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RESEARCH ARTICLE

Growth Performance and Blood Profiles of Indigenous Venda Chickens Under Intensive and Semi-Intensive Rearing Systems

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Abstract: A 91-day trial examined the impact of two production systems on crop content, growth performance, hematology, and blood chemistry of indigenous Venda chickens. One-day-old Venda chickens (n = 100) were randomly assigned to two treatments (T1 and T2) and replicated five times with 10 birds per replication. Venda chickens in each group were placed in five replicate pens, each having 10 chicks arranged in a completely randomized design. Birds in the T1 (intensive) and T2 (semi-intensive) groups received a starter diet (19.52% CP, 3141.48 kcal/kg ME) from 1-49 days and a grower diet (18.03% CP, 3155.58 kcal/kg ME) from 50-91 days. The proximate analysis indicated that the crop content of semi-intensively reared birds had higher phosphorus and ME values than those of intensively reared birds. During the starter and grower phases, birds managed semi-intensively had significantly better ($p<0.05$) growth indices in all production phases than the intensive group. Hematological values revealed that T2 birds had significantly increased ($p<0.05$) Hemoglobin (Hb) level and red cell indices compared with the T1 birds. Heterophil counts were statistically ($p<0.05$) lower in T1 birds than in T2 birds. Blood chemistry results demonstrated that birds on T1 treatment had their serum Alkaline Phosphatase (ALP) reduced by 4% compared to those on T2 treatment. In conclusion, these results indicate that Venda chickens raised in a semi-intensive production system had higher phosphorus and ME values in their crop content and better ADG and blood indicators than birds raised in an intensive production system. This study generates baseline data that help clarify how rearing systems influence the productivity of indigenous Venda chickens.

Keywords: Indigenous Chickens, Production Systems, Crop Content, Growth, Blood Characteristics

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Introduction

Poultry farming in South Africa is broadly categorized into traditional and industrial sub-sectors [1]. Each of these sub-sectors has unique characteristics that enable it to contribute to nutritional security. The industrial sub-sector comprises mostly broilers and layers with a high ability to produce meat and eggs [2]. They are often farmed in urban and semi-urban zones where the facilities for the rearing and marketing of their products are available. In contrast, the traditional system comprises mostly indigenous chickens, including Ovambo, Venda, etc. This system makes up roughly 94% African rural chicken population, supplying most chicken products eaten in rural regions and accounting for roughly 20% of the poultry products consumed in urban areas [3]. The productivity of indigenous chickens is less compared with the intensively reared birds; however, they require minimal labour, inputs, and rearing costs [3]. Furthermore, village chickens thrive regardless of several challenges such as climate change impact, theft, poor housing, disease prevalence, absence of veterinary services, scavenge-based feeding, inadequate nutrition, and unchecked breeding [4, 5]. Despite their ability to withstand difficult production environments, indigenous chickens have been kept out of mainstream research because of their low output when compared to commercial chicken breeds [6, 7]. The probable constraint associated with indigenous chicken production is poor nutrition, resulting in poor productivity when compared with the exotic (broiler) chickens. Against this background and considering the great variability in productivity associated with the traditional production system, it thus becomes very imperative to evaluate the impact of rearing (production) systems on the health and productivity of local chickens. Blood profiles are routinely used in animal production as an index of the health and physiological well-being of chickens. Improved performance of South African local, including Venda chickens and synthetic chickens reared under an intensive system of production, has been studied [8-11]. Data on growth characteristics and blood values of locally adapted indigenous chickens managed in semi-intensive and scavenging systems are, however, limited.

The South African indigenous chickens are dual-purpose chickens that are reared for their eggs and meat under scavenging management systems by rural households [9]. Data on nutrient requirements of indigenous chicken breeds is, however, limited. Kingori et al. [12] found that a diet with a 16% crude protein level is adequate for intensively reared indigenous chickens during the growth phase. Duguma [13] reported that the major feed resources for indigenous chickens under scavenging management in Ethiopia were grain supplements, earthworms, damaged seeds, insects, homemade wastes, and green leaves. Despite their low productivity in terms of poor feed conversion and growth rate [14], they are hardy, well-adapted to harsh environments, and can thrive under low or no inputs [15]. Indigenous chickens have excellent mothering ability and have the capacity to resist common chicken diseases [13]. However, little is known about how rearing systems influence crop contents, growth metrics, and blood characteristics of indigenous Venda chickens.

