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Haemato-Biochemical Indices of Red Sokoto Goats Fed Various Levels of Earthworm Meal-Based Diets

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Abstract: Blood is essential to life and it is vital for the transportation of oxygen from the lungs to every cell of the body for metabolism purposes. Hence, blood samples were collected from thirty (30) healthy Red Sokoto goats fed an earthworm meal-based diet with ten goats per treatment constituting a replicate in a Completely Randomized design model to evaluate the influence of various levels of Earthworm Meal (EWM) based diets [Control diet (A) 0% EWM), 3% (B) and 6% (C)] on their haemato-biochemical profile. Blood samples were drawn from the jugular vein of the experimental animals on the last day of the study for the determination of hematology parameters [Haemoglobin (Hb) concentration, Packed Cell Volume (PCV), Red Blood Cell (RBC) count, White Blood Cell (WBC) count, neutrophil, lymphocyte, eosinophil, mean corpuscular volume (MCV), Mean Corpuscular Haemoglobin Concentration (MCHC), Mean Corpuscular Haemoglobin Concentration (MCH]. The Serum indices [Glucose, ALT, AST, ALP, Total Protein, Albumin, Globulin] were also assessed. All haemato-biochemical procedures were determined following the standard methods. The results showed significant variations ($p<0.05$) in the PVC and MCHC which ranged from 23.30-38.33 and 31.33-35.67 diets A -C respectively with higher concentrations noted for animals on the EWM-based diets {3% (B) and 6% (C)}. Neutrophil and lymphocyte values varied significantly ($p<0.05$) with higher values recorded for animals on the Diet (C). Different hematological parameters Hb, MCV, MCH< neutrophil, monocyte, eosinophil, and basophil were higher for Diet C compared with other Diets. It is noteworthy that the RBC and MCV MCH, Neutrophil, and Eosinophil Basophil are ($p>0.05$) enhanced with the accelerated levels of EWM in Diet C. Total Protein concentration and Albumin values significantly ($p<0.05$) ranged between 7.67 and 8.67 and 25.56-278.33 respectively. Additionally, Glucose levels increased significantly as the levels of EWM increased in the experimental diets. The ALT and ALP reduced significantly ($p<0.05\%$) as the levels of EWM enhanced from diets A to C. AST and Globulin levels however, indicated significant differences ($p<0.05$) but did not follow any specific direction with increasing levels of EWM. In addition, Cholesterol levels were 2.06 (A), 2.37 (B), and 2.43(C) but insignificant ($p>0.05$). The report concluded that goat farmers may include 6% EWM in the diet of red Sokoto goats since it showed no health implication on the hematological and Serum biochemical indices of the animals.

Keywords: Red Sokoto Goat, Earthworm Meal, Haematology Parameters, Serum Biochemistry

Introduction

Goats are triple-purpose animals (meat, milk, and ritual sacrifices) and are in great demand due to their hardy nature (withstands harsh environments) and less stressful management practices. They are key to ensuring economic and social sustainability (Geoff and Wilson, 2009) in various villages of developing countries like Nigeria. Goat production in Nigeria is severely hampered by a lack of feed (Belewu *et al*., 2007; Ahamefule and Elendu, 2010). Seasonal variations in nutritional value render sustainable production gains from good management and disease control programs unfeasible, even in areas with an abundance of fodder resources (Alli-Balogun *et al*., 2003).

Among the major breeds of goat found in Nigeria are the Sahel (West African Long-legged), Red Sokoto/Maradi, and the West African dwarf. Red Sokoto goats are found majorly in the Northern sub-humid and semi-arid zones of Nigeria (Akpa *et al*., 2001) and they have good dairy potential. The average range of daily milk production was between 469 and 545 g (Ehoche and Buvanendran, 1983). The matured male and female weighed 27 kg and 25 kg respectively Devendra and Burns (1983). Reported a weight of between 23 and 30 kg. The animal which is one of the well-defined breeds in Africa has a uniform dark-red body colour with both male and female being horned. The types of ration food fed to the animal could influence the physiological and metabolic activities of Red Sokoto goats. Hence, assessment of the blood profile of animals may give a clue as to the potential of dietary treatment to meet the physiological and metabolic requirements of animals.

