International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 22s, 2025
https://theaspd.com/index.php

Comparative Study of Hematological Parameters Across Various Chicken Breeds: Implications for Health and Productivity

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Abstract: *Hematological parameters serve as crucial indicators of the health, immunity, and adaptability of poultry. This research compares essential blood parameters—white blood cells (WBC), red blood cells (RBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and hemoglobin (Hb)—among nine chicken breeds: Kadakanth, Kalinga Brown, White Leghorn, Rhode Island Red (RIR), Banaraja, Broiler, Sonali, Aseel, and Backyard. A total of 90 healthy chickens (10 from each breed) were evaluated using established diagnostic techniques. One-way ANOVA, along with Welch and Brown-Forsythe tests, evaluated the differences among the breeds. Notable variation ($p < 0.05$) was detected across all hematological parameters. The Kadakanth, Aseel, and Backyard breeds demonstrated superior hematological values, indicating enhanced immune status, efficient oxygen transport, and increased adaptability to environmental stressors. Conversely, the Banaraja and Broiler breeds presented relatively lower values, potentially reflecting diminished physiological resilience in extensive or less-than-optimal conditions. These results highlight the significance of breed-specific management approaches. Resilient breeds such as Kadakanth and Backyard are likely to flourish in low-input systems, while breeds with lower hematological indices, like Banaraja and Broiler, may need focused nutritional and breeding strategies. The study offers valuable insights for enhancing poultry health, productivity, and sustainability through customized breeding and management practices.*

Keywords: *Hematological parameters, adaptability, chicken breeds, hemoglobin, Poultry Health, Productivity, breed-specific differences, breeding interventions*

1. INTRODUCTION

Poultry accounts for over one-fourth of the world's meat production. In terms of human nutrition, it is a significant source of protein. In less than six weeks, broiler chickens suitable for the market may be produced using modern intensive production techniques. Better feeding, health management techniques, and increased output via genetic selection are the causes of this accomplishment (Apata, 2012). Genetic advancements are thought to be responsible for 90% of the changes in chicken phenotype. Thus, primary breeders' major goal was to choose breeds that would provide their clients with the highest economic return and the greatest commercial performance (growth rate, feed conversion, and meat output) (Seyedabadi et al., 2010). Domestic or local animal breeds with genetic variation preserve genetic diversity and increase production by enabling researchers and breeders to create new traits in response to changing environmental, illness, or market situations. The combined impacts of environmental factors and genetics determine animal productivity. The animal's genetic structure must be improved through selection and crossbreeding, and environmental circumstances must be optimized to raise the production level (ÇİLEK & Tekin, 2005).

One of the main areas of focus for poultry breeding and management is the goal of increasing laying hens' egg production (Kang et al., 2012). Its genetic composition and environment influence an animal's ability to generate eggs and how these three factors interact (Rodríguez-Hernández et al., 2021). The eggs' internal and exterior quality may be impacted by changes in gene transcription and protein synthesis in the hen oviduct throughout the poultry production process (Jung et al., 2011). The demand for broiler meat has grown over the last ten years due to customers' desire for premium foods that are rich in protein and low in fat. Customers are thus conscious of the quality and care of animals. Researchers seek techniques to reduce production costs to produce the most significant broiler meat from the lowest floor space (Chmelnicna & Solcianska, 2007). Poultry breeding programs will be made easier, and genetic improvement will be possible if the quantitative trait loci causing the economically significant characteristics in chickens are identified, as well as the genetic and metabolic regulation of growth. Growth rate and carcass quality have grown due to the chicken industry's genetic selection techniques (Zhou et al., 2005) In India, chicken farming was mostly a home hobby before 1960, but today, it has been transformed into a vigorous agribusiness valued at about `80,000 crore (Mohanta et al., 2022). Poultry farming in rural backyards is essential to India's quickly expanding economy. In addition to guaranteeing food supply, it gives the family financial stability. Poultry production is another source of income for women and unemployed youth. The foundation of a small-scale backyard farming operation in rural regions comprises indigenous or local poultry birds. Indigenous poultry are widely scattered in rural and peri-urban areas and play an important role in food production, income generation, and social life (Moreki et al., 2010). They can live, grow, and multiply on a plane of poor nutrition and can better adapt to their native habitat. The native chickens are famous for their capacity to adjust to tropical conditions, their tolerance to disease, and their ability to protect themselves from predators through the colour of their feathers (Padhi et al., 2012). Native chicken eggs and meat form a source of sustenance for most households throughout the country. Indigenous chickens have been employed in traditional medicine as well as for a range of cultural ceremonies. (Moreki et al., 2010).

Within a culinary niche market, the employment of indigenous hens is promoted by the recent development of ecologically rural connections and customer demands for food safety (Ekka et al., 2016). Local chicken meat and eggs are becoming increasingly popular in India due to their distinct flavour and superior nutritional content compared to goods from far-off commercial breeds. In this sense, quality must keep up with the rising demand, mostly relying on the implemented management systems. The number of native chicken populations in a given location may fluctuate between declining and growing. The sale of animals from outside the region, slaughter, disease, accidents, and predator consumption may all contribute to this. Ankaleshwar, Aseel, Busra, Chittagong (Malay), Danki, Daothigir, Ghagus, Harringhata Black, Kadaknath, Kalasthi, Kashmir Favorolla, Miri, Nicobari, Punjab Brown, Tellichery, Mewari, Kaunayen chicken, Hansli, and Uttara are among the 19 native breeds of India, according to ICAR-NBAGR (Mogilicherla et al., 2022). To implement preservation and improvement initiatives that will benefit the country, it is necessary to describe local chicken lines at the molecular level. When choosing to stay up with native variations, notable alleles may be useful, given the increased emphasis on genetic preservation. Effective management and genetic preservation depend on an awareness of the physiological health of Indigenous chicken breeds, given their increasing demand and the need to guarantee their quality and sustainability via haematological analysis.

