



## Studies on Haematological and Biochemical Parameters in Broiler Chickens Fed Diets Containing Different Supplements

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### Abstract

*The present study evaluated the effect of dietary inclusion of various feed supplements and their combination on the haematological and biochemical parameters. Day-old broiler chicks (n=252) were randomly assigned to seven treatment groups, each with 3 replicates. The first treatment was designated as control (T0) in which no supplement was added to the feed, while in treatments T1; organic mineral mixture (Organomin forte), T2; organic mineral mixture (Vannamin), T3; probiotics (Microguard), T4; enzyme (Brozyme -XPR) and probiotics, T5; emulsifier (Lipigon) were provided through the feed. In the T6 group, 3 percent less energy was given through feed from 1st to 6th weeks of age respectively. TEC, MCHC, and DLC values were significantly increased in the broilers of feed supplemented groups in comparison to control. TLC, PCV and Hb and was significantly increased in the broilers of feed supplemented groups in comparison to control except the T6 group. MCV and MCH values were significantly (P<0.05) decreased in the broilers of supplemented groups in comparison to control. Biochemical estimations showed a significant increase in TSP, albumin, and globulin and AST and ALT significant decrease in supplemented groups.*

**Keywords:** Biochemical Parameters, Haematological Parameters, Supplements, Ven Cobb400 Broilers

## Introduction

Poultry production has garnered significant landmarks in animal production. From a backyard venture five decades ago (Singh *et al.*, 2017), the Indian Poultry industry has evolved as the most vibrant fast-growing and dynamic sub-sector of agriculture with 16.8 % growth in poultry population over the previous census (Livestock Census 2019), has witnessed one of the fastest global share of about 6.3 % in egg and 3.3 % in meat production over the year 2015-16, India stands 3rd and 5th position, respectively. The industry has not only grown in size but also productivity. With rapidly changing lifestyles, affluent culture, and a conscious need for general wellness, Indian consumers are now opting for a more protein-rich diet (CARI VISION 2050). The changing trends are a boon for the poultry sector in India. Feed additives or growth promoters have been used to improve growth rate, feed efficiency, and product quality and to reduce the production cost in poultry (Craig *et al.*, 2008). Various antibiotics, anthelmintic, anti-coccidial and hepatic-protectants are used for increasing production. They not only increase the cost of production but have adverse effects on long term usage. Due to the prohibition of most of the antimicrobial feed additives in animal feed and their residual effects in animals (Singh *et al.*, 2014), organic mineral mixtures, probiotics, enzymes, and emulsifiers are becoming more popular. Through the incorporation of the above supplements and their combination in the poultry, the diet had been tried by various workers but consistent results with respect to haematological and biochemical aspects is lacking. Therefore, the present investigation was undertaken to study the effect of various feed supplements on the haematological and biochemical parameters in broilers.

## Materials and Methods

The study was conducted on 252 day-old straight run Ven Cobb400 broiler chicks which were randomly assigned to seven treatment groups, each with 3 replicates. The duration of trial was of 6 weeks. The first treatment was designated as control (T<sub>0</sub>) in which no supplement was added to the feed, while in treatments T<sub>1</sub>; organic mineral mixture (Organomin forte), T<sub>2</sub>; organic mineral mixture (Vannamin), T<sub>3</sub>; probiotics (Microguard), T<sub>4</sub>; enzyme (Brozyme -XPR) and probiotics, T<sub>5</sub>; emulsifier (Lipigon) were provided through the feed. In the T<sub>6</sub> group, 3 percent less energy was given through feed from 1<sup>st</sup> to 6<sup>th</sup> weeks of age respectively. The treatment group T<sub>6</sub> was very important in terms of profit making in poultry production. Broilers having good liver function and immunity even after slightly less energy provided in comparison to control group will be financially beneficial. The study was conducted under standard management conditions. Feed and water were provided *ad libitum*.

### Collection of Blood Samples

Blood samples were collected from six experimental birds of each group *i.e.* two broiler chicks from each replicate on the 21<sup>st</sup> and 42<sup>nd</sup> day of experimental feeding. Blood collection at 21<sup>st</sup> day is important as biochemical changes during growing phase after supplement feeding affects much proportion of growth which ultimately decide profit making. Blood samples (about 4.0 ml) were collected aseptically from their wing vein, using sterilized syringes and needles (24-gauge needle). Collected blood samples were divided into two parts. One part (2 ml) was transferred to the vials containing anticoagulant ethylene diamine tetraacetate (EDTA) and used for estimation of hemoglobin (Hb), packed cell volume (PCV), red blood cells (RBC) and white blood cells (WBC). The second part (2 ml) of blood was used for the separation of serum.