Blood profile research is vital since blood is the major vehicle of transportation of oxygen and nutrients to various target organs of the body. Blood is essential for the survival of multicellular organisms (Jain, 1986) and the importance of evaluating the hematology and serum indices is well documented in the literature (Yaqub *et al*., 2013; Church *et al*., 1984) reported that dietary components have a measurable effect on the blood components such that significant changes in the values can be used to draw logical conclusions on the nutritive quality of the feedstuffs fed to animals.

Feed shortage poses a major constraint to goat production in Nigeria (Belewu *et al*., 2007; Ahamefule and Elendu, 2010). Even where fodder resources abound, seasonal fluctuations in nutritive value make sustainable gains in production from good management and disease control programs unrealistic (Alli-Balogun *et al*., 2003). The present system of livestock production is not sustainable due to the use of natural resources and there is competition between man and his livestock animals on the available edible crops. Currently, earthworms are considered a rich source of essential nutrients that can be reared on waste agricultural residues.

Many studies have reported that earthworm meal can be used as one alternative source of animal protein in feed. Earthworm meal contains high protein content (63.06%) as a nutrient source for the animal. Essential amino acids in earthworm meals were dominated by isoleucine (1.98% on a dry matter basis). Earthworm (L. Rubellus) contained 'lumbricin I', which has antibacterial activity included in the peptide group which contains 62 amino acids.

However, due to the unconventional increase in the problem of feeding in goat production, animal scientists are now looking inward to develop the intake and productivity by adding some ingredients like earthworm meal to enhance the performance characteristics of goats. The thrust of this study was to evaluate the efficacy of earthworm meal on the hematology parameters and serum indices of red Sokoto goats fed on Earthworm meal-based diets.

Materials and Methods

Experimental Location

The experiment was carried out at the Ruminant Section of the Teaching and Research Farm, University of Abuja, FCT, Abuja, Nigeria. The University of Abuja is located at geographical coordinates with latitude 8*58'50N and longitude 7*10'43E http://en.Wikipedia.org/wiki/University of _Abuja.2013, with the temperature at 370°C, the humidity at 21% and winds of 5 km/h (Wikipedia, 2013).

Gathering and Handling of Earthworms

The majority of the earthworms used in this study were raised using a method called Vermiculture. Worms are being artificially raised or cultivated and the technology involved is the scientific method of employing them to advance industrial goals.

The earthworm was collected and stored. To prevent the earthworms from rotting, they were first sun-dried for roughly two days and then dried for 6 h at about 40°C in an oven. After being ground, the earthworms were kept in a plastic container.

Management of Experimental Animals

For this study, thirty healthy West African dwarf goats, aged eight to fourteen months were purchased from a reliable source in Abuja (FCT), Nigeria. They weighed between 8 and 12 kg. The animals received excellent care, including Ivermectin (Bimectin®) to treat internal and external parasites and antibiotics (Terramycin® L.A.) to treat colds and catarrh.

To stabilize, adapt, and adjust to environmental changes, the animals were housed individually in metabolic pens or cages measuring 1.5×11. 0 m and constructed on wood standings approximately three feet high. The floor of the cages was created by arranging thin, sturdy wood across its length so that the goats' legs would not enter the spaces between them and that the goats could freely deposit urine and feces directly beneath the cage. The animals were allowed to adjust to the experimental diets. This was accomplished by adding components of the experimental diets, such as rice husk and cassava waste, to their meals so that they would be easier to adapt to their surroundings and spend roughly two weeks getting used to the experimental diet. Trial Diets and water were given ad libitum (Table 1).