However, an animal's haematological examination aims to analyze the animal's physiological state, diagnose, and give an overall picture of health and the body's capacity to fight illness (Thrall et al., 2022). Blood is a component that plays a vital part in the physiological processes of poultry, especially native chickens, according to (Syamsuryadi et al., 2020), who claim that the body's physiological characteristics indicate the condition of livestock. Therefore, Blood-related biochemical indicators, including serum and haematological, have been used to evaluate an animal's fitness and nutritional state. Packed cell volume (PCV), haemoglobin, white blood cells (WBCs), red blood cells (RBCs), as well as lymphocytes are some of the indicators that may be used to determine a feed's nutritional content. It is thus important to identify if the count of blood cells in an animal is normal, excessive, or uncommonly low and whether or not the cells are abnormal. (Kehinde et al., 2023).

In this regard, the current study is concerned with the haematological alterations of the majority of chicken breeds, including Kadaknath, Kalinga Brown, White Leghorn, Rhode Island Red (RIR), Banaraja, Broiler, Sonali, Aseel, and Indigenous chickens. Breed-specific physiological traits regarding health, adaptation, and productivity are investigated by the major blood parameters RBC count, WBC count, haemoglobin level, mean corpuscular volume (MCV), and mean corpuscular haemoglobin concentration (MCHC). This study also investigates gender variations among such breeds, which could provide an accurate evaluation of male and female haematological status. The result will likely help demystify the interface between genetic and environmental influences on production and health in different breeds. Finally, it provides relevant information to make breeding programs improve genetic diversity and chicken production practices for sustainable development.

The hematologic profile of different breeds of chickens has been the subject of various studies investigating various contributing factors. For example, (Horhoruw & Kewilaa, 2024) study analyzed the influence of age on haematological indicators in chickens. According to their observations, red and white blood cells, among other blood elements, may demonstrate notable alterations in chickens with increased age. Knowledge of this difference by age is vital to understanding the evolution and adaptability of hens' immune systems. Environmental influences have also been under the limelight, in addition to age. Based on (Oleforuh-Okoleh et al., 2024) research on the health impact of poultry exposure to crude oil, exposure may lead to negative alterations of the parameters in the chicken blood. To help maximize poultry-keeping practices, knowledge of environmental conditions under which hens are kept and their contribution to poultry well-being would be essential. Studies of poultry health have also concentrated extensively on nutrition treatments. According to (Youssef, Khalil, Shakoori, et al., 2023) and (Youssef, Khalil, Jaber, et al., 2023), mannan-oligosaccharides and chitosan-oligosaccharides enhance the health parameters of hens and enhance the immune response. These dietary supplements are thought to strengthen gut and immune function, increasing growth and resistance to disease overall. These nutritional changes are particularly relevant in modern chicken rearing, where optimising health through diet is a key objective. Differences in haematological parameters specific to an individual's genotype have also been well established. The importance of determining breed-specific variation in blood constituents has been emphasised by (Lugata et al., 2022) since different breeds of chicken can present with unique haematological characteristics. These breed-specific differences highlight establishing reference values for different breeds to ensure accurate and meaningful health assessment. Without breed-specific standards, generalizations concerning the health status of chickens will lead to misunderstandings. Such studies as by (Taha et al., 2022), (Hassan & Reda, 2021), and (Nwaigwe et al., 2020) emphasize the role that environmental conditions, seasonality, and physiological stress play in influencing the blood parameters of chickens. The experiments illustrate the dynamic nature of haematological profiles to external influence, which must be accounted for when considering poultry health and performance.

Although previous studies have examined the haematological indices of chickens from different breeds exposed to diverse environments, there are still knowledge gaps in understanding the whole spectrum of these variations, particularly in productivity characteristics. Though age, nutrition, and environmental stressors have been shown to affect parameters such as erythrocyte numbers, haemoglobin, hematocrit, and immune response, the literature shows that breed differences in blood parameters are poorly understood. For example, the age-related variation in hematocrit and haemoglobin levels, the impact of crude oil exhaust on red cell counts, and the immunoenhancing effect of COS- and MOS-enriched diets have been noted. Yet, a comprehensive, breed-specific haematological profile, particularly one related to productivity traits, remains to be fully explored. This research tries to fill these gaps through the undertaking of a comprehensive comparative examination of haematological parameters among various chicken breeds to further enhance breed choice, management strategies, and overall poultry health and productivity.

Aim and Objectives

This study's objective is to compare the basic hematological characteristics of several chicken breeds to comprehend their physiological characteristics regarding adaptation, production, and health. This research assesses important blood variables to improve breed selection and poultry farming methods for sustainable expansion.

Objectives:

- Data collection of various hematological parameters among various breeds
- Comparision of haematological parameters (WBC, RBC, haemoglobin, MCV, MCHC) across chicken breeds.

MATERIALS AND METHODS

Study Design

Comparable cross-sectional research was conducted at department of Zoology, Centurion University of Technology and Management campus, Bhubaneswar. Blood samples from chicken breeds were drawn for the determination of hematological profile includes MCHC and Hb levels. The chicken breeds involved in the study were Kadakanth, Kalinga Brown, White Leg Horn, RIR, Banaraja, Broiler, Sonali, Aseel, and Backyard chickens.