Thus, the performance parameters of Venda chickens reared in intensive and semi-intensive management systems in South Africa need to be studied, given their role in boosting socioeconomic status and nutrition security for most households. Furthermore, it is envisaged that the availability of information on the performance parameters of Venda chickens reared intensively and semi-intensively in South Africa will help in the understanding of the best rearing system for improved performance of Venda chickens reared in South Africa. Thus, this study aimed to examine the crop contents, growth dynamics, and blood parameters of indigenous Venda birds on two production systems. It is therefore hypothesized that there are no significant differences in experimental diet, proximate composition of crop contents, growth performance, and blood profiles of Venda chickens.

Materials and Methods

This experiment was performed at the Livestock Unit, James Nxumalo Agricultural High School Farm, in the Zululand District of KZN, South Africa, with coordinates of 28°20'S and 31°23'E. The temperature in the study area spans from 9-30°C throughout the year, with temperatures rarely falling below 9°C or rising over 30°C. The study was conducted in accordance with the Institution's ethics guidelines (ID: 2022/CAES-AREC/082).

One-day-old Venda chickens (n = 100) were randomly assigned to two treatments (T1 and T2) and replicated five times with 10 birds per replication. Venda chickens in each group were placed in five replicate pens, each having 10 chicks arranged in a completely randomized design. The experimental chicks were housed in a poultry house with the floor spread with wood shavings to a depth of 0.2 m. The semi-intensive system has an indoor and outdoor area of 0.6 and 1.4 m2/bird, respectively. Access to the outdoor run from the pens was allowed from 8:00 am to 3:00 pm. Outdoor access allowed the birds to scavenge, scratching the ground and searching for insects and worms. The intensive system has an indoor area of 0.6 m2/bird without an outdoor run availability. The chickens were exposed to natural ventilation and lighting and received a starter diet (d1-49) and grower feed (d 50-91), as displayed in Table 1. Birds had unrestricted access to feed and water during the 13 weeks the experiment lasted.

The chicks were weighed at the onset of the research. Thereafter, weights per chick were taken weekly. Average daily feed intake per bird was calculated as the weight of feed offered minus the weight of leftovers the next day, divided by the total number of birds in the pen. Average Daily Gain (ADG) was computed by subtracting the Initial Live Weight (ILW) from the Final Live Weight (FLW), divided by the duration of the study, while FCR was calculated from feed intake and ADG.

Table 1: Composition of the diets

Nutrients (g/kg)*	Composition	
	Starter diet (d1-49)	Grower diet (d 50-91)
Crude protein	180	170
Crude fat	25	25
Crude fibre	50	60
Moisture	120	120
Lysine	11	10
Methionine	4.2	3.8
Calcium	6	5.5
Phosphorus	5	4.5

*As presented in the feed label

At day 91 of the study, between 7.00 h and 9.00 h, five chickens were randomly chosen from each treatment group, denied feed for six hours, and blood was collected through the jugular vein. The selected birds were carefully restrained with one hand holding the head and the other supporting the body and the legs, as described by Kelly and Alworth [16]. The neck was first extended to reveal the right jugular vein. The right jugular vein was chosen over the left jugular vein because it was often larger in chickens and easier to locate. Then pressure was gently applied to the vein to occlude and distend it, as to stabilize the vein and make it easier to puncture. Thereafter, the vein was punctured using a 20-gauge needle, and 7 mL of blood was aspirated into Bijou containers. Thereafter, bleeding was stopped by applying a little pressure to the punctured site. Three milliliters out of 7 ml of blood were transferred into EDTA-treated collection tubes for hematological analysis. The collected samples are stored in ice-packed containers and taken to the laboratory within 3 hours of collection. Packed Cell Volume (PCV), Hb, Red Blood Cell (RBC) counts, White Blood Cell (WBC) counts, and differential WBC counts (heterophils, lymphocytes, monocytes, and basophils) were determined following the procedures of Schalm et al. [17]. MCH, MCV, and MCHC values were computed following the formulae of Schalm et al. [17]. The remaining 4 ml of blood was placed into a non-EDTA tube to assay total serum protein, albumin, glucose, uric acid, cholesterol, triglyceride, Alanine Transaminase (ALT), Aspartate Transaminase (AST), and Alkaline Phosphatase (ALP). Blood samples will be analyzed using an auto hematology blood analyzer (Model No: XFA6100) and an auto blood chemistry analyzer (Model: SMT-120).