Blood Sample Collection

At the conclusion of the trial, blood samples were taken with a 5.0 mL syringe from the external jugular vein of every goat and placed into a bottle containing K3-EDTA, the anticoagulant for the determination of blood hematological parameters and another 5.0.0 mL without EDTA for serum indices evaluation. Blood samples were sent immediately to the laboratory in ice packed flask for the serum biochemical index analysis and haematology analysis.

Hematological Determination

Blood hematology was processed using a specific blood lysing buffer approved for goat hematology while the CELL_DYN 3700 analyzer was used to evaluate total Red Blood Cell (RBC), White Blood Cell (WBC), and the differentials hemoglobin, PCV, Mean Corpuscular Volume (MCV) and Mean Corpuscular Haemoglobin (MCH).

Table 1: Composition of the test diets

Diets (%)	Diet A (Control)	Diet B	Diet C
Cassava waste	53.00	53.00	53.00
Rice husk	35.00	35.00	35.00
Soybean cake	10.00	7.00	4.00
Salt	1.00	1.00	1.00
Premix	1.00	1.00	1.00
Earthworm meal	0.00	3.00	6.00
Total	100.00	100.00	100.00

Serum Index

The blood samples that were left to coagulate were centrifuged at 300 rpm for 15 min and the serum was collected and frozen (-20OC) until needed for biochemical indices determination using a Vet scan (VS2) analyzer. The parameters evaluated include Albumin, Alanine aminotransferase (ALT), Alkaline Phosphotase (ALP), total protein, AST, Globulin, creatinine glucose, and cholesterol.

Analytical Statistics

A complete randomized design (Steel *et al*., 1997) model's analysis of variance was applied to all of the data that were gathered. Whereas the Duncan multiple range test was used to separate the means.

Results and Discussion

Hematological Parameters of the Experimental Red Sokoto Goats

Table (2) shows the impact of supplementing with earthworm meal on the hematological parameters in Red Sokoto goats. There were statistically significant differences between the treatment groups based on the hematological index results. Table (3) displayed that there was a significant difference ($p<0.05$) in the means of the PCV, MCV, MCH, MCHC, WBC, Neuro, Lympho, and Esinophil parameters among treatments.

The parameters for Hb, RBC, and WBC, however, showed statistically similar values ($p>0.05$). The blood sample Control (A) (8.30) parameters, treatment B (9.23), and treatment C (8.83) Hb values were comparable. However, the PCV values showed a significant difference ($p<0.05$), increasing in treatment B (26.00) and treatment C (39.33) when compared to the control group (A).

When compared to the control group, goats fed diets supplemented with earthworm meal had higher concentrations of PCV and hemoglobin in their blood. This indicates that the earthworm meal had sufficient amounts of protein and minerals, which were necessary for the synthesis of hemoglobin. The WBC decrease in goats fed earthworm meal did not differ significantly, indicating that the control diet had stimulated the immune system.

Table 2: Physicochemical analysis of the experimental diets and earthwo

Parameters (%)	Control (A)	Diet (B)	Diet (C)	Earthworm meal (EWM)
Dry matter	94.04	94.12	90.32	25.30
Crude protein	8.45	8.96	8.10	571.35
Ether extract	4.35	3.95	5.66	3.50
Crude fibre	17.38	17.32	17.32	-------
Ash	11.09	11.18	11.14	2.35
Organic matter	82.95	82.94	79.18	22.95
NFE	58.73	58.59	57.78	-------
ME (K.cal/Kg)	2798.56	3272.56	3329.20	2340 K.cal/kg

Table 3: Effects of earthworm meal-based diets on the hematological parameters of red SOKOTO goats