Sampling

The study population is chickens from different poultry farms, specifically those in controlled conditions. Out of 90 chickens, where 10 are sampled per breed, they were sampled to have an even representation of each breed. Stratified random sampling was done to select the chickens, and the sample will represent the general health status and the age groups of each breed. Healthy chickens only, with no disease or parasitic infections, were used in the study. The chicken selection was also based on the same age category to reduce the influence of age on the haematological parameters.

Data Collection

Data collection in this study used a range of haematological examinations to evaluate the chickens' health parameters. Each chicken had a blood sample obtained using routine procedures, either wing vein or jugular vein. Mean Corpuscular Hemoglobin Concentration (MCHC) was determined using an automated blood tester, showing the amount of haemoglobin in the red blood cells. On average and the oxygen-carrying capacity of these cells. Haemoglobin concentrations were quantified by hemoglobinometer since haemoglobin concentration is critical for assessing oxygen transport capacity in the blood. Also recorded as part of the data set for each breed were observational data pertaining to the chickens' overall health, including growth rate, feed intake, and any health issues.

Estimation of Hemoglobin Concentration in Chicken Breeds Using Sahli's Hemoglobinometer

The hemoglobin levels in various chicken breeds were determined using a Sahli hemoglobinometer. A volume of 20 µL of EDTA-treated blood obtained from the wing vein of each bird was added to a Sahli tube filled with 0.1N hydrochloric acid up to the 2 g/dL line. The sample was left undisturbed for 10 minutes to enable the conversion of hemoglobin to acid hematin. Afterward, distilled water was meticulously added dropwise while gently stirring until the solution's color matched that of the comparator. The hemoglobin concentration was then read directly from the calibrated tube and recorded in g/dL. All samples were analyzed under consistent lighting conditions, and triplicate measurements were taken to ensure accuracy (Bain, B. J. 2006).

Estimation of Hematological Parameters in Chicken Breeds Using Automated Analyzer

Hematological parameters were assessed in blood samples obtained from different chicken breeds using the Sysmex KX-40 automated hematology analyzer. This analyzer functions on the principle of electrical impedance (Coulter method) for counting blood cells and employs a non-cyanide photometric technique for the estimation of hemoglobin. Approximately 1–2 mL of whole blood was aseptically harvested from the wing vein of each chicken with sterile 23G needles and syringes, and subsequently transferred into 2 mL EDTA-coated vacutainer tubes to inhibit clot formation. The samples were gently mixed and analyzed within 2 hours of collection to preserve their integrity. The analyzer drew an internal volume of roughly 100–200 µL from each sample for evaluation. Before testing, the device underwent calibration with quality control reagents provided by the manufacturer and was cross-validated with control avian blood samples. The recorded parameters consisted of red blood cell count (RBC), white blood cell count (WBC), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). Each sample underwent triplicate analysis, and the coefficient of variation (CV) for intra-assay precision was kept under 5% to ensure accuracy and efficiency. Daily maintenance and quality checks were conducted according to the manufacturer's guidelines to maintain analytical reliability throughout the study (Jain, N. C. 1993; Sysmex K-40 corporation. 2000).

Statistical Analysis

Statistical analysis in this research comprised descriptive and inferential techniques for comparison of haematological features of various breeds of chicken. First, it was determined the mean and ranges of MCHC values and Hb content in every breed that gives insights about the distribution of their attributes. Using one way ANOVA, considerable differences among the breeds using significant statistical measures such as the p-value, F-statistic, mean square, and sum of squares.

Robust tests of equality of means

Both the Welch and Brown-Forsythe tests were used to verify ANOVA findings in the context of the decomposition of homogeneity of variance. Both tests resist non-compliance with the equal variance of groups, so the results can be trusted. If ANOVA findings proved significant, post-hoc testing was also performed to examine specific differences between individual pairs of breeds. To achieve this, pairwise comparisons by Tukey's HSD test were made to determine which specific chicken breeds significantly differed from one another in the MCHC and Hb levels, further explaining the nature of differences among the groups.

RESULTS AND DISCUSSION

The haematological parameter evaluation of WBC, RBC, MCV, MCHC, and Hb indicates various chicken breeds' physiological traits and health conditions. These parameters are crucial indicators of immune protection efficiency, oxygen-carrying efficiency, and general adaptability to environmental and management conditions. By comparing these factors in different breeds, their relative weaknesses and strengths are established and can be utilized in breed-specific health management and productivity plans. Based on these results, poultry farmers, veterinarians, and scientists can develop breed-specific management practices, maximize selective breeding schemes, and enhance health interventions to improve chicken breeds' performance, resilience, and adaptability in different production systems.

WBC – White Blood Cell Count

This analysis's goal was to confirm the theory that there is a significant variation in white blood cell (WBC) counts across different chicken breeds. For these purposes, descriptive statistics, ANOVA, and resistant tests were used for data analysis.