On day 91 of the study, 10 chickens in each treatment were randomly chosen, weighed, stunned at 70 V, and killed via cervical dislocation [18]. The crop was cut open, its contents emptied and weighed, then dried at 60 °C to constant weight. The oven-dried feed and crop contents were milled via a 2 mm screen and homogenized. The milled crop content and feed samples were analyzed for Ether Extract (EE) value (method 954.02), Dry Matter (DM) value (method no 930.15), total ash (method no 924.05), Crude Fiber (CF) value (method no 978.10), and Nitrogen (N) content (method no 984.13) as described [19]. Nitrogen was converted to CP using a 6.25 factor. Nitrogen-Free Extract (NFE) was estimated: % NFE = 100% − (% moisture + % CP + % EE + % CF + % ash). Calcium and phosphorus values were analyzed by atomic absorption spectrophotometry (SP90 AA Spectrophotometer, Pye Unica Model, Cambridge, England). The crop content samples were milled in triplicate. ME was computed using the prediction equation of Pauzenga [20].

Data generated on crop contents, growth dynamics, blood chemistry, and hematology of indigenous Venda chickens were analyzed using IBM SPSS [21] Version 27. Means, Standard Deviations (SD), and Standard Error of the Mean (SEM) were calculated for each parameter using the IBM SPSS [21] Version 27. Statistical significance was tested between treatment means via the Student's t-test. Means were deemed significant when $p<0.05$.

Results

The analyzed nutrient contents of treatment diets (Table 2) revealed no differences ($p>0.05$) in DM, CP, CF, ash, EE, NFE, Ca, P, and ME. The proximate composition of the crop contents of indigenous Venda birds, as shown in Table 3, demonstrated that production systems had no effect on mean DM, CP, CF, ash, EE, NFE, and calcium in Venda chickens. However, Venda chickens in the T2 group recorded significantly ($p<0.05$) higher P and ME values than the T1 group. The Coefficient of Variation (CV) spanned 0.69 -18.38 %, with ME giving the lowest value and calcium the highest.

The effects of production systems on the growth dynamics of Venda birds are displayed in Table 4. The CV varied from 1.02 to 12.20%, with FLW having the highest value and FCR returning the lowest during the starter stage. Feed intake was not affected (P>0.05) by production systems during the starter phase. However, semi-intensively reared Venda chickens recorded better (P<0.05) ADG and FCR than the intensively reared birds. For the grower phase, the CV values ranged from 2.43 to 5.50%, with feed intake having the highest value, while ADG returned the lowest value. Results indicate that Venda chickens reared under a semi-intensive system had improved feed intake, FCR, and ADG when compared to intensively managed chickens. The CV values ranged from 2.94 to 4.14%, with the feed intake having the highest value, while FCR returned the lowest value. Results show that semi-intensively managed birds had statistically better (p<0.05) growth parameters than the intensively managed Venda chickens.

The results of the hematological characteristics of birds on the two production systems are shown in Table 5. Mean Hemoglobin (Hb) value was higher (P<0.05) for T2 chickens than for T1 chickens. PCV, RBC, WBC, lymphocytes, and H/L ratio were not affected by production systems. In contrast, semi-intensively reared birds had increased (P<0.05) heterophils, MCV, MCH, and MCHC values compared with those managed intensively.

