Haematological and Serum Biochemical Responses of Broiler Chickens to Lactobacillus Probiotic Supplementation

Nwankwo, V. C.[1*]; Ebenebe C. I.[2]; Nwankwo E.C.[3]

[*1,2]Department of Animal Science and Technology, Nnamdi Azikiwe University, Awka, Nigeria;
[3]Department of Soil Science and Land Resource Management, Nnamdi Azikiwe University, Awka, Nigeria
*Corresponding Author

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Abstract— *This study evaluated the haematological and serum biochemical responses of two broiler chicken breeds, Arbor Acre and Ross, to different levels of Lactobacillus probiotic supplementation. This experiment was a completely randomized design with 2 × 4 factorial arrangements where 240 day-old mixed-sex broiler chicks of both Arbor Acre and Ross chicken breeds were allotted to four groups and fed 0, 5, 10, and 15 mL of Lactobacillus, respectively. The results of the haematological analysis indicated that the packed cell volume, RBC count, and haemoglobin were significantly enhanced, and the best enhancements were with 10 mL supplementation level. These changes were more pronounced in Ross chickens, breed specifically. The promising results in serum biochemistry took in renal function markers, lowered total cholesterol levels, and possible immunomodulatory consequences. Dietary supplementation with Lactobacillus positively altered the blood characteristic within the normal physiological range. Significantly different mineral profiles, enzymatic activities, and protein metabolisms between breeds and levels of dietary supplementation were recorded. The results suggest that probiotic supplementation can optimize broilers' health, and the daily dosage of 10 ml seems to impart the most pronounced benefits.*

Keywords— Lactobacillus, broiler chickens, probiotic supplementation, haematology, serum biochemistry.

I. INTRODUCTION

Poultry production is one of the mainstays in ensuring global food security, with broiler chicken meat being one of the key protein sources for millions of people around the world. With growing demand for improved efficiency and sustainable meat production, scientists and agricultural professionals are turning more toward nutritional interventions that could optimize health, performance, and immune function in birds. Probiotics have emerged as one of the promising strategies in improving broiler chicken production because they have certain advantages over antibiotic interventions (Gadde *et al.,* 2017).

In general, probiotics have been a good area for animal nutrition scientists as they modulate gut microbiota, digestion, and immunity. These populations can attach to the gastrointestinal tract as a competitor against pathogenic microorganisms to promote better health in birds as evidenced by Mohd Shaufi *et al.,* (2015). The modes of action for these are rather complex because of interactions between microbial population populations with intestinal epithelium cells and the immune system as a whole, making this an interesting area of science to venture into.

Haematological and serum biochemical parameters are vital in assessing the physiological response of broilers to dietary manipulations. These parameters are sensitive indicators of metabolic status, immunity and health, thus providing insight to the researcher on nutritional supplements, including probiotics, which influence the physiology of birds (Bah *et al.,* 2022). Probiotics have also been seen in various studies to alter characteristics of blood profiles across different animals, which may indicate better metabolic efficiency and immunity.

Despite the increased interest in probiotic applications, results have been highly variable due to a variety of probiotic strains, dosages, and conditions of the experiment (Al-Shawi *et al.,* 2020). That variability showed the need for broad-based studies that assess the effects of certain Lactobacillus strains on several health markers of broiler chickens. According to Shokryazdan *et al.* (2017), understanding such disparate responses is crucial in developing target nutritional strategies that will enhance the production potential and welfare of broiler chickens.

This present study is aimed at comprehensively investigating the haematological and serum biochemical responses of broiler chickens fed with Lactobacillus probiotic supplementation. A battery of physiological parameters was employed to see the possible mechanism through which these useful microorganisms impact the health and performance of birds. This work also contributes to the ever-growing knowledge in the application of probiotics in poultry nutrition and helps to foster more efficient, sustainable agricultural practices.

II. MATERIALS AND METHODS

2.1 Experimental Site and Design:

The study was conducted at the Poultry Unit of the Teaching and Research Farm, Department of Animal Science and Technology, Nnamdi Azikiwe University, Awka campus, which is located at Latitude 6°12'25"N and Longitude 7°04'04"E, with an average elevation of 9 metres above sea level. Two hundred and forty (240) day-old mixed-sex broiler chicks of two breeds (Arbor Acre and ROSS) were procured from Agrited Farms and CHI Farms, Ibadan. Birds were then taken to the experimental site and allowed to acclimate for one week.