Table 1 Descriptive Statistics of White Blood Cell (WBC) Count Across Chicken Breeds

White Blood Cell Count			
Type of Breed	**N**	**Mean**	**Std. Deviation**
Kadakanth	10	53.8895	4.27156
Kalinga Brown	10	25.0153	3.75074
White Leg Horn	10	24.2756	3.30162
RIR	10	26.3303	4.61756
Banaraja	10	26.0496	3.93927
Broiler	10	24.1480	4.57643
Sonali	10	22.7520	3.03093
Aseel	10	26.7062	4.20862
Backyard	10	53.6264	5.51288
Total	90	31.4214	12.70896

Table 1 depicts WBC counts for nine chicken breeds, each with 10 observations and was highly variant across the breeds. The Kadakanth breed exhibited the highest mean WBC count (53.8895), closely followed by the Backyard breed (53.6264), indicating that these breeds may have stronger immune responses. In contrast, the Sonali breed had the lowest mean WBC count (22.7520), suggesting potential differences in immune function compared to other breeds. The standard deviations ranged from 3.03093 (Sonali) to 5.51288 (Backyard), reflecting the variation in WBC counts within each breed. The overall mean WBC count across all breeds was 31.4214, and a standard deviation of 12.70896. Thus, it reflects that the breeds have significantly variable WBC counts.

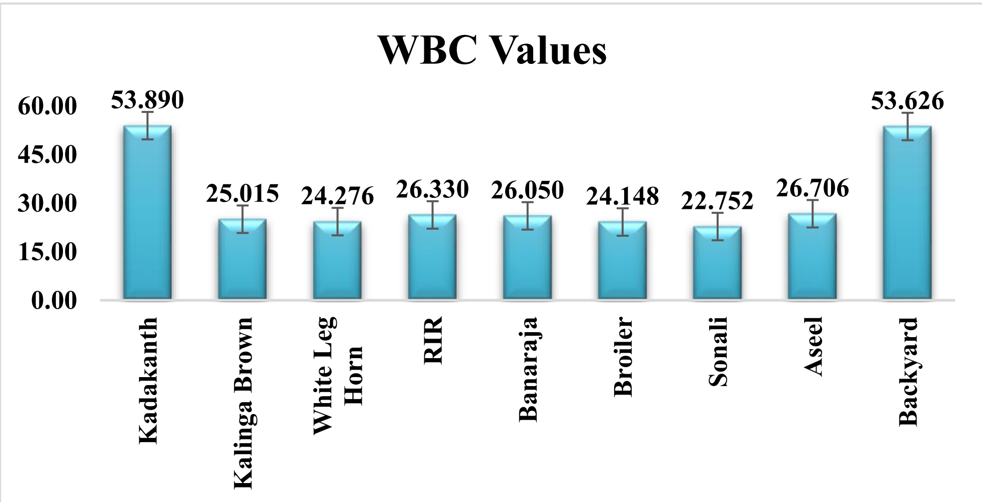

Table 2 ANOVA Table for WBC Counts Across Chicken Breeds

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12950.476	8	1618.810	92.042	.000
Within Groups	1424.604	81	17.588		
Total	14375.080	89			

The purpose of Table 2 is to check if there is a statistically significant variation in the WBC counts between the breeds. The sum of squares between groups is 12,950.476, and the mean square value is 1,618.810. It can be seen that most of the variation in WBC counts happens because of differences between breeds. The F-statistic is 92.042. This is highly significant ($p < 0.001$), proving the difference in WBC counts between chicken breeds. This result supports the hypothesis that breeds significantly influence WBC levels, likely due to genetic and physiological variations.

Table 3 Robust Tests of Equality of Means for WBC Counts Across Chicken Breeds

Robust Tests of Equality of Means				
	Statistica	df1	df2	Sig.
Welch	69.860	8	33.686	.000
a. Asymptotically F distributed.				

The robust Welch test, as seen in table 3, was utilized to verify the ANOVA findings, particularly when the homogeneity of variances could be compromised. The test provided a value of 69.860 (df1 = 8, df2 = 33.686, $p < 0.001$), which indicates that the variation of WBC counts among chicken breeds is still significant even with unequal variances. This outcome confirms the validity of the observed differences, ensuring that they are not affected by the assumption that homogeneity of variance was violated.

Hence, the results show significant variations in white blood cell counts across chicken breeds, as shown by the ANOVA and robust tests. Dogs with higher white blood cell counts, like Kadakanth and Backyard, may have better immune systems and are less susceptible to illnesses and infections. Sonali dogs, in contrast, require more advanced care and treatments to improve their immunity as they record the lowest white blood cells. Changes in the number of blood cells this wide depict how breed-specific determinants of genetic and physiological types impact immunological mechanisms. These findings are indispensable in optimizing poultry production to make breeding-specific healthcare approaches optimal. The findings indicate the presence of a breed-specific difference in the white blood cell count.

RBC (Red Blood Cell Count)

The goal of this analysis was to confirm the hypothesis. (H2), there is a notable difference in red blood cell (RBC) counts among chicken breeds. Descriptive statistics, ANOVA, and robust tests were used to analyze the data and determine breed-specific differences in RBC counts.

Table 4 Descriptive Statistics for RBC (Red Blood Cell Count) Across Chicken Breeds

Red Blood Cell Count			
Type of Breed	**N**	**Mean**	**SD**
Kadakanth	10	4.4691	1.43086
Kalinga Brown	10	2.5851	1.09503
White Leg Horn	10	2.8591	1.07467
RIR	10	2.4786	0.65890
Banaraja	10	2.2951	1.16002
Broiler	10	2.5638	1.11725
Sonali	10	2.3130	0.62423
Aseel	10	2.3475	0.43219
Backyard	10	4.2257	1.59815
Total	90	2.9041	1.30386

The descriptive statistics in table 4 summarize the RBC counts for nine chicken breeds, with each breed having 10 observations. The mean RBC count was varying across the breeds. The highest value was observed in the Kadakanth breed with a mean RBC count of 4.4691, followed by the Backyard breed at

4.2257, indicating that these breeds might have a better oxygen transport efficiency that supports metabolic activity and performance. On the other hand, the Banaraja breed had the lowest mean RBC count of 2.2951, with similar values being seen with Sonali at 2.3130 and Aseel at 2.3475. These lower RBC counts may suggest lower oxygen-carrying capacity in these breeds. The standard deviations varied from 0.43219 (Aseel) to 1.59815 (Backyard), indicating the variability in RBC counts within the breeds. There was substantial variation across breeds, as seen by the total mean RBC count of 2.9041 across all breeds and a standard deviation of 1.30386.