### Separation of Serum

For separation of serum, the remaining 2 ml blood sample was allowed to stand at room temperature in a slanting position for clot formation for three to four hours. After clotting of blood, the plunger was removed from the syringes and serum was stored at -20°C for further analysis.

Total erythrocytes count (TEC) was done as described by Natt and Herrick (1952). Total leukocyte count (TLC) was performed with Neubauer's counting chamber (Jain, 1986). Packed cell volume (PCV) was estimated using the microhematocrit method as described by Sharma and Singh (2000). Hemoglobin (Hb) concentration was estimated spectrophotometrically at 540 nm by the cyanomethemoglobin method, using Drabkin's solution (Fudge, 2000). Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were done by a fully automatic blood cell counter model PCE 210. All other biochemical characteristics like total protein, albumin, globulin, albumin/globulin ratio, Aspartate Aminotransferase (AST) and Alanine Aminotrasferase (ALT) were determined calorimetrically (Span Diagnostics Ltd(R), Surat, India).

## Statistical Analysis

All data pertaining to various parameters were analyzed statistically by running ANOVAs using SPSS 19 software. Significant mean differences between the treatments were determined at a 5% significance level ( $P < 0.05$ ) using Duncan's Multiple Range Test (DMRT) as modified by Kramer (1957).

## Results and Discussion

Mean haematological and serum protein profiles of broilers in different experimental groups at 21 and 42 days are given in Table 1, Table 2 and Table 3.

**Table 1:** Effect of different feed supplements on haematological profile of broilers at 21 days

Treatments	Haematological Parameters						
	TEC(106/ $\mu$ l)	TLC (10 <sup>3</sup> / $\mu$ l)	PCV (%)	Hb (g/dl)	MCV (fl)	MCH (pg)	MCHC (%)
T <sub>0</sub>	2.22 <sup>a</sup> ± 0.04	24.29 <sup>a</sup> ± 0.01	25.81 <sup>a</sup> ± 0.09	8.45 <sup>a</sup> ± 0.05	116.26 <sup>a</sup> ± 0.03	38.06 <sup>a</sup> ± 0.01	32.73 <sup>a</sup> ± 0.01
T <sub>1</sub>	2.70 <sup>b</sup> ± 0.02	25.70 <sup>b</sup> ± 0.13	27.31 <sup>b</sup> ± 0.14	9.23 <sup>b</sup> ± 0.04	101.14 <sup>b</sup> ± 0.19	34.18 <sup>b</sup> ± 0.04	33.79 <sup>b</sup> ± 0.02
T <sub>2</sub>	2.75 <sup>b</sup> ± 0.00	25.98 <sup>b</sup> ± 0.02	27.63 <sup>b</sup> ± 0.04	9.36 <sup>bc</sup> ± 0.02	100.47 <sup>bc</sup> ± 0.08	34.03 <sup>b</sup> ± 0.00	33.87 <sup>b</sup> ± 0.02
T <sub>3</sub>	2.83 <sup>c</sup> ± 0.00	26.51 <sup>c</sup> ± 0.01	28.25 <sup>c</sup> ± 0.02	9.60 <sup>c</sup> ± 0.02	99.82 <sup>bc</sup> ± 0.29	33.92 <sup>b</sup> ± 0.03	33.98 <sup>b</sup> ± 0.05
T <sub>4</sub>	2.88 <sup>cs</sup> ± 0.02	26.63 <sup>c</sup> ± 0.04	28.46 <sup>cc</sup> ± 0.09	9.73 <sup>cc</sup> ± 0.04	98.81 <sup>bc</sup> ± 0.24	33.78 <sup>b</sup> ± 0.05	34.18 <sup>b</sup> ± 0.02
T <sub>5</sub>	2.79 <sup>c</sup> ± 0.01	26.23 <sup>c</sup> ± 0.13	27.95 <sup>c</sup> ± 0.13	9.49 <sup>c</sup> ± 0.04	100.17 <sup>bc</sup> ± 0.09	34.01 <sup>b</sup> ± 0.01	33.95 <sup>b</sup> ± 0.00
T <sub>6</sub>	2.38 <sup>d</sup> ± 0.04	24.53 <sup>ad</sup> ± 0.12	26.05 <sup>ad</sup> ± 0.02	8.64 <sup>ad</sup> ± 0.04	109.45 <sup>c</sup> ± 0.03	36.30 <sup>c</sup> ± 0.01	33.16 <sup>b</sup> ± 0.01