Table 2: Analysed nutrient content of experimental diets (Mean ± standard deviations)

Nutrients (%)	Starter feed	Grower feed
Dry matter	89.44±6.40	89.38±2.14
Crude protein	19.52±0.90	18.03±1.71
Crude fiber	5.30±0.61	5.95±0.85
Ash	5.80±0.55	4.69±1.07
Ether extract	2.50±0.26	2.50±0.46
Nitrogen-free extract	66.88±2.51	68.83±4.36
Calcium	0.60±0.09	0.55±0.07
Phosphorus	0.50±0.13	0.45±0.06
Metabolisable energy (kcal/kg)	3141.48±12.70	3155.58±5.10

Table 3: Proximate composition of crop contents of birds on the two production systems

Nutrients (%)	T1	T2	Mean	SD	SEM	P val	CV (%)
Dry matter	86.13	87.96	87.05	1.98	0.81	0.307	2.28
Crude protein	17.04	17.14	17.09	0.86	0.35	0.904	7.07
Crude fibre	4.55	5.55	5.05	0.68	0.28	0.053	13.46
Ash	5.10	5.30	5.20	0.21	0.09	0.288	4.03
Ether extract	2.56	2.62	2.59	0.37	0.15	0.867	14.25
Nitrogen-free extract	70.65	69.49	75.07	1.55	0.63	0.420	2.07
Calcium	0.65	0.76	0.71	0.17	0.07	0.480	18.38
Phosphorus	0.34b	0.38a	0.36	0.03	0.01	0.036	7.24
ME (Kcal/kg)	3311.45a	3349.62b	3330.54	23.04	9.40	0.003	0.69

Means with unlike letters differ significantly (P<0.05). *T1* intensive production system; *T2* Semi-intensive production system

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Table 4: Effect of production systems on growth dynamics of birds aged from 1 to 49 days

Variables	T1	T2	Mean	SD	SEM	P val	CV (%)
d 1-49							
Initial live weight (g/b)	39.94	39.86	39.90	0.56	0.17	0.829	1.42
Final live weight (g/b)	596.62b	644.84a	620.73	1.13	2.30	0.031	12.2
Feed intake (g/b/d)	39.88	37.06	38.47	2.24	2.62	0.871	2.43
Average daily gain (g/b/d)	11.36b	12.35a	11.86	1.06	0.02	0.044	2.58
Feed conversion ratio	3.51a	3.00b	3.26	0.27	0.27	0.001	1.02
d 50-91							
Feed intake (g/b/d)	57.62b	60.94a	59.28	3.21	0.35	0.032	5.50
Average daily gain (g/b/d)	15.11b	16.87a	15.99	0.24	0.52	0.015	2.43
Feed conversion ratio	3.81a	3.61b	3.71	1.10	0.06	0.021	3.13
d 1-91							
Feed intake (g/b/d)	45.37b	48.20a	46.79	1.94	0.59	0.056	4.14
Average daily gain (g/b/d)	12.69b	13.90a	13.30	0.47	0.09	0.039	3.66
Feed conversion ratio	3.58a	3.46b	3.66	0.11	0.04	0.048	2.94

Means with unlike letters differ significantly ($P<0.05$). *T1* intensive production system; *T2* Semi-intensive production system

Table 5: Impact of rearing systems on hematological traits of Venda chickens

Parameters	T1	T2	Mean	SD	SEM	P val	CV
Hb (g/dl)	9.10b	10.5a	9.80	0.83	0.34	0.009	8.49
PCV (%)	30.10	30.8	30.45	1.22	0.50	0.542	4.00
RBC (×106/μl)	2.51	2.48	2.50	0.10	0.04	0.746	3.86
MCV (fl)	119.92b	124.19a	122.06	2.72	1.11	0.028	2.23
MCH (pg)	36.25b	42.34a	39.30	3.53	1.44	0.005	8.99
MCHC (g/dl)	30.23b	34.09a	32.16	2.33	0.95	0.012	7.23
WBC (×103/μl)	2.29	2.20	2.25	0.47	0.19	0.843	20.90
Lymphocytes (%)	60.00	61.20	60.60	1.19	0.48	0.254	1.96
Heterophils (%)	38.40a	36.00b	37.20	1.33	0.54	0.001	3.57
H/L ratio	0.64	0.59	0.62	0.06	0.02	0.343	9.41

Means with unlike letters differ significantly ($P < 0.05$). pg picogram; H heterophils, dl decilitre; L lymphocytes, μl microliter, fl femtoliter

The influence of production systems on the blood chemistry of Venda chickens reared from d 1 to 91 is displayed in Table 6. The CV spanned 1.30 % - 25.71 %, with total serum protein giving the lowest value and the ALT/AST ratio giving the highest. Serum proteins, glucose, creatine, urea, cholesterol, AST, ALT, and ALT/AST ratio were not affected by production systems. In contrast, intensively managed birds had significantly higher ($P<0.05$) serum ALP than those managed semi-intensively.