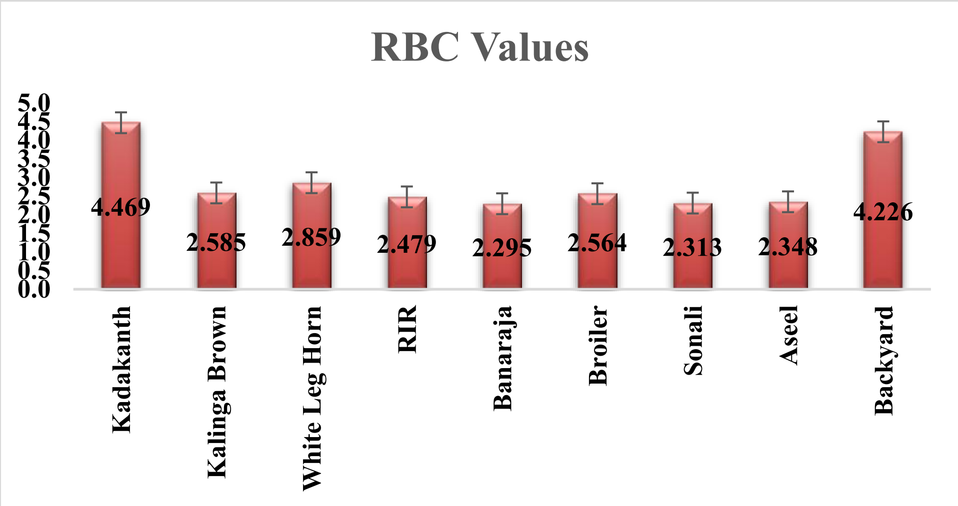

Table 5 ANOVA Table for WBC Counts Across Chicken Breeds

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	56.266	8	7.033	5.994	.000
Within Groups	95.039	81	1.173		
Total	151.305	89			

Table 5 assesses the breed-wise differences that are statistically significant across the mean RBC counts. A high value for the sum of squares between the groups (56.266) and the subsequent mean square value of 7.033 shows a big part of the total variation in the RBC counts of different breeds. The F-statistic of 5.994 is highly significant ($p < 0.001$), showing that RBC counts differ significantly across chicken breeds. Breed-specific genetic and physiological factors will likely be implicated in the differences in RBC counts.

Table 6 Robust Tests of Equality of Means for WBC Counts Across Chicken Breeds

Robust Tests of Equality of Means				
	Statistic[a]	df1	df2	Sig.
Welch	3.732	8	33.279	0.003
a. Asymptotically F distributed.				

The Robust Tests of Equality of Means Table 6 shows that Welch's test was used to account for any violations of the homogeneity of variances assumption. The test produced a statistic of 3.732 ($p = 0.003$), showing that the differences observed in the RBC count across breeds are statistically significant even when more stringent conditions are used. This further supports the ANOVA findings, with more assurance that the differences observed are not a result of variance homogeneity violations and are robust.

Thus, the results show statistically significant variations in RBC counts between chicken breeds, as shown by the ANOVA and the Welch test. Having a greater red blood cell count suggests that breeds like Kadakanth and Backyard are better able to transport oxygen, which in turn supports a faster rate of metabolic activity and overall productivity. Breeds like Banaraja and Sonali, on the other hand, may benefit from targeted nutritional and health programs to boost their overall performance and oxygen transport efficiency due to their lower numbers. Haematological profiles are determined by breed-specific genetic and physiological variables, which are reflected in the large diversity in RBC count. Results like this provide credence to the null hypothesis (H2) that chicken breeds have significantly different RBC levels, which may help manage poultry health, improve production, and select genetic lines.

MCV – (Mean Corpuscular Volume)

The study attempts to verify the hypothesis (H3) that there is a substantial variation in mean corpuscular volume among chicken breeds. To this end, descriptive statistics, ANOVA, and robust tests were applied to analyze MCV data in the breeds.

Table 7 Quantification of MCV among various chicken breeds

MCV	N	Mean
Kadakanth	10	168.6275
Kalinga Brown	10	147.5262
White Leg Horn	10	142.6726
RIR	10	149.6226
Banaraja	10	144.7037
Broiler	10	144.7694
Sonali	10	142.1130
Aseel	10	115.7574
Backyard	10	161.4340
Total	90	146.3585

Table 7 present the MCV of nine chicken breeds, each with a sample size 10 and across the breeds was relatively high in its variation. Kadakanth recorded the highest mean MCV at 168.6275, followed by the Backyard breed with a mean of 161.4340, indicating that such breeds can possess larger red blood cells that, in turn, can facilitate higher oxygen transportation as well as more efficient metabolism. Conversely, the Aseel breed had the lowest mean MCV of 115.7574, which implies smaller red blood cells and potentially compromised oxygen-carrying capacity. Other breeds like Kalinga Brown (147.5262) and RIR (149.6226) had mid-range MCV values. The mean MCV for all the breeds combined was 146.3585, which implies extreme variation in the size of red blood cells between the breeds.