The experimental design was a 2 × 4 factorial arrangement in a completely randomized design. Birds were divided into four treatments: T1 (control), T2 (5 ml Lactobacillus), T3 (10 ml Lactobacillus), and T4 (15 ml Lactobacillus). Each treatment group per breed was replicated thrice with ten chicks per replicate.

2.2 Animal Housing and Management:

The birds were brooded on deep litter within detergent and Izal-disinfected pens. 0.05m²/bird was provided for 0-3 weeks and 0.11m²/bird from 4-8 weeks. The pens were spread with five centimetres of wood shavings while 100-watt bulbs were provided as the source of heat. New Hope commercial feeds were provided ad libitum during both starter and finisher phases; water was supplied through three-litre drinkers.

2.3 Probiotic Preparation and Administration:

The Lactobacillus cultures were isolated from the fermented yam wash water and raw cow milk. As identified by Bergey's Manual of Systematic Bacteriology (Kandler and Weiss, 1986), the technique adopted for identification included a check on the colony morphology, Gram staining and biochemical tests. The cultures were prepared in MRS broth, centrifuged, washed with buffered salt solution and stored in 30% glycerol at -80oC. The Lactobacillus was administered daily through drinking water with different volumes including 5mL, 10mL and 15mL for eight weeks.

2.4 Blood Sample Collection and Analysis:

Blood was collected from three birds per treatment randomly selected at the termination of the experiment (day 55) with the aid of wing web venipuncture. The blood was collected into heparinized and nonheparinized bottles with utmost care taken to prevent haematoma and stress on the animals.

Haematological parameters were made following standard procedures. The red blood cell count and white blood cell count were made by haemocytometer using Natt-Herrick solution. Haematocrit (packed cell volume) and haemoglobin were estimated using micro haematocrit and Sahli's method respectively (Brundha and Priyadharshini, 2019). Peripheral blood leukocyte percentage was done using May Grunwald-Giemsa stained blood smears (Chari and Prasad, 2018).

2.5 Serum Biochemistry Analysis:

Serum was harvested following centrifugation of blood at 930.7g for 10 minutes. Biochemical assay was carried out for different biochemical parameters, viz., total protein by biuret reaction, creatinine by Jaffe reaction, and cholesterol by the method of Kaneko *et al.* (2008). Alanine transaminase (ALT), aspartate transaminase (AST) and alkaline phosphatase were assayed calorimetrically using Randox reagent kit.

2.6 Statistical Analysis:

Data were analysed using Analysis of Variance (ANOVA) through Statistical Package for Social Sciences (SPSS version 20). Significant means were separated using Least Significant Difference (LSD) at a 5% significance level.

III. RESULTS AND DISCUSSION

3.1 HAEMATOLOGAL Biochemical Responses:

TABLE 1
MEAN HAEMATOLOGY PERFORMANCE OF ARBOR ACRE AND ROSS BROILER BREEDS

Parameter	Breed		SEM	P-value
	Arbor Acre	Ross		
PCV (100%)	27.67b	29.83a	0.31	0
RBC(10^{12}/mm^3)	1.74b	2.25a	0.03	0
HB(g/dl)	9.19b	10.00a	0.12	0
MCV(fl)	158.92a	134.33b	1.54	0
MCH(pg)	52.79a	45.02b	0.55	0
MCHC(%)	33.22a	33.77b	0.15	0.21
WBC(10^3/mm^3)	57.92b	59.06a	1.18	0.504

a-c Means on the same row with different superscripts are significantly different(P<0.05)
PCV= parked cell volume, RBC= Red blood cell, HB= Haemoglobin, MCV= mean corpuscular volume, MCH= mean corpuscular haemoglobin, MCHC= mean corpuscular haemoglobin concentration, WBC= white blood cell

TABLE 2
MEAN HAEMATOLOGY PERFORMANCE OF BROILERS INJECTED DIFFERENT LEVELS OF LACTOBACILLUS BACTERIA

Parameter	Levels of Lactobacilus				SEM	P-value
	0%	5%	10%	15%		
PCV (100%)	26.00^C	28.17^b	30.83^a	30.00^a	0.44	0
RBC(10^{12}/mm^3)	2.39^b	2.59^a	2.77^a	2.62^a	0.44	0
HB(g/dl)	8.65^C	9.43^b	10.28^a	10.02^a	0.17	0
MCV(fl)	153.67^a	143.83^b	145.00^b	144.00^b	2.18	0.026
MCH(pg)	51.17^a	48.03^b	48.37^b	48.05^b	0.78	0.032
MCHC(%)	33.27	33.32	33.32	33.9	0.21	0.189
WBC(10^3/mm^3)	54.28b	59.72a	59.78a	60.17a	1.67	0.072

a-c Means on the same row with different superscripts are significantly different(P<0.05)
PCV= parked cell volume, RBC= Red blood cell, HB= Haemoglobin, MCV= mean corpuscular volume, MCH= mean corpuscular haemoglobin, MCHC= mean corpuscular haemoglobin concentration, WBC= white blood cell