Means bearing different superscripts in a column differ significantly ( $P < 0.05$ )

**Table 2:** Effect of different feed supplements on differential leucocyte count (%) of broilers at 21 and 42 days

Treatments	Days	Differential Leucocyte Count (%)				
		Heterophil	Lymphocyte	Monocyte	Eosinophil	Basophil
T <sub>0</sub>	21	34.49 <sup>a</sup> ± 0.12	57.81 <sup>a</sup> ± 0.03	2.82 <sup>a</sup> ± 0.03	2.08 <sup>a</sup> ± 0.03	0.27 <sup>a</sup> ± 0.01
	42	35.63 <sup>a</sup> ± 0.12	59.35 <sup>a</sup> ± 0.11	3.27 <sup>a</sup> ± 0.00	2.30 <sup>a</sup> ± 0.02	0.58 <sup>a</sup> ± 0.03
T <sub>1</sub>	21	35.78 <sup>b</sup> ± 0.00	59.52 <sup>b</sup> ± 0.14	3.60 <sup>b</sup> ± 0.01	2.49 <sup>b</sup> ± 0.02	0.29 <sup>b</sup> ± 0.02
	42	37.48 <sup>b</sup> ± 0.01	61.62 <sup>b</sup> ± 0.01	3.77 <sup>b</sup> ± 0.06	2.89 <sup>b</sup> ± 0.07	0.61 <sup>b</sup> ± 0.04
T <sub>2</sub>	21	35.92 <sup>b</sup> ± 0.06	59.85 <sup>c</sup> ± 0.08	3.68 <sup>b</sup> ± 0.03	2.54 <sup>b</sup> ± 0.00	0.32 <sup>c</sup> ± 0.01
	42	37.70 <sup>bc</sup> ± 0.09	61.70 <sup>b</sup> ± 0.02	3.88 <sup>bc</sup> ± 0.00	3.14 <sup>c</sup> ± 0.06	0.63 <sup>c</sup> ± 0.01
T <sub>3</sub>	21	36.25 <sup>c</sup> ± 0.01	60.40 <sup>d</sup> ± 0.02	3.79 <sup>c</sup> ± 0.00	2.63 <sup>c</sup> ± 0.00	0.28 <sup>d</sup> ± 0.00
	42	38.00 <sup>bc</sup> ± 0.09	62.58 <sup>bc</sup> ± 0.11	3.99 <sup>c</sup> ± 0.00	3.34 <sup>d</sup> ± 0.05	0.61 <sup>b</sup> ± 0.00
T <sub>4</sub>	21	36.35 <sup>c</sup> ± 0.03	60.58 <sup>dg</sup> ± 0.06	3.85 <sup>cf</sup> ± 0.02	2.69 <sup>eg</sup> ± 0.02	0.31 <sup>e</sup> ± 0.01
	42	38.26 <sup>c</sup> ± 0.03	62.98 <sup>c</sup> ± 0.09	4.13 <sup>d</sup> ± 0.05	3.47 <sup>e</sup> ± 0.01	0.64 <sup>c</sup> ± 0.01
T <sub>5</sub>	21	36.13 <sup>c</sup> ± 0.05	60.19 <sup>d</sup> ± 0.09	3.77 <sup>c</sup> ± 0.00	2.59 <sup>c</sup> ± 0.01	0.29 <sup>b</sup> ± 0.03
	42	37.85 <sup>cb</sup> ± 0.01	62.03 <sup>bc</sup> ± 0.18	3.94 <sup>c</sup> ± 0.02	3.23 <sup>f</sup> ± 0.00	0.64 <sup>c</sup> ± 0.02
T <sub>6</sub>	21	35.42 <sup>d</sup> ± 0.08	58.55 <sup>e</sup> ± 0.14	3.24 <sup>d</sup> ± 0.06	2.30 <sup>d</sup> ± 0.02	0.28 <sup>d</sup> ± 0.03
	42	36.40 <sup>d</sup> ± 0.14	59.84 <sup>a</sup> ± 0.18	3.44 <sup>e</sup> ± 0.07	2.42 <sup>g</sup> ± 0.04	0.60 <sup>b</sup> ± 0.05