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Table 6: Impact of production systems on blood chemistry of Venda chickens

Parameters	T1	T2	Mean	SD	SEM	P val	CV
Total serum protein (g/dl)	5.32	5.30	5.31	0.07	0.03	0.764	1.30
Albumin (g/dl)	1.54	1.62	1.58	0.06	0.02	0.070	3.58
Globulin (g/dl)	3.78	3.68	3.73	0.13	0.05	0.411	3.52
Glucose (mmol/L)	14.42	13.84	14.13	0.72	0.30	0.384	5.13
Creatine (mg/dl)	0.28	0.24	0.26	0.04	0.01	0.196	13.76
Urea (mmol/L)	0.44	0.42	0.43	0.08	0.03	0.796	18.60
Cholesterol (mmol/L)	3.11	3.34	3.23	0.18	0.07	0.109	5.46
AST (μ/dl)	22.27	21.00	21.64	1.24	0.50	0.245	5.71
ALT (μ/dl)	2.42	2.41	2.42	0.25	0.10	0.872	10.20
ALT/AST ratio	0.10	0.12	0.11	0.03	0.01	0.448	25.71
ALP (μ/dl)	163.40a	156.31b	159.86	4.18	1.71	0.007	2.61

Means with unlike letters differ significantly (P<0.05)

Discussion

Nutrient Intake

Nutrition is critical in evaluating chicken performance, necessitating diet formulation that meets all the nutrient needs for optimum performance. The results suggested that experimental diets contained 18.03-19.52% CP, 5.30-5.95% crude fiber (CF), 4.69-5.80% ash, 2.50% Ether Extract (EE), 66.88-68.83% nitrogen free extract (NFE), and 3141.48-3155.58 kcal/kg Metabolizable Energy (ME), aligning with values reported by Maoba et al. [11] for the same parameters. The proximate composition of experimental diets showed higher Crude Protein (CP) and ME values when compared with the values 15.34-16.00% CP and 2,993.29 kcal/kg ME stated by Lisnahan and Harimurti [22]. This implies that experimental diets meet the nutritional requirements of indigenous Venda chickens. Furthermore, the ME levels of the experimental diets exceeded the 2850 kcal/kg recommended by the NRC [23] for a slow-growing chicken strain. The EE and CF content of diets determined in this trial is higher than the values obtained by Sebola et al. [2]. This variation might be connected to differences in ingredient composition and analytical methods. Nevertheless, the values obtained in this investigation are within the level recorded for chickens [23]. The calcium and phosphorus content of the analyzed diets met the level recommended for chickens [23]. Similar calcium and phosphorus values were obtained by other investigators [24].

Proximate Composition of Crop Content

Proximate analysis results are widely used in nutritional studies for the fast determination of nutrient contents of feed resources. While these findings don't capture the full nutritive profile of feeds or feedstuffs, they furnish research with hints about feedstuffs that merit deeper investigation [25]. Visual observation of chickens' crop contents of birds reared semi-intensively showed the presence of green forages, insects, and earthworms. The numerically high CP level in the crops of birds managed semi-intensively might be attributed to the presence of insects in their crops, which, according to Rodríguez et al. [26], are high in protein. The mean CP level of 17.09% obtained in this study was higher than 12.90-15.50% obtained for local chickens in Ethiopia, but similar to the CP value of 16% recommended for grower chickens [23]. However, the mean CP value was higher than the values of 8.00-12.20% recorded for scavenging chickens [27,28]. The observed difference was expected, given that the Venda chickens used in this study were fed protein-rich commercial diets.