TABLE 3
MEAN HAEMATOLOGY PERFORMANCE OF ARBOR ACRE AND ROSS BROILER BREEDS INJECTED WITH DIFFERENT LEVELS OF LACTOBACILLUS SUPPLEMENTATION

Parameter	Breed x Level of Lactobacilus									
	AAx0%	AAx5 %	AAx10 %	AAx15 %	Rx0%	Rx5%	Rx10 %	Rx15 %	SE M	Pvalu e
PCV (100%)	25.67	27	29.33	28.67	26.33	29.33	32.33	31.33	0.62	0.285
RBC(10^{12}/L)	1.64c	2.73a	2.80a	2.20b	1.75c	2.24b	2.54ab	2.45ab	0.57	0
HB(g/dl)	8.5	8.93	9.73	9.6	8.8	9.93	10.83	10.43	0.24	0.363
MCV(fl)	157.00a b	142.00b	162.67a	160.00ab	150.33 b	131.67 c	127.33 c	128.00 c	3.08	0.001
MCH(pg)	52.00ab	51.53ab	54.07a	53.57ab	50.33b	44.53c	42.67c	42.53c	1.1	0.001
MCHC(%)	33.13	33.1	33.13	33.5	33.4	33.87	33.5	34.3	0.3	0.752
WBC(10^3/mm^3)	55.6	57.03	58.7	60.33	52.97	62.4	60.87	60	2.36	0.396

a-***c Means on the same row with different superscripts are significantly different(P<0.05)***
PCV= parked cell volume, RBC= Red blood cell, HB= Haemoglobin, MCV= mean corpuscular volume, MCH= mean corpuscular haemoglobin, MCHC= mean corpuscular haemoglobin concentration, WBC= white blood cell

Haematological examination between chickens revealed marked significant differences due to the different levels of Lactobacillus supplementation and chicken breed, as presented in tables 1, 2 and 3. The Pack Cell Volume was significantly different ($p < 0.05$). The birds treated with 10 ml Lactobacillus had the highest value of PCV as 30.83%. Though very important, all are within the normal physiological value that is expected in chickens, ranging from 22 to 35%. For breeds, Ross chickens were significantly higher with a PCV of 29.83% compared to Arbor Acre chickens, accounting for 27.67%. The bird's blood composition and oxygen carrying will be improved, though its normal physiological range is between 22 and 35%. Breed variations between Ross and Arbor Acre chickens also hint at genetic variations affecting the blood cell concentration.

Haemoglobin levels showed a significant difference ($p < 0.05$) due to Lactobacillus inclusion levels. Thus, the T3 treatment group revealed significantly higher levels of haemoglobin when compared to the control group. Range for the observed haemoglobin was between 8.65 g/dl to 10.28 g/dl. No significant differences were witnessed due to breed or their interactions with Lactobacillus. In RBCs, a significant difference was noted on Lactobacillus inclusion levels with the highest of 2.77 × 106 observed in T3. Significant differences were also found between Arbor Acre and Ross; however, no significant interaction was noted between breed and Lactobacillus inclusion. The increase in such aspects indeed reflects an increase in the production of blood cells, probably an improved immune system and overall optimization of blood health. These differences among breeds further point out that the interaction between supplementation and genetic makeup is complicated.

MCV has presented significant differences ($p < 0.05$), and the highest value was expressed by the control group. Values ranged between 143.83 fl - 153.67 fl. Significant differences were observed among breeds and in breed-Lactobacillus interactions. In MCH, there was a significant difference ($p < 0.05$), and the control group (T1) is the highest with a value of 51.17 pg, while T2 had the lowest with 48.03 pg. The Arbor Acre chickens had presented a higher value of 52.79 than that of Ross chickens, which was 45.02. Significant differences had been obtained in the interaction between breed and Lactobacillus.

