementation with clove essential oil lowers glucose levels compared to the control.
Hernandez *et al*. (2006) [31] found that food supplementation with organic acid had no significant (p<0.05) influence on serum glucose levels in broiler hens. Kalafova *et al*. (2014) [37] observed that that dietary supplementation with 0.25 percent citric acid had no significant (p<0.05) influence on blood glucose levels in broiler chickens. Rathore (2013) [32] found no significant (p<0.05) change in blood glucose concentrations in goats after fed *Mentha arvensis*. Tariq *et al*. (2014) [29] observed that aloe vera and clove supplementation had no effect on serum glucose levels. The higher blood glucose in the control group can be attributed to elevated cortisol levels in the blood caused by stress, which affects glucose metabolism and raises glucose concentration in broilers.

Serum cholesterol

Serum cholesterol levels are important because they indicate the likelihood of heart disease and stroke. High blood cholesterol levels are a substantial risk factor for heart disease. LDL and HDL cholesterol account for the entirety of the cholesterol in the blood (Charlton-Menys and Durrington, 2008) [38]. The average cholesterol concentrations (mg/dl) in this study were 139.69±1.13, 154.79±0.68, 156.79±0.68, 148.24 ±1.93, 152.67±2.24, 150.35±2.43 and 148.91±2.73 mg/dl in T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups respectively in Narmadanidhi birds. There was significantly (p<0.05) higher cholesterol concentrations observed in the T_2, T_3, T_4, T_5, T_6, and T_7 groups compared to T_1 group.
Tabari *et al*. (2018) [27] found that broiler chickens fed clove aqueous extract had a significant (p<0.05) decrease in cholesterol concentration. The main components of clove (*Eugenia caryophyllus*) essential oils that inhibit hepatic 3-hydroxy-3-methylglutaryl co-enzyme or HMG-COA reductase activity, which is a critical regulatory enzyme in cholesterol production and causes hypocholesterolemia (Shimaa, 2015) [39]. Jin and Cho (2011) [40] discovered that cold-pressed clove oil lowered blood cholesterol and tri-acylglycerol levels in a hyperlipidemic zebra fish model by 68% and 80%, respectively. Khaksar *et al*. (2012) [41] found that supplementing thyme essential oil reduced serum total cholesterol, triglycerides, and glucose in Japanese quails.
Tollba (2010) [42], who observed that the addition of organic acid and essential oil lowered plasma cholesterol and plasma lipids, and Mehr *et al*. (2014) [43], who discovered that clove oil supplementation dramatically reduced blood cholesterol levels. Lee *et al*. (2004)[44] discovered that the primary components of essential oils inhibit hepatic 3-hydroxy-3 methylglutaryl coenzyme A (HMG-COA) reductase activity, which is a key regulator of cholesterol production. As a result, essential oils are likely to lower cholesterol levels.

Serum total protein, albumin and globulin

Serum protein

The liver produces serum proteins to maintain blood volume through the colloidal osmotic effect, buffer blood pH, transport hormones and medications, aid in cell coagulation, catalyze enzymatic reactions, control hormones, and protect the body from external toxins (Mmereole, 2008) [45]. The average total protein concentrations (g/dl) in this study were 4.54±0.04, 4.67±0.04, 4.69±0.04, 4.61±0.04, 4.83±0.02, 4.80±0.04 and 4.71±0.02 g/dl in T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups respectively in Narmadanidhi birds. There were significantly (p<0.05) higher total protein concentrations observed in the all treatment T_2, T_3, T_4, T_5, T_6 and T_7 groups as compared to control T_1 group.

Serum albumin

Serum albumin is an important protein in the blood that helps to regulate plasma oncotic pressure and transports chemicals including hormones, vitamins, fatty acids, and medications throughout the body. Its significance stems from its ability to serve as a major biomarker for assessing liver function, nutritional health, and potential disease states, particularly in cases like kidney disease, where low blood albumin levels may indicate a poor prognosis and increased mortality risk (Finlayson, 1975) [46]. The average albumin concentrations (g/dl) in this study were 2.68±0.02, 2.73±0.02, 2.76 ±0.02, 2.72±0.02, 2.85 ±0.01, 2.83±0.02 and 2.78±0.01bc g/dl in T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups respectively in Narmadanidhi birds. There were (p<0.05) significantly higher albumin concentrations observed in the all treatment T_2, T_3, T_5, T_6 and T_7 groups compared to control T_1 group.