Semi-intensively raised Venda chickens showed a higher calculated ME in their crop content compared with intensively raised birds. This high ME value can be related to differences in Scavengeable Feed Resource Base (SFRB) available to birds, which could be high in insects and green leaves known to contain essential fatty acids [29]. The mean ME in the crop content of semi-intensively reared Venda chickens exceeded the 2746.07-2781 kcal/kg stated by Sheikh et al. [28]. The mean ME value of crop contents of Venda chickens in both treatment groups in the current experiment exceeded the NRC [23] recommended value of 2900 kcal/kg. This suggests that Venda chickens raised under the two production systems met their energy requirements.

The significant variation in phosphorus levels in the crop content of Venda chickens reared in both intensively and semi-intensively is in harmony with the reports of others [27]. The mean phosphorus content was below the value of 0.60% obtained by Tadele and Ogle [27]. The significantly high phosphorus level in the crop contents of Venda chickens reared semi-intensively may be ascribed to green forages consumed by these chickens, which have been demonstrated to be abundant in phosphorus [30]. This result is consistent with [27], who found green forages, herbs, insects, and worms in the crop of free-range chickens. However, this observation warrants further study. The elevated phosphorus levels in the crop of T2 Venda chickens can have an adverse effect on bone mineralization and gut health [31]. However, the increased phosphorus level in the crop of birds in this study is not a source of concern since the calcium-to-phosphorus ratio is 2:1, which is within the level recommended for chickens [32].

Growth Performance

Chicken production systems have an impact on chicken welfare, production efficiency, and health [33]. Growth performance parameters are important indices for measuring chicken productivity and can be affected by production systems [33]. Studies comparing the effect of production systems on feed intake, FCR, and ADG in Venda chickens are scarce. Numerous studies assessed the influence of production systems on the growth dynamics and health status of chickens other than indigenous chickens [33,34]. The superior FCR obtained in Venda chickens aged 1 to 49 days managed under a semi-intensive production system indicates reduced stress due to enhanced bird welfare, resulting in increased ADG. This significant increase may be explained by increased utilization of nutrients and retention due to improved bird welfare [35]. This suggests that indigenous Venda chickens given a concentrate diet and reared under a semi-intensive system utilize feed more efficiently than those reared intensively.

In this study, the increased ADG in Venda chickens managed semi-intensively can be related to the insects found in the crop content of these birds, which, according to Rodríguez et al. [26], are high in protein and Essential Amino Acids (EAAs) needed for muscle protein synthesis in chickens [36]. However, this investigation found no differences in the production system on feed intake in birds during the starter phase (d 1 to 49). However, birds aged d 50-91 and d 1-91 on the T2 treatment consumed more feed than birds on the T1 treatment. The fact that birds on T2 treatment gained weight with less feed intake when compared with birds on T1 treatment during the starter phase implies better feed conversion, as confirmed by the FCR result.

The mechanisms underlying the enhanced FCR in T2 chickens are not clear. However, it is possible that the provision of outdoor access to these birds allows them to ingest potentially beneficial microbes into their digestive tract [37], which have been shown to enhance nutrient digestion and utilization in chickens [38]. Exercise in the form of flight is energy demanding and changes how chickens utilize feed [39]. The enhanced nutrient utilization in T2 chickens might be an attempt to meet their nutrient requirements. This finding agrees with Ayorinde [40], who reported improved FCR in indigenous chickens reared semi-intensively.

Blood Characteristics

Hematological components are used as an index of the welfare of chickens and, hence, are used as a vital tool for monitoring animal health [41]. Results reveal that PCV, RBC, WBC, and lymphocytes remained within the normative values given for commercial chickens [42]. The significantly high Hb value obtained for birds on T2 treatment might be attributed to improved welfare, as exercise has been found to increase Hb concentrations by causing hemocytoblasts to generate more RBCs, which increases the chicken's ability to carry oxygen [43]. The significantly high Hb level of the T2 birds in this investigation could thus be ascribed to the presence of forages and insects in the crops of birds in this group, which are high in proteins, EAAs, and micronutrients [26] that may support the production of this blood component. However, the Hb concentrations obtained in this study were below the 13 g/dl obtained for indigenous Venda chickens by Mabelebele et al. [9]. This discrepancy may be linked to handling, diet composition, and season, which are reported to influence Hb in chickens [14,41].