While MCHC did not show significant variation across the different levels of Lactobacillus inclusions, significant variations were recorded among breeds with no significant breed-Lactobacillus interaction detected. This stability only creates a consistent concentration of haemoglobin inside the cells, hence a sign that supplementation does not alter the basic cellular haemoglobin density. White Blood Cell values also varied significantly across the different inclusions of Lactobacillus ($p < 0.05$). Significant variations were also obtained among breeds, though no significant breed × Lactobacillus inclusion interaction was detected. These variations may result from possible alterations to inflammatory responses or because breeds show different immune cell production.

The comprehensive haematological analysis conducted in the study provides an overview of the broiler chicken physiological responses due to the supplementation of Lactobacillus probiotic. From the result, it can be observed that the supplementation of Lactobacillus showed positive effects on the various haematological parameters across studies. There was a significant elevation at 10 mL (T3) of PCV, RBC, and haemoglobin. Significant increase of Red Blood Cell and Packed Cell Volume upon the administration of Lactobacillus probiotics may indicate better erythropoiesis and absorption of iron. This is in agreement with our finding, where Pertiwi and Mahendra (2021) stated that probiotics may enhance nutrient absorption and increase erythrocytes production.

The differences noted between Arbor Acre and Ross breeds on all parameters underline genetic factors that are very important in probiotic response. Ross chickens gave consistently higher values, indicating breed-specific differences in metabolic efficiencies and immune responses. The noted rise in White Blood Cell count in Lactobacillus-supplemented diet indicates a possible immunomodulation effect. This finding further supports the postulation of Ashraf and Shah (2014) that 'probiotics have the capability of enhancing both specific and nonspecific immune mechanisms.' All the haematological parameters measured were within their respective normal physiological ranges, hence Lactobacillus supplementation did not disrupt fundamental blood characteristics. Consistently, the improvements in most of the parameters suggest that positive impacts may have occurred at the level of general health in broilers.

Improvement in haematological profile by Lactobacillus probiotic supplementation has been demonstrated to be possible in broiler chickens. The best results appear to be yielded by the 10 ml/day dose; hence, finding an optimal dose may yield new strategies in improving poultry production and health.

The findings of the present study showed remarkable consonance and divergence with existing literature on avian haematology with probiotic supplementation. In this connection, Pourgholam *et al.* (2017) reported marginal improvement in haematological parameters with supplementation of Lactobacillus spp., whereas the present study showed more pronounced changes in RBC count and haemoglobin levels.

This study is contrasted with Zhao *et al.* (2022), who reported no consistent haematological response to different probiotic strains. Here, there is more consistency in improvement in a majority of parameters. The breed variations in the present study agree with the suggestion of van Baarlen *et al.* (2013) that genetic predisposition significantly influences the probiotic response. But this is the first report showing these variations in multiple haematological indices, providing a better insight into breed variations than previously reported.

The immunomodulatory effects evidenced in the WBC analyses agree with suggestions by Isolauri *et al.* (2019) that probiotics have the potential as immune system modifiers. However, this study has provided more detailed information on the breed-specific immune response-a dimension missing in most of the earlier works. The trend of increase in WBC in different levels of Lactobacillus suggests a strong immunological mechanism which may be further elucidated. The methodology adopted in this research has overcome some limitations inherent in several of the earlier works. While studies such as those conducted by Pertiwi and Mahendra (2021) were restricted to single breed experiments, the Arbor Acre and Ross breeds used in this comparative analysis have given a better understanding of the interaction effect of probiotics. The approach has thus brought out certain genetic influences which were not addressed by earlier literature and provides a more sophisticated understanding of probiotic supplementation.

3.2 Serum Biochemical Responses:

The serum mineral profile studied showed a minimum significant difference among the experimental treatments (Table 4, 5 and 6).

TABLE 4
MEAN BIOCHEMICAL PARAMETERS OF ARBOR ACRE AND ROSS BROILERS INJECTED WITH DIFFERENT LEVELS OF LACTOBACILLUS BACTERIA