Parameters	Control (A)	Treatment (B)	Treatment (C)	± SEM	Reference values
Hb (g/dL)	8.30	9.23	8.83	0.24	8-12
PCV (%)	23.33^{c}	26.00^{b}	38.33^{a}	3.91	22-38
RBC (10^{6}/mcL)	8.27^{b}	9.59^{b}	12.41^{a}	0.34	8-18
MCV (fl)	17.50^{b}	20.00	25.50	4.22	16-25
MCH (pg)	5.30c	6.08b	8.13a	2.49	2.2-8.0
MCHC (g/dL)	35.67	31.33	34.67	3.58	30-36
WBC ($10^{9//L}$)	13.00	12.70	12.77	2.23	2.50-3.13
Neutro (%)	32.00^{ab}	31.33^{b}	35.67^{a}	4.05	30-48
Lympho (%)	56.00	44.23	47.57	6.07	50-70
Monocyte	1.00	0.50	0.90	0.08	0-0.40
Eosinophils	1.20	1.15	1.22	0.50	1.80
Basophils	0.00	0.01	0.02	0.002	0.0-1.00

Serum Index

The glucose, AST, TP, and Albumin levels were higher for the Earthworm meal-based diet{(2.17(A), 3.13 (B) and 3.33 (C), 125.30 (A), 195.33 (B) and 177.67 (C); 7.67 (A), 7.33 (B) and 8.67 (C). Contrarily, the ALT and ALP were higher for the Control diet compared with other Diets. While the Globulin, Cholesterol, and Creatinine did not show any particular trend among diets.

Discussion

Hematological Parameters

PCV was performed to evaluate for anemia, polycythemia, or dehydration so the value reported in this study was higher than the value of 8.6-19.47%. However, the PCV reported here falls within the values (2.0-38.0%) reported by Olusoji Oni *et al*. (2012); Linda *et al*. (2006); Ajagbe *et al.* (2020) (27.4-29.9) reported by Opara *et al*. (2010) and 22.0-38.0% for the normal physiological reference range of healthy goats and within the normal range (24-48%) for goats recorded by (Banerjee, 2018). This means the animal has increased red blood cell production and dehydration. In addition, the animals were active and alert with shiny skin throughout the study period. The hemoglobin value (5.70-6.20%) reported by Bukola was lower than the value (8.30-9.23) reported in this study. Interestingly, hemoglobin levels below 7 g/dL have been shown to be dangerous for goats, which are considered severely anemic animals. However, the values recorded in this study were within the range (7-15%) reported by Njjida *et al.* (2013) and the 8-12 reference range. Notably, the animals showed no signs of microcytic anemia or hypochromic anemia due to iron deficiency or inadequate hemoglobin utilization. The higher value found in this study confers an additional advantage on the oxygen-carrying capacity of the blood.

The erythrocyte value reported in this study was higher than the value (2.19-6.87) reported by (Ajagbe *et al*., 2020) but greater than the value of 9.2 and 9.9 g/dL reported by Opara *et al*. (2010) and 1.57-1.90. Goat red blood cells were reported to decrease from 0.79-9.44 consistent with the values reported here.

The WBC values recorded in the present study were slightly lower than the values (13.35-15.45) reported by Ajagbe *et al*. (2020). In contrast, values ranging from 6.8-20.1% were reported by Bawa *et al*. (2007); and Opara *et al*., 2010). This shows that Sokoto Red goats appear to possess a defense system that can provide a rapid and active defense to the goats used in the study. Additionally, a high white blood cell count is a sign of bacterial or parasitic infection (Olabanji *et al*., 2007). Although the animals used in this experiment did not exhibit any of these symptoms.

Lymphocytic values of 56.00% (Diet A), 44.23 (Diet B), and 47.57% (Diet C) were within the range of 17-75% reported by Opara *et al*. (2010); Ajagbe *et al*. (2020); Tambuwal and Agele (2002). This showed and suggested a well-developed immune system in the Red Sokoto goats used for the study.

In a study conducted on Red Sokoto goats, the authors found higher values (55.6 and 62.80) than those reported here for MCV, ranging from 40.56-43.81, but ranged between 368, 7, and 381.98 g/dL reported by Shittu *et al.* (2023) for Western. African Dwarf and Kalahari goats. However, the result of this study fell within the reference range (16-25). Additionally, the MCH and MCHC values are within the reference ranges.