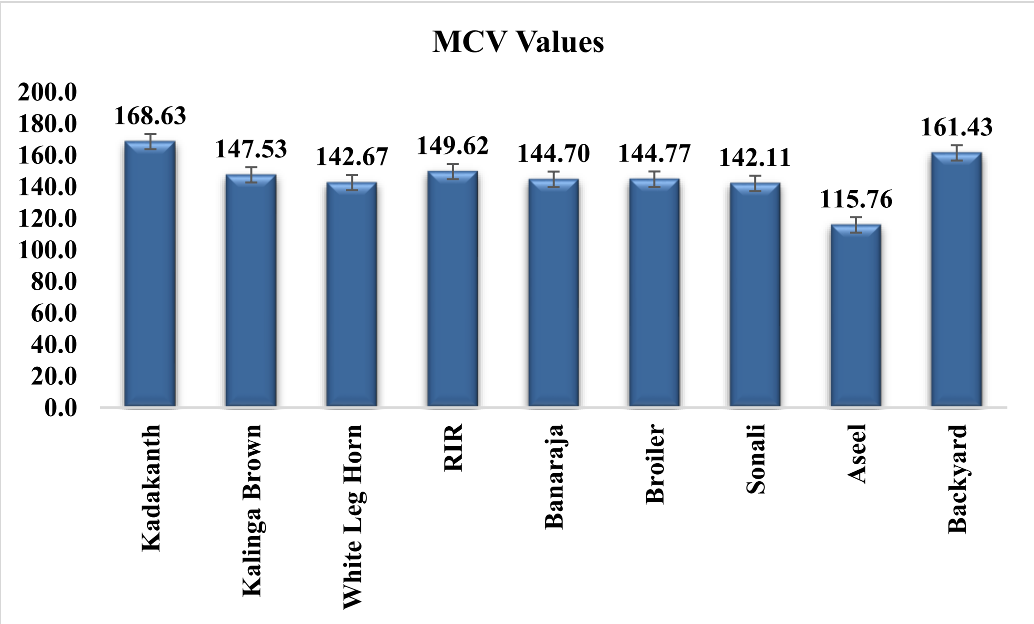

Table 8 MCV variations among Different Chicken Breeds.

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17084.980	8	2135.622	5.474	.000
Within Groups	31600.907	81	390.135		
Total	48685.887	89			

Table 8 depicts MCV differences between breeds which are statistically significant. The sum of squares between groups is 17,084.980, and the mean square value is 2,135.622. This shows that most MCV total variation results from differences between breeds. The F-statistic was 5.474, which is important. with $p < 0.001$. This means there's a difference in MCV values among different chicken breeds. This implies genetic and physiological factors for each breed affect the size of red blood cells.

Table 9 Robust Tests of Equality of Means for WBC Counts Across Chicken Breeds

Robust Tests of Equality of Means				
MCV				
	Statistic[a]	df1	df2	Sig.
Welch	6.452	8	33.669	0.000
a. Asymptotically F distributed.				

According to Table 9, the robust test (Welch test) was used to confirm the ANOVA results in cases where There may be a breach of the uniformity of variances premise. The Welch test gave a statistic of 6.452 ($p < 0.001$), which confirms that the differences in MCV values among breeds are statistically significant even under stricter conditions. This robust test reinforces the reliability of the results, ensuring that the observed differences are not artefacts of unequal variances.

The ANOVA and Welch test shows significant differences in the MCV values of the chicken breeds. Breeds like Kadakanth and Backyard with the largest MCV values most likely possess bigger red blood cells, which might enhance oxygen delivery and fitness to stressful environmental conditions. On the other hand, the Aseel breed with the smallest MCV value may suffer from lower efficiency in oxygen transport and, thus, its productivity. These findings demonstrate the role of breed-specific genetic and physiological factors in influencing MCV and their significance about health and performance. The large variation in MCV validates the hypothesis (H3) that there is a notable variation in MCV among chicken breeds. It provides valuable information for selective breeding, healthcare, and productivity improvement in poultry farming.

MCHC – (Mean Corpuscular Hemoglobin Concentration)

The test tries to prove the hypothesis (H4) that there is a significant mean corpuscular haemoglobin concentration difference (MCHC) across chicken breeds. To this end, descriptive statistics, ANOVA, and robust tests were used to analyze the data of the various breeds.

Table 10 Quantification of MCHC among various chicken breeds.

MCHC	**N**	**Mean**
Kadakanth	10	37.3608
Kalinga Brown	10	26.6961
White Leg Horn	10	26.8589
RIR	10	26.5683
Banaraja	10	25.5485
Broiler	10	25.5750
Sonali	10	25.7572
Aseel	10	32.6368
Backyard	10	37.0840
Total	90	29.3428

Concentration of MCHC for nine breeds of chickens, each breed with 10 observations were recorded as shown in the table 10. The mean MCHC showed significant differences between breeds and higher value was seen in the Kadakanth breed (37.3608), followed by Backyard (37.0840). This explains that these breeds have higher haemoglobin concentrations in red blood cells that enhances oxygen-carrying efficiency. Banaraja and Broiler breeds recorded the lowest (25.5485 and 25.5750) might reflects low haemoglobin concentration and could be inefficient oxygen carriers. Other breeds, Kalinga Brown (26.6961) and White Leg Horn (26.8589), bears intermediate levels. Mean MCHC of all the breeds (29.3428) indicated significant variation in the breed's haemoglobin concentration.