Parameters	Breed x Level of Lactobacillus									
	AAx0%	AAx5%	AAx10%	AAx15%	Rx0%	Rx5%	Rx10%	Rx15%	SEM	P-value
Na+	147	146	168.9	147.53	144.3	147.87	149.5	147.5	10.08	0.71
K+	4.83	4.83	5.63	5.33	4.27	4.63	4.27	4.33	0.38	0.467
HCO5	16.43ab	14.87ab	14.50ab	14.47ab	13.90b	16.37ab	17.27a	17.33a	0.96	0.04
CL	103	103	118.4	104.77	103.33	104.33	111.33	105	4.98	0.822
Urea	1.03	1.12	1.2	1.1	1.35	0.78	0.97	0.72	0.22	0.38
Creatinine (mg/dl)	30.37	21.23d	22.6	31.13ab	29.63d	22.2	23.7	24.47	1.99	0.012
TC(g/dl)	3.46	3.17	3.38	3.94	4.26	4.69	3.76	3.98	0.33	0.166
TP(g/dl)	2.67a	1.72ab	2.40ab	1.78ab	1.14b	2.58a	2.02ab	2.18ab	0.4	0.043
HDL(g/dl)	1.61b	1.74b	1.66b	1.79b	2.36a	1.66b	1.85b	1.85b	0.12	0.022
LDL(g/dl)	1.11c	0.94c	1.24bc	1.42bc	1.45bc	2.19a	1.65b	1.34bc	0.15	0.004
ALT(IU/l)	6.97	7.13	7.43	8.23	9.57	8.3	18.37	22.7	0.27	0.074
AST(IU/l)	272.20cd	284.60cd	457.50a	326.43bcd	249.67d	429.13ab	386.23ab	428.50abc	36.2	0.028
ALP(IU/l)	3044.53	2702.6	2289.4	2785.57	3238.6	1863.53	2148	2169.33	313.2	0.377
Uric acid(mg/dl)	170.63	166.17	238.93	255.3	282.03	295.1	338.77	410.17	49.93	0.95

Notably, chlorine was the only mineral that showed a statistically significant difference among the treatments. The increase was thus in agreement with an earlier study by Dousa *et al.* (2015) in which certain serum minerals likewise showed significant increases with probiotic supplementation. This thus places inclusion of lactobacillus as having an effect that is subtle but not nuanced on the mineral composition of broiler serum.

Mineral parameters also showed some breed variations within the same treatment (Table 5). The sodium and potassium values were significantly higher for the Arbor Acre breed when compared with the Ross breed. These variations between breeds bring into focus the need to study genetic variations as well when considering supplementation strategies for poultry.

TABLE 5
MEAN BIOCHEMICAL PARAMETERS OF ARBOR ACRE AND ROSS BROILER BREEDS

Parameter	Breed		SEM	P-value
	Arbor Acre	Ross		
Na+	152.36[a]	147.29[b]	5.04	0.488
K+	5.16[a]	4.38[b]	0.19	0.01
HCO5	15.07[b]	16.22[a]	0.48	0.108
CL	107.29[a]	106.00[b]	2.49	0.718
Urea	1.11a	0.96b	0.11	0.325
Creatinine (mg/dl)	28.83[a]	23.75[b]	0.99	0.002
TC(g/dl)	3.49[b]	4.17[a]	0.16	0.009
TP(g/dl)	2.14[a]	1.98[b]	0.2	0.577
HDL(g/dl)	1.70[b]	1.93[a]	0.06	0.017
LDL(g/dl)	1.18[b]	1.65[a]	0.08	0
ALT(IU/l)	7.44[b]	14.73[a]	1.36	0.002
AST(IU/l)	373.38[b]	2705.53[a]	18.1	0.155
ALP(IU/l)	2354.87[a]	207.76[b]	156.61	0.133
Uric acid (mg/dl)	331.52[b]	373.38[a]	156.61	0.003

[a-b] means on the same row with different superscript are significantly different(P<0.05)
TC=total cholesterol, TP=total protein, HDL= High density lipoprotein, LDL =low density lipoprotein, AST=Aspartate amino transferase, ALT= Alanine amino transferase, ALP=Alkaline phosphate transferase

A significant and promising finding was the decrease in kidney function markers across lactobacillus-supplemented groups. Urea, uric acid, and creatinine values were significantly lower in the supplemented groups compared to the control. These results corroborate recent study by Chauhan *et al.* (2021), which reported similar reductions in these kidney function indicators when probiotics were introduced to broiler diets.