Means bearing different superscripts in a column differ significantly ( $P < 0.05$ )

**Table 3:** Effect of different feed supplements on serum protein profile of broilers at 21 and 42 days

Treatments	Days	Biochemical Parameters					
		g/dl				IU/L	
		Total protein	Albumin (A)	Globulin (G)	A/G ratio	AST	ALT
T <sub>0</sub>	21	3.11 <sup>a</sup> ± 0.03	1.10 <sup>a</sup> ± 0.02	2.13 <sup>a</sup> ± 0.03	0.51 <sup>a</sup> ± 0.00	167.04 <sup>a</sup> ± 0.13	26.32 <sup>a</sup> ± 0.20
	42	3.53 <sup>a</sup> ± 0.07	1.29 <sup>a</sup> ± 0.03	1.51 <sup>a</sup> ± 0.00	0.85 <sup>a</sup> ± 0.00		
T <sub>1</sub>	21	3.41 <sup>b</sup> ± 0.03	1.43 <sup>b</sup> ± 0.01	2.60 <sup>b</sup> ± 0.00	0.55 <sup>b</sup> ± 0.00	164.97 <sup>ab</sup> ± 0.20	23.49 <sup>b</sup> ± 0.18
	42	4.00 <sup>b</sup> ± 0.00	1.50 <sup>b</sup> ± 0.13	2.04 <sup>b</sup> ± 0.02	0.73 <sup>b</sup> ± 0.00		
T <sub>2</sub>	21	3.48 <sup>b</sup> ± 0.00	1.49 <sup>b</sup> ± 0.01	2.71 <sup>c</sup> ± 0.05	0.54 <sup>ab</sup> ± 0.01	164.55 <sup>ab</sup> ± 0.06	23.92 <sup>b</sup> ± 0.09
	42	4.10 <sup>b</sup> ± 0.04	1.57 <sup>c</sup> ± 0.03	2.18 <sup>c</sup> ± 0.05	0.72 <sup>b</sup> ± 0.00		
T <sub>3</sub>	21	3.58 <sup>c</sup> ± 0.00	1.62 <sup>c</sup> ± 0.00	2.95 <sup>d</sup> ± 0.00	0.54 <sup>ab</sup> ± 0.02	163.40 <sup>b</sup> ± 0.06	24.87 <sup>c</sup> ± 0.07
	42	4.22 <sup>c</sup> ± 0.00	1.64 <sup>d</sup> ± 0.00	2.35 <sup>d</sup> ± 0.03	0.69 <sup>c</sup> ± 0.00		
T <sub>4</sub>	21	3.63 <sup>c</sup> ± 0.01	1.72 <sup>d</sup> ± 0.03	3.03 <sup>e</sup> ± 0.02	0.56 <sup>b</sup> ± 0.00	162.60 <sup>b</sup> ± 0.33	25.42 <sup>d</sup> ± 0.22
	42	4.31 <sup>ce</sup> ± 0.03	1.71 <sup>e</sup> ± 0.02	2.43 <sup>e</sup> ± 0.00	0.70 <sup>c</sup> ± 0.00		
T <sub>5</sub>	21	3.54 <sup>c</sup> ± 0.02	1.56 <sup>c</sup> ± 0.02	2.86 <sup>f</sup> ± 0.03	0.54 <sup>ba</sup> ± 0.00	163.99 <sup>b</sup> ± 0.27	24.44 <sup>c</sup> ± 0.18
	42	4.18 <sup>c</sup> ± 0.00	1.64 <sup>d</sup> ± 0.02	2.27 <sup>f</sup> ± 0.01	0.72 <sup>b</sup> ± 0.01		
T <sub>6</sub>	21	3.26 <sup>d</sup> ± 0.02	1.32 <sup>e</sup> ± 0.02	2.36 <sup>g</sup> ± 0.01	0.55 <sup>b</sup> ± 0.00	166.67 <sup>ba</sup> ± 0.06	22.35 <sup>e</sup> ± 0.05
	42	3.83 <sup>d</sup> ± 0.00	1.69 <sup>e</sup> ± 0.06	1.76 <sup>g</sup> ± 0.06	0.96 <sup>d</sup> ± 0.00		

Means bearing different superscripts in a column differ significantly ( $P < 0.05$ )

### Haematological Profiles (21days)

TEC and MCHC values were significantly increased in the broilers of feed supplemented groups in comparison to control. TLC, PCV and Hb and was significantly increased in the broilers of feed supplemented groups in comparison to control except the T6 group. MCV and MCH values were significantly ( $P < 0.05$ ) decreased in the broilers of supplemented groups in comparison to control.