Serum globulin

Serum globulin is an essential blood protein marker that primarily shows the presence of inflammation in the body; increased levels are usually associated with conditions such as autoimmune diseases, chronic infections, liver disease, and some cancers (Finlayson, 1975) [46]. The average globulin concentrations (g/dl) in this study were 1.77±0.01, 1.83±0.01, 1.84±0.01, 1.80±0.01, 1.88±0.01, 1.87±0.01 and 1.84±0.01 g/dl in in T_1, T_2, T_3, T_4, T_5, T_6, and T_7 groups respectively in Narmadanidhi birds. There were (p<0.05) significantly higher globulin concentrations observed in the all treatment T_2, T_3, T_4, T_5, T_6, and T_7 groups compared to control T_1 group.
Hariharan and Gangadevi (2015) [47], who found that dietary supplementation of organic acid in broiler chicks dramatically raised serum total protein and albumin concentrations. Tollba (2010) [42] also found that essential oil and organic acid supplementation boosted plasma total protein, albumin, and globulin concentrations in broiler chickens. Nourmohammadi and Khosravinia (2015 [48] found that dietary supplementation of citric acid in broiler chicks had no significant (p<0.05) influence on blood total protein content. Similarly, Hassan *et al*. (2016) [49] discovered that dietary citric acid supplementation in broiler ducks resulted in no significant (p<0.05) variation in blood total protein. Rathore (2013) [32] also found that feeding *Mentha arvensis* to goats resulted in no significant (p<0.05) difference in blood total protein across treatment groups.

Serum enzymes

SGPT

The enzyme known as alanine aminotransferase (ALT), or serum glutamic pyruvic transaminase (SGPT), evaluates liver function. Elevated blood SGPT levels could indicate a liver disease or injury. A normal range for SGPT indicates healthy liver function. Significantly high SGPT levels may suggest liver disease, such as cirrhosis, inflammation, or hepatitis, while elevated SGPT levels may suggest hepatic stress or injury (Cohen and Kaplan, 1979) [50]. The average SGPT

concentrations (IU/L) in this study were 9.42±0.55, 10.54±0.46, 10.72±0.56, 5.97±0.29, 11.55±0.55, 10.33±0.49 and 10.19±0.42 IU/L in T_1, T_2, T_3, T_4, T_5, T_6 and T_7 groups respectively in Narmadanidhi birds. There was significant (p<0.05) difference in SGPT values observed among different groups T_1, T_2, T_3, T_4, T_5, T_6 and T_7.

SGOT

The liver enzyme serum glutamic-oxaloacetic transaminase (SGOT) aids in assessing liver health. Blood SGOT levels can identify liver illness or damage before symptoms appear. Increased SGOT readings may be a sign of injury or damage to the liver. Hepatitis, alcoholism, certain drugs, or other liver diseases may be the cause of this. Although they are less frequent, low SGOT readings may indicate severe liver damage or dysfunction (Cohen and Kaplan, 1979) [50]. The average SGPT concentrations (IU/L) in this study were 163.26±1.62, 169.90±2.07, 172.50±2.16, 237.53±6.77, 184.19±2.25, 178.69±2.45 and 164.09±1.90 IU/L in T_1, T_2, T_3, T_4, T_5, T_6 and T_7 groups respectively in Narmadanidhi birds. There was significantly (p<0.05) higher SGPT concentrations observed in the T_4 group compared to other groups.

Salgado-Transito *et al*. (2011) [51], who indicated that dietary addition of organic acid in broiler chicken diets had no significant (p<0.05) influence on AST, ALT, or ALP levels. Nourmohammadi and Khosravinia (2015) [48] found that supplementing broiler chickens' diets with citric acid decreased alkaline phosphatase activity while increasing aspartate transaminase activity. Saleh *et al*. (2014) [52] found that thyme oil significantly (p<0.05) lowered ALT levels while having no effect on AST activity. Toghyani *et al*. (2010) [33], who discovered that include black seed and peppermint in the basal diet had no statistically significant (p<0.05) influence on AST and ALT enzyme concentrations. Shewita and Taha (2011) [53] found no significant (p<0.05) differences in AST levels between groups given varied doses of *Nigella sativa*.

Conclusion

This study found that including essential oils in the diet considerably changed blood and serum parameters such as Hb, PCV, TEC, TLC, albumin, globulin total protein, glucose, cholesterol, SGOT, and SGPT. All of the readings were found to be within the normal physiological range, implying that essential oils at 150 and 300 ppm of basal food had no adverse effect on the hematological and biochemical parameters of Narmadanidhi birds.

Conflict of Interest

Not available

Financial Support

Not available

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