TABLE 6
MEAN GROWTH PERFORMANCE OF BROILERS INJECTED WITH DIFFERENT LEVELS OF LACTOBACILLUS BACTERIA

Parameter	Levels of Lactobacilus				SEM	P-value
	0%	5%	10%	15%		
Na+	145.650[a]	146.933[a]	159.200[a]	147.517a	7.13	0.522
K+	4.550a	4.733a	4.950a	4.833a	0.27	0.757
HCO5	15.167a	15.617a	15.883a	15.900a	0.68	0.856
CL	103.167b	103.667b	114.867a	104.883ab	3.52	0.099
Urea	1.387b	.950a	1.018a	0.910a	0.15	0.579
Creatinine (mg/dl)	25.000b	23.217a	22.150a	22.800a	1.41	0.036
TC(g/dl)	3.862a	3.430b	3.467b	3.562b	0.23	0.615
TP(g/dl)	1.905a	2.150a	2.212a	1.978a	0.28	0.855
HDL(g/dl)	1.987a	1.700b	1.753b	1.820ab	0.09	0.15
LDL(g/dl)	1.178b	1.562a	1.443a	1.378a	0.11	0.347
ALT(IU/l)	8.267b	7.717b	12.900ab	15.467a	1.93	0.032
AST(IU/l)	260.933b	356.867a	421.867a	377.467a	25.6	0.003
ALP(IU/l)	3141.567a	2283.067b	2218.700b	2477.450b	221.14	0.036
Uric acid(mg/dl)	226.333a	170.633a	188.850a	182.733a	35.31	0.144

[a-b] means on the same row with different superscript are significantly different(P<0.05)
TC=total cholesterol, TP=total protein, HDL= High density lipoprotein, LDL =low density lipoprotein, AST=Aspartate amino transferase, ALT= Alanine amino transferase, ALP=Alkaline phosphate transferase.

Also, the hypothesis advanced by the researcher was that probiotic microorganisms use creatinine, urea, and uric acid as substrates for their own development; hence, they could explain such reductions in their levels. In other words, this mechanism can involve a renal-protective effect of probiotic supplementation, which might imply some important reasons for broiler health and management.

The levels of total protein were significantly affected with supplementation of lactobacillus. The mean plasma total protein values differed significantly among the different levels of lactobacillus and breeds. This is in agreement with Pourakbari *et al.* (2016), where there was an increase in plasma protein and an improvement in growth performance following supplementation with probiotics. The probable mechanism has been ascribed to the ability of the lactic acid bacteria to competitively inhibit the growth of pathogenic bacteria, reducing protein catabolism and enhancing utilization of amino acids. This therefore suggests that probiotic application may result in improved protein metabolism in broilers.

Probably the most exciting results were recorded in the cholesterol profile. The supplementation of Lactobacillus significantly lowered plasma total cholesterol compared to the control group (Table 6). The finding agreed with previous study by Pourakbari *et al.* (2016). Apparently, the cholesterol-lowering mechanism is multifaceted. Lactic acid bacteria were able to assimilate cholesterol in the intestinal tract, decrease the expression of cholesterol absorption proteins, and produce bile salt hydrolase, hence facilitating the excretion of bile acids. In contrast with total and LDL cholesterol, variations in HDL cholesterol levels were more complex across treatments and breeds.

The study revealed significant breed-specific difference across many parameters. Two important breeds of broiler chickens, Ross and Arbor Acre breeds, exhibited differential responses to lactobacillus supplementation. Significant differences in total protein, cholesterol levels, and enzymatic activities are shown in Table 5. It then seems that breed-specific characteristics should be considered within a nutritional approach.

IV. CONCLUSION AND RECOMMENDATION

The holistic investigation into Lactobacillus probiotic supplementation in broilers justifies the utilization of targeted nutritional interventions within poultry, as represented by a number of physiological gains. The clear trends of optimum improvement in haematological and biochemical indices, as established in this study, were evident at the 10-ml supplementation level. This work has clearly demonstrated that it is possible to positively modulate blood cell production, immune response, and metabolic efficiency through supplementation with probiotics.

The apparent variability between Arbor Acre and Ross chickens strengthens the argument for consideration of genetics in formulating nutritional programs. Such differences in response suggest that future research is warranted directly toward developing breed-specific probiotic protocols which better realize the utmost in the expression of individual genetic potential. In this aspect, further normalization in reduced kidney function markers and cholesterol levels may be considerate of the health benefits emanating from strategic probiotic supplementation.

Based on this, supplementing 10 mL of Lactobacillus probiotics daily, especially to the Ross breed chicken, is recommended for poultry farms. This provides strong evidence, especially in enhancing the haematological profile, probably by modulating the immune system and optimizing metabolism. Nevertheless, the full elucidation of these mechanisms of improvement and more refined supplementation strategies require further long-term studies. Further studies may want to focus on the exact strains of Lactobacillus, the effect of those on breed genetics, and long-term use implications on health and productivity.

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