The present results are in agreement with the findings of Cowieson *et al.* (2006), Rahman *et al.* (2013) and Kaushal *et al.* (2015) who found significant ( $P < 0.05$ ) increase in TEC, TLC, PCV, Hb content of broilers fed the diet supplemented with enzymes and probiotics. Ferdous *et al.* (2018) noted a significant ( $P < 0.01$ ) increase in TEC, PCV, and Hb of broilers fed the diet supplemented with enzymes and multivitamins. Hosseini (2011) noted a significantly ( $P < 0.05$ ) increase in Hb, TEC, and TLC of broilers fed the diet supplemented with yeast (*Saccharomyces cerevisiae*). Ahmed *et al.* (2007) found a significantly ( $P < 0.05$ ) increase in TEC, PCV and Hb value of broilers fed the diet supplemented with enzymes (Alquerzim). Milanovic *et al.* (2008) noted an increase in PCV and Hb of broilers fed the diet supplemented with organic iron.

In contrast, Shareef and Al-Dabbagh (2009) and Alkhalf *et al.* (2010) observed a non-significant ( $P > 0.05$ ) difference in TEC, TLC and PCV of broilers fed the diet supplemented with probiotics. Devrim *et al.* (2010) found non-significant ( $P > 0.05$ ) differences in TEC and TLC of broilers fed the diet supplemented with organic Zn, Cu, and Mn. Cho *et al.* (2012) and Upadhaya *et al.* (2017) noted non-significant ( $P > 0.05$ ) difference in TEC and TLC of broilers fed the diet supplemented with emulsifier and multienzyme. Shehab *et al.* (2012) observed non-significant ( $P > 0.05$ ) differences in MCV of broilers fed the diet supplemented with enzymes. Chuka (2014) found non-significant ( $P > 0.05$ ) difference in MCV, MCH, MCHC of broilers fed the diet supplemented with enzymes and probiotics. An increase in TEC, TLC, PCV and Hb in supplemented groups might have been due to increased absorption of iron and copper minerals required for the synthesis of haem pigment resulting in improved TE proliferation, the formation of Hb and maturation of blood cells (Kaushal *et al.*, 2015). Increased absorption might be due to better condition of intestinal epithelium as results of probiotic supplementation. Mineral supplement may have increased the availability of these minerals in the intestinal lumen. This had helped birds to live with maximum physiological fitness and excel in performance and fetch more income.

## Differential Leucocyte Count

Heterophil, lymphocyte, monocyte, eosinophil and basophil values were significantly ( $P<0.05$ ) increased in the broilers of feed supplemented groups in comparison to control at 21 and 42 days.

The results of the present study are in agreement with the Chuka (2014) who found significant ( $P<0.05$ ) increase in eosinophil levels in P3 (enzymes and probiotic) and P4 (probiotic) group of broilers fed the diet supplemented with probiotic (*Saccharomyces cerevisiae*) and enzyme (Zyme®). Mahmud *et al.* (2014) noted a significant ( $P<0.05$ ) increase in lymphocyte, heterophil, monocyte, eosinophil, and neutrophil of broilers fed the diet supplemented with probiotics (Biocyn®, Grow-fast® and El-rox®). Rawat *et al.* (2016) found a significant ( $P<0.05$ ) increase in eosinophils, neutrophils and lymphocyte in broilers fed the diet supplemented with a liver stimulant (Superliv). In contrast, Sugiharto *et al.* (2018) found a significant ( $p<0.05$ ) decrease in leukocytes, eosinophils, lymphocytes, and heterophils in broilers fed the diet supplemented with probiotics. Elevated levels of DLC values (within normal range) in supplemented groups indicated that these broilers have better immune status.