The results show that red cell indices (MCV, MCH, and MCHC) of Venda chickens on T2 treatments were significantly higher than those on T1 treatment; however, these values fell within the normative levels of 90-140 fL, 33-47 pg, and 26-35 g/dl found for MCV, MCH, and MCHC, respectively, in healthy chickens [42]. The increased red cell indices in birds on T2 treatment might be related to improved physiological well-being and nutrition, as exercise and nutrition improved Hb content and red cell mass, which are used for the computation of red cell indices in chickens [16]. The fact that the MCHC value of birds in both groups was within the reference value for healthy chickens indicates macrocytic normochromic red cells, which

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occur when RBCs are larger and contain more Hb than normal [16]. The MCV and MCH obtained in this study were lower than the levels of 137 fl and 45 pg documented for indigenous Venda chickens by Mabelebele et al. [9]. The exact reason for the observed differences was not known; however, the discrepancy may relate to nutrition, sex, and environmental variables reported to affect the production of these blood components in chickens [14,43].

Heterophils, which are crucial to birds' immune defense, are significantly low for Venda chickens on T2 treatment. The H/L ratio is used to monitor the immunity status of chickens and to evaluate their stress responses [44,45]. Results showed that the H/L ratio is lower in T2 birds than in T1 birds. The observed changes in immune response parameters of birds in both production systems might be attributed in part to the housing conditions. It is possible that housing conditions were stressful (social stress) to the Venda chickens on T1 treatment, thereby causing heterophils to proliferate in the blood [46]. Apart from serum ALP, all the blood biochemicals measured were not influenced by production systems. The lower serum ALP value obtained in Venda chickens under a semi-intensive system in the current investigation suggests improved well-being and behavior. This finding corroborated the low H/L ratio results observed in birds managed under semi-intensive conditions in the present investigation.

Serum enzyme levels usually increase following damage to liver cells, as enzymes escape from the cells into the bloodstream [44]. The exact reason for the decreased serum ALP level in Venda chickens managed in a semi-intensive system in this study is not known. However, it is possible that additional outdoor run provided to the Venda chickens reared semi-intensively in this investigation may decrease the production of adrenocorticotropin (ACTH), which stimulates the adrenal gland to produce cortisol, the "stress hormone" from immune cells, such as lymphocytes, which in turn reduces the production of alkaline phosphatase in the adrenocortical cells [47]. This observation agrees with the findings of Bari et al. [48], who reported that exercise decreased the concentrations of ALP in the blood. The comparable serum levels of glucose, urea, and creatinine in T1 and T2 chickens suggest that the two production systems had no adverse effect on the production of these parameters. This finding also corroborates the similar serum ALT and AST values in the present study, which are responsible for breaking down amino acids generated during muscle protein breakdown to produce precursors for gluconeogenesis.

Conclusion

The results revealed that crop contents of indigenous Venda chickens were affected by the production systems, with birds managed under a semi-intensive system having significantly higher phosphorus and ME values than those under an intensive system. Birds raised for 1-49 days in a semi-intensive system gain weight at comparable feed intake compared to those reared in an intensive system. In contrast, Venda chickens aged from 50 to 91 days and 1 to 91 days reared semi-intensively had improved growth performance compared to those reared intensively. Results revealed that birds reared semi-intensively had higher Hb and red cell indices than those reared intensively. In contrast, Venda chickens in an intensive production system had significantly higher heterophil counts and ALP than birds reared in a semi-intensive system. In conclusion, these results indicate that Venda chickens raised semi-intensively performed better than birds raised intensively. The results of this investigation provide baseline data to poultry farmers, policymakers, researchers, and other relevant stakeholders that can assist in better discovering the influence of rearing systems on the productivity of indigenous Venda chickens. The practical implication of these findings is that poultry farmers should adopt the semi-intensive system of production to increase the productivity and health of their chickens.

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Ethics

The study was conducted in accordance with the University of South Africa's (UNISA) ethics guidelines for the use of live animals in research; the ethics approval number is 2022/CAES-AREC/082.

Conflict of Interest

The authors have no competing interests to declare.

Data Availability

Data will be provided on reasonable demand.

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