Neutrophil values were significantly higher in animals fed Diet C (35.67%) and lower in animals fed Diet B (31.33%). The values are within the reference values of between 22.25 and 39.50% reported by Njidda *et al*. (2013); and Ajagbe *et al*. (2020) but less than 28-40.3% reported by Opara *et al*. (2010). Co consistent with our results, Eosinophil values were also within the values (0.2-0.4 and 0.5-21.0%) reported by Opara *et al*. (2010); and Etim *et al*. (2013).

Serum Index

The serum which is about 55% of the blood needs to be analyzed for its biochemistry values so as to obtain vital information about the status of organs and tissues in the body, it also indicates the metabolic condition of the animal. Hence, the Serum indices of experimental animals are presented in Table (4). The total protein value, which increased from Diet A to Diet C (7.33-8.67%), was higher than the values of 6.6 and 6.8 mg/dL reported by Pereira *et al*. (2022) for castrated and uncastrated goats and (Ajagbe *et al*., 2020). Total protein intake was analyzed to identify nutritional problems, inflammation, and kidney/liver disease, however, not all of these were recorded in this study and there were no symptoms of dehydration. Increases or decreases in serum protein concentrations can be caused by a variety of factors, but it can be challenging, if not impossible, to predict and control every possible factor during an experimental period.

Albumin helps prevent blood from leaking from blood vessels, which carry hormones, drugs, vitamins, and other important substances throughout the body, it also indicates nutritional deficiency. Therefore, the albumin value (2.55-2.83 g/dL) reported herein falls were slightly higher than the range of 1.93-2.55 reported by Ajagbe *et al*. (2020). However, the value fell within the reference range (2.7-3.9 g/dL). (https://www.uoguelph.ca; msdvetmanual.com; https://www.vetmed.ucdavis.edu) Variation in this and other results may be due to age and sex differences.

The Globulin values (1.73-1.76 g/dL) reported in this study are lower than the values in the range of 2.69-3.03 g/dL reported by Ajagbe *et al*. (2020) but fell within the reference range (2.7-4.1 g/dL) However, the animals used were very active throughout the study and showed no symptoms of liver or kidney disease.

Serum urea concentration is an indicator of protein breakdown in the rumen. Therefore, the urea values reported here are 22.40 mg/dL (Diet A), 22.05 mg/dL (Diet B), and 23.65 mg/dL (Diet C)). These values were within the normal range (17.60 23.75 mg/dL). This is also consistent with the normal range of 3.57-7.14 mmol/L or 21.44-42.88 mg/dL reported by Kaneko *et al*. (1997). Normal urea indicates the protein is of good quality and is well utilized by the goat. However, differences may be due to nutrition, blood sample handling, genetics, gender, age, and environment (Belewu and Ogunsola, 2010; Oloche *et al*., 2015).

Creatinine values were reported as 1.00, 1.12, and 1.10 mg/dL for Diet A, Diet B, and Diet C, respectively. However, these values are within the range of 0.08-1.28 mg/dL reported by Ajagbe *et al*. (2020) and reference values of between 1.0 and 1.8 mg/dL. The difference may be due to the age and type of food given to the animals.

Aspartate aminotransferase (AST) is an important enzyme that helps metabolize amino acids. Overall Aspartate aminotransferase (AST) values were 125.30 (Diet A), 195.33 (Diet B), and 177.67 (Diet C), which are higher than the reported values of between 16.17 and 17.58%. by Ajagbe *et al*. (2020). The mean values shown here range from 39.9-159.9 reported by Pereira *et al*. (2022) for castrated and uncastrated goats and from 78.0-178 U/L reported by Kiran *et al*. (2012) for goats in southern Punjab, Pakistan. However, the values noted fell within the reference range (167-513U/L).