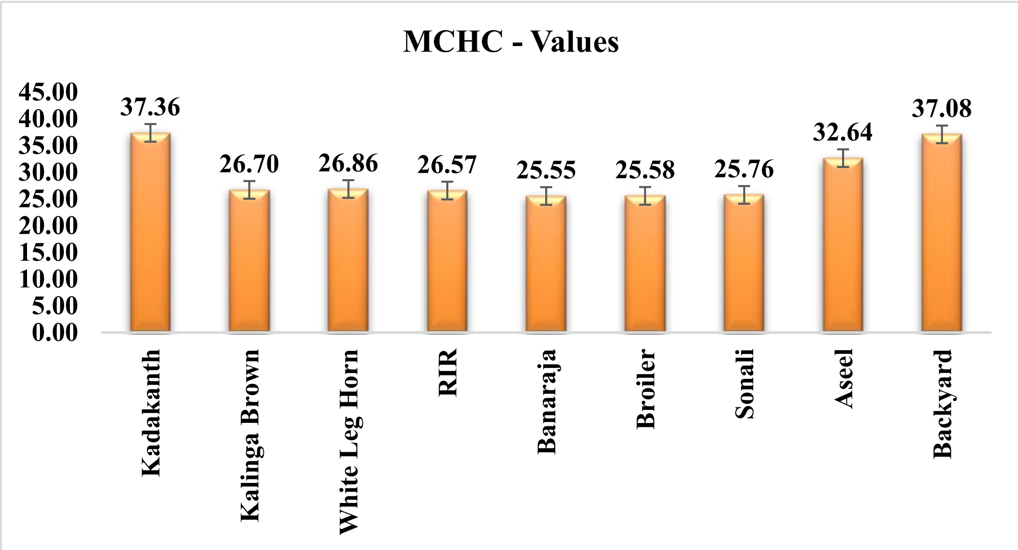

Table 11 MCHC among Different Chicken Breeds.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1973.871	8	246.734	12.574	0.000
Within Groups	1589.400	81	19.622		
Total	3563.271	89			

Table 11 determines the sum of squares between groups (1,973.871) and the mean square value (246.734) which indicates that a substantial portion of the total variation in MCHC is due to differences between breeds. The extremely significant F-statistic of 12.574 ($p < 0.001$) indicates that the MCHC differences across breeds are not random. Thus, breed-specific genetic and physiological factors significantly influence MCHC levels.

Table 12 Robust Tests of Equality of Means for WBC Counts Across Chicken Breeds

Robust Tests of Equality of Means				
MCHC				
	Statistic[a]	df1	df2	Sig.
Welch	11.358	8	33.707	0.000
a. Asymptotically F distributed.				

Robust Test of Equality of Means:

A robust test was applied to further test the results of the ANOVA test, particularly in the case of the Welch test, whenever there was a breach of the homogeneity of variances assumption. Accordingly, the Welch test produced 11.358 ($p < 0.001$), thereby upholding that differences between breeds in MCHC continue to attain statistical significance even under stricter conditions. This robust test consolidates the reliability of the outcome to ensure the observed differences are not upsurged due to variance heterogeneity.

So, according to both the ANOVA and the Welch tests, A notable variation was seen in the MCHC levels of the different chicken breeds. With their elevated haemoglobin levels, the breeds Kadakanth and Backyard exhibited superior physiological performance and oxygen transport efficiency, as shown by their highest MCHC values. Optimised nutrition and health management might be targeted treatments that breed with the lowest MCHC, such as Broiler and Banaraja, need to boost production and oxygen-carrying capacity. Significant differences in MCHC point to genetic and physiological influences on breed-specific haemoglobin concentration. This lends credence to hypothesis H4, which posits that chicken breeds exhibit significantly different MCH. Poultry farmers and researchers may utilise them to create management plans customised to each breed of chicken, improving their health and production.

Hb – (Hemoglobin)

The analysis aims to evaluate the theory (H4) that there are notable distinctions between breeds for the concentration of haemoglobin (Hb). This is therefore achieved by performing descriptive statistics, ANOVA, and robust tests on the data generated across the respective breeds.

Table 13 Estimation of Hb

Hb	N	Mean
Kadakanth	10	14.8377
Kalinga Brown	10	12.8317
White Leg Horn	10	13.3646
RIR	10	10.9105
Banaraja	10	10.4273
Broiler	10	10.4483
Sonali	10	11.6889
Aseel	10	13.6527
Backyard	10	13.7537
Total	90	12.4350

Table 13 shows summary of hemoglobin concentrations in nine breeds with 10 observations of each and was different between breeds. The Kadakanth breed showed the highest mean Hb concentration, which was 14.8377. The Backyard breed and Aseel breed showed a mean Hb concentration of 13.7537 and 13.6527, respectively. This may imply that these breeds have better oxygen-carrying capacity and physiological performance. In contrast, the Banaraja and Broiler breeds showed the lowest mean Hb concentrations at 10.4273 and 10.4483, respectively, suggesting reduced oxygen transport efficiency, which may affect their productivity and adaptability. The overall mean Hb concentration across all breeds was 12.4350, which reflected moderate variation in haemoglobin levels among breeds.