## Serum Biochemical Parameters (21 day)

AST and ALT values were significantly ( $P<0.05$ ) decrease in broilers of supplemented groups in comparison to control except T<sub>1</sub>, T<sub>2</sub>, and T<sub>6</sub>. It might be due to better liver functioning in broiler groups fed with probiotic, enzymes and emulsifier. Probiotic supplementation improves intestinal epithelium condition by eliminating pathogenic microbes, enzyme make digestion of nutrients easy and emulsifier helps in emulsification and better absorption of fat molecules. All these functions of feed supplements thus reduces metabolic load on liver. ALT values were significantly ( $P<0.05$ ) decrease in broilers of supplemented group control.

Toghyani *et al.* (2011) and Rahman *et al.* (2013) found a significant ( $P<0.05$ ) decrease in ALT and AST values in broilers fed the diet supplemented with enzymes and probiotics. Haque *et al.*, (2017) noted a significant ( $P<0.05$ ) decrease in AST and ALT levels of broilers fed the diet supplemented with probiotics. Jouybari *et al.* (2009), Shareef and Al-Dabbagh (2009) and Saleh (2014) noted a significant ( $P<0.05$ ) decrease in AST of broilers fed the diet supplemented with probiotics. Ahmed *et al.* (2007) found a significant ( $P<0.05$ ) decrease in ALT and AST values of broilers fed the diet supplemented with enzymes.

In contrast, Chuka (2014) found non-significant ( $P>0.05$ ) differences in serum alanine amino transaminase and significant ( $P<0.05$ ) increase in AST of broilers fed the diet supplemented with enzymes and probiotics. Kundu *et al.* (2004) and Shehab *et al.* (2012) noted non-significant ( $P>0.05$ ) differences in ALT and AST of broilers fed the diet supplemented with enzymes.

## Serum Protein Profile (21 and 42 days)

Total protein, albumin and globulin values were significantly ( $P<0.05$ ) increased in supplemented groups as compared to the T<sub>0</sub> control (group) at 21 and 42 days. Albumin: globulin ratio was significantly ( $P<0.05$ ) increased in supplemented groups as compared to the T<sub>0</sub>(control) group except for T<sub>2</sub>, T<sub>3</sub>, and T<sub>5</sub> at 21 days. Albumin: globulin ratio was significantly ( $P<0.05$ ) increase in T<sub>6</sub> group and significantly ( $P<0.05$ ) decrease in T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub> group at 42 days.

The results of the present experiment were in accordance with the findings of Hassen and Chauhan (2003) who found a significant ( $P<0.05$ ) increase in serum globulin levels of broilers fed the diet supplemented with enzymes. Paryad and Mahmoudi (2008) and Yazhini *et al.* (2018) noted a significant ( $P<0.05$ ) increase in total protein, albumin and globulin concentrations in broilers fed the diet supplemented with probiotic (*S. cerevisiae*). Shareef and Al-Dabbagh (2009) and Chaudhary *et al.* (2017) observed a significant ( $P<0.05$ ) increase in serum total protein of broilers fed the diet supplemented with probiotics. Chuka (2014) and Kaushal *et al.* (2019) found a significant ( $P<0.05$ ) increase in the total protein of broilers fed the diet supplemented with enzymes and probiotics. Stef *et al.* (2016) noted a significant ( $P<0.05$ ) increase in serum albumin: globulin ratio of broilers fed the diet supplemented with probiotics.

In contrast, Chuka (2014) noted non-significant ( $P>0.05$ ) differences in serum globulin, serum albumin-globulin ratio of broilers fed the diet supplemented with enzymes and probiotics.

Increased total protein levels in feed supplemented groups of broilers in the present experiment may be attributed to the stimulating effect of feed supplements on the synthesis of protein in the body and better protein retention and their mobilization may be induced by the supplements. Another possible reason may be the fact the lactic acid bacteria competitively exclude the pathogenic bacteria which reduce the breakdown of proteins to nitrogen.

## Conclusion

An Increase in TEC, TLC, PCV, and Hb in supplemented groups might have been due to increase absorption of iron and copper minerals required for the synthesis of haem pigment resulting in improved TE proliferation, the formation of Hb and maturation of blood cells. This had helped birds to live with maximum physiological fitness and excel in performance and fetch more income. The increased concentration of total serum protein was observed in treated birds which may be because of the increased amount of globulins as enhanced humoral immune response.

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## Conflict of Interests

There is no conflict of interest.

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