Alkaline Phosphatase (ALP) reported herein for goats is higher than the range (25-75.07) observed by Pereira *et al*. (2022) for castrated and uncastrated goats but fell within the values of between 93 and 387 U/I noted by Kaneko *et al*. (1997). The discrepancy between this study and the authors may be due to differences in the age of the animals. In younger animals, ALP is the predominant serum form of ALP and it gradually decreases as the animal ages until the epiphysis closes (Toba *et al*., 1992). However, higher ALP had been reported to cause bone disorders, but this was not observed in this study.

In the present study, goats fed the Earthworm meal-based diets showed no significant differences ($p>0.05$) in alanine transaminase (ALT) between dietary treatments (Table 3). The current values (12.67, Diet A; 7.33, Diet B and 9.67, Diet C) were lower than the previous values of between 15.0 and 313.0 (Kiran *et al*., 2012) but however, fell within the reference values (6-19U/L).

Table 4: Serum Biochemistry of the Experimental Red Sokoto Goats

Parameters	Control (A)	Treatment B	Treatment C	SEM Reference values
Glucose (g/L)	2.17	3.13	3.33	45-75 mg/dl
ALT (U/L)	12.67^{a}	7.33^{c}	9.67^{b}	6-19
AST	125.30^{c}	195.33^{b}	177.67^{a}	167-513
ALP	175.00^{a}	136.00^{ab}	97.33^{b}	93-387
Total protein (g/dL)	7.67^{ab}	7.33^{b}	8.67^{a}	6.4-7.0 g/dl
Albumin (g/L)	25.56^{c}	27.00^{b}	28.33^{a}	2.7-3.9 g/dl
Globulin (g/L)	17.33^{a}	14.67^{b}	17.67^{a}	2.7-4.1 g/dl
Cholesterol	2.06^{c}	2.37^{b}	2.43^{a}	80-130
Creatinine (mg/dL)	1.00	1.12	1.10	1.0-1.8 mg/dl
Urea nitrogen	22.40	22.05	23.65	10 42.88 mg/dl

This means having different superscripts in a row differ significantly ($p<0.05$)

The results noted a cholesterol level of 2.06 (Diet A), 2.37 (Diet B), and 2.43 (Diet C) which showed that there was no excessive cholesterol deposition in the animals. Cholesterol values reported herein agreed with the values noted by msdvetmanul.com and 64.60-36.40 mg/dL but lower than 22.60-35.68 reported by Oloche *et al*. (2015).

It is noteworthy that important components of blood plasma include albumin and globulin. The albumin, globulin, and total protein values in this study are consistent with the reference drawn by https://www.uoguelph.ca; msdvetmanual.com; https://www.vetmed.ucdavis.edu. According to reports, total protein, albumin, and globulin are directly related to the quantity and quality of protein consumed (Onifade *et al*., 1999).

The results of this research highlight that goat diets can include earthworm meals without having a negative impact on the health of the animals. Future research should explore the effect of Earthworm meal on Feed intake, milk quality, and quantity of lactating goat to fully harness the potential of the novel feed.

Conclusion

The results of this study showed that there is potential to introduce Earthworm meal (EWM) into the diet of Red Sokoto goats without causing health problems for the animals and it is therefore very promising for goat nutrition.

Suggestion

A similar experiment with a higher degree of inclusion of earthworm meal should be carried out in the future.

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Author's Contributions

Moshood Adewale Belewu, Akeem Abolade Oyerinde, Olurotimi Ayobami Olafadehan, and Kehinde Matthias Okukpe: Conceived the study, and performed the field work in conjunction. Collection of the samples and laboratory work

Ling Shing Wong: Drafting of the manuscript.

Ridwan Olarewaju Imam: Collection of the samples and laboratory work. Data analysis.

Proofreading and final submission for publication were approved by every author.

Ethics

The article is comprised solely of original content and no materials previously published elsewhere were included. The corresponding author confirms that all co-authors have reviewed and approved the final manuscript and there are no clashes associated with this publication.

Conflicting Interest

All authors declare that there is no conflict of interest.

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