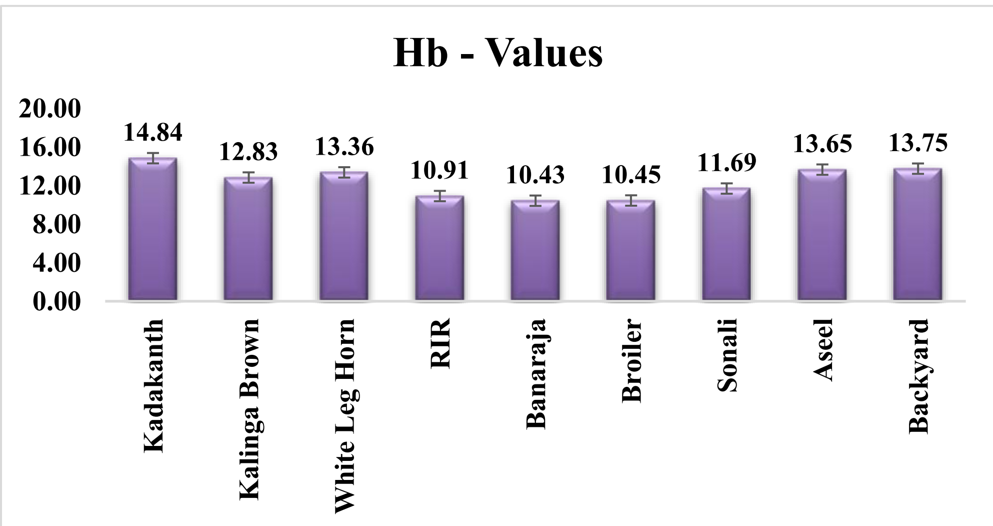

Table 14 variations in Hb levels Among Different Chicken Breeds.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	208.749	8	26.094	2.809	.008
Within Groups	752.417	81	9.289		
Total	961.165	89			

The ANOVA table 14 assesses the statistical significance of the observed variations in Hb values between the breeds. The sum of squares between groups amounted to 208.749, with a mean square value of 26.094. This suggests that part of the variation in Hb concentration is attributed to differences among breeds. An F-statistic of 2.809 results as significant given p = 0.008. It simply shows that chicken breeds differ substantially in Hb concentration. Breed-related genetic factors, among others in physiology, are implied by such a difference.

Table 15 Robust Tests of Equality of Means for WBC Counts Across Chicken Breeds

	Statistic[a]	df1	df2	Sig.
Welch	3.155	8	32.389	.009
a. Asymptotically F distributed.				

Test for the Equality of Means

Table 15 shows that the Welch test was used to check whether the ANOVA findings were accurate and to account for any possible breaches based on the notion that variances are homogeneous. Under more stringent circumstances, the test still returned a significant statistic of 3.155 (p = 0.009), demonstrating that there are still substantial differences across the groups. This guarantees that the observed changes are not affected by differential variances between the groups, strengthening their validity.

Consequently, there is a statistically significant variation in Hb concentration between chicken breeds, as shown by the ANOVA and Welch tests. Because of this, breeds like Kadakanth, Backyard, and Aseel, which have a larger haemoglobin concentration, are more equipped to transfer oxygen efficiently and operate more productively under different settings. This is particularly true when considering the need to specifically target and treat breeds like Banaraja and Broiler, which have a lower Hb content, to enhance their physiological performance and oxygen-carrying ability. Therefore, breed-specific genetic features will never allow the perfect pairing of animals with widely differing Hb concentrations. Based on the results, it can be validated that various chicken breeds contain varied haemoglobin concentrations which is possible of utilizing for breed-specific health and production management on chicken farms.

CONCLUSION

The study documents important distinctions among haematological measures like WBC, RBC, MCV, MCHC, and Hb of different chicken breeds, emphasising breed-specific physiological traits impacting productivity and health. Backyard, Kadakanth, and Aseel exhibited increased values of these parameters, demonstrating greater immunity, efficient oxygen supply, and improvement in the handling of environmental stress. On the other hand, Banaraja, Broiler, and Sonali types had lower values with physiological restraint that could affect performance and survival. All such results are being utilized to establish the significance of breed-specific management plans for breed health, where there is minimal need for disease medications in highly WBC-positive breeds such as Kadakanth and Backyard since their immune system is healthy, and for less WBC-present breeds such as Banaraja and Broiler more vaccines and health monitoring programs can be administered. Further, superior oxygen transport parameters in Kadakanth, Backyard, and Aseel suggest their ability to achieve high-performance conditions, while Banaraja and Sonali can be upgraded with precise nutritional and genetic interventions. Such findings are crucial for scientists, veterinarians, and poultry farmers to make wise choices in selecting breeds, healthcare, and enhancing productivity. By breed-specific interventions, sustainable poultry farming can be ensured to enhance yields, adaptability, and welfare levels. This study also underscores the need for further studies on environmental and genetic factors influencing haematological variation to optimise chicken breeding programs. Overall, breeders' understanding of and sensitization to breeds' physiological needs could bring economic sustainment and security in poultry chicken production and optimize utmost health and poultry chickens' wellness.

Conflicts of Interests:
Authors declare no conflicts of interest.

Acknowledgements:
The authors gratefully acknowledge the invaluable support of the faculty members of the Department of Zoology, Centurion University of Technology and Management. Special thanks are extended to Mr. Vikash Ranjan Sahoo (Laboratory In-Charge) and Mr. Manoj Kumar Mahana (Laboratory Attendant) for their dedicated assistance in sample collection, handling, and laboratory procedures. We are also thankful to Centurion University of Technology and Management for providing the necessary infrastructure and research facilities that enabled the smooth execution of this poultry-based study. The authors further extend their appreciation to their colleagues for their encouragement, cooperation, and constructive input throughout the course of the research.

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