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HAEMATOLOGY AND SERUM BIOCHEMICAL RESPONSE OF WEST AFRICAN DWARF GOATS FED DIFFERENT GRASSES SUPPLEMENTED WITH PALM KERNEL CAKE AND CASSAVA PEELS

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ABSTRACT

This study was conducted to investigate the haematological and serum biochemical responses of West African Dwarf (WAD) goats to diets comprising different grass species supplemented with palm kernel cake (PKC) and cassava peels. Sixteen growing WAD goats were randomly allocated to four dietary treatments in a completely randomised design: T1 (Guinea grass only), T2 (Brachiaria Mulato II + PKC + cassava peels), T3 (Congo grass + PKC + cassava peels), and T4 (Guinea grass + PKC + cassava peels). Haematological and serum biochemical parameters of goats were measured to assess animal health and physiological response to experimental diets. Results indicated significant variation in packed cell volume (PCV), haemoglobin (Hb), white blood cell (WBC) count, and platelet count, with T4 yielding the highest WBC and platelet values, suggesting an improved immune status. Serum biochemical analysis revealed that T2 had significantly higher glucose, albumin, ALT, cholesterol, and ALP levels, indicating enhanced metabolic and liver function. In contrast, creatinine levels were highest in the control (T1), potentially reflecting lower protein utilisation. The findings indicate that the inclusion of PKC and cassava peels as feed supplements, particularly with Mulato II and Congo grass, can have a

positive influence on health indicators in WAD goats. The findings of this study provide evidence supporting the use of PKC and cassava peels as agro-industrial by-products in small ruminant feeding to reduce costs and enhance animal produc
Keywords: **West African Dwarf goats, Haematology, Serum biochemical indices, Palm kernel cake, Cassava peels, Forage supplementation**

INTRODUCTION

Nigeria has recognised the significance of ruminant production in livestock output (Aruwayo *et al*., 2015). Ruminants significantly contribute to Nigeria's livestock production and have distinct advantages over other livestock, including essential roles in the daily lives of rural households (Aruwayo *et al*., 2015). He further stated that in order of significance, small ruminants are primarily raised for their meat, milk, skin, and wool. Many developing nations rely heavily on goats (*Capra aegagrus hircus*) for their livestock economy. In 2014, the FAO estimated that there were 1,050 million goats in the world, with approximately 300 species identified. Goats have been domesticated worldwide for their meat, hides, milk, and hair. Bornu red, Kano brown, Bauchi type, and West African dwarfs are the main domestic goat breeds raised in Nigeria. The eastern and southern regions of the country are home to West African dwarfs raised for their meat, while the northern region is home to the others raised for their milk and meat.

Additionally, the West African dwarfs produce meat that tastes better than any other meat (FAO, 2008). The use of locally available feed sources aligns with the principles of sustainable agriculture by promoting resource efficiency and minimising feed cost (Ekeocha *et al.,* 2023). According to Aganga *et al.* (2005), supplementation of forages with concentrates is necessary to optimise production outcomes in small ruminants. The biofuel business produces palm kernel (*Elaeis guineensis*) cake (PKC), a by-product that is regularly available all year round when palm oil fruit oil is extracted. Palm kernel cake (PKC) is an excellent supplement for improving goats' diets because of its low cost. PKC will make ruminant production more economical and cost-effective by reducing the cost of feed for livestock. Forages such as grasses (*Digitaria debilis*, *Brachiaria ruziziensis*, *Panicum maximum, Mulato II*, etc.) are the primary source of feeds for ruminants to meet their nutritional requirements, either for maintenance or production (Dandara *et al.,* 2023a; Dandara *et al.,* 2023b; Bacorro *et al.,* 2025; Dandara *et al.,* 2025).

Natural pastures in Nigeria are generally high in fibre, low in protein and energy, and yet they form the primary source of animal feed in the country (FAO, 2019; Dandara *et al.,* 2023). These resources are overutilised to the extent that they fail to meet even the basic maintenance requirements of indigenous animals, especially when the dry season persists for extended periods. Forages have always provided the basis upon which ruminant nutrition is built (Dandara *et al.,* 2025). Ruminants can utilise a wide range of feed resources, but the bulk of their feed comes from forages; hence, they are primarily considered as forage consumers. In the tropics, the natural pasture, which supplies the bulk of ruminants' feed, becomes dry and of low nutritive value during the dry season, leading to a marked decrease in voluntary intake and digestibility. Over the years, remarkable improvements in forage cell wall digestibility have been achieved through forage breeding programs and agronomic advances. The plant becomes coarser and less digestible over time, with significant changes in key nutritional parameters. To maintain high forage quality, it is recommended that harvesting of forage grasses at early stages be practised, as the plant will have higher protein, lower fibre, and better overall digestibility at this stage (Dandara *et al.,* 2013a; Dandara *et al.,* 2025). The increasing cost and competition for conventional livestock feeds, such as maise and soybean meals, necessitate the exploration of alternative feed resources that are cost-effective and locally available (FAO, 2019). Therefore, there is a need for farmers to transition into pasture production to meet the nutritional requirements of their ruminant animals at a minimal cost compared to conventional feedstuffs. Jonah *et al.* (2024) studied the haematological parameters of West African Dwarf goats fed a mixture of cassava peels with groundnut husk supplement and reported improved haematological indices in goats fed a diet containing 50% Guinea grass and 27% cassava sievate. Ogunbosoye *et al.* (2022) reported that PKC and cassava peels improve protein metabolism and liver enzyme regulation. Blood indices are important indicators of farm animals' physiological performance, as they have shown the relationship between nutrition and health status of the animals (Jiwuba *et al.,* 2016). Hence, this study was designed to evaluate serum biochemical indices and haematological parameters of West African dwarf growing goats fed selected agro-industrial waste (PKC and cassava peels) with hay of different grasses.

METHODOLOGY

Experimental Area

The experiment was conducted at the Teaching and Research Farm of the Federal University Oye Ekiti, located on the Ikole Campus in Ikole Local Government Area, Ekiti State, Nigeria. Ekiti State lies between latitudes 7°15′ and 8°51′ North and longitudes 4°51′ and 5°45′ East of the Greenwich Meridian, situated just north of the Equator (NPC, 2006). The entire Ikole Local Government Area is located within the tropical rainforest zone of southwestern Nigeria. Its coordinates are approximately latitude 7°–8°15′ North and longitude 4°5′ East (Wikipedia, 2025).

Experimental Animals and Design

Sixteen growing West African Dwarf Goats were used in this research. The animals were purchased from Ikole market, Ekiti state. The animals were acclimatised for seven (7) days before the commencement of the study. The animals were randomly allocated to four (4) treatments (T1, T2, T3 and T4), with four goats per treatment in a Completely Randomised Design (CRD). Each treatment was replicated four times with one goat per replicate.

Harvesting and processing experimental diets

The forages were harvested from the pasture research plots of the university farm. Guinea grass, Mulato II and Congo grass forages were cut at 2cm above the ground level at pre-flowering stage, chopped at 3 cm long and wilted for 2-3hours in the sun and air dried under shade for four to five days by spreading on a concrete floor and turning thoroughly to facilitate uniform drying for saving storage to prevent bleaching and loss of nutrients. The hay was packed into different sacks and then stored. Cassava peels and palm kernel cake were purchased from garri and palm oil processing factories within the Ikole Local Government Area.

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Table 1: Experimental diets formulation

Diet/10kg	T1 (%)	T2 (%)	T3 (%)	T4 (%)
Guinea grass	100	-	-	60
Mulato II	-	60	-	-
Congo grass	-	-	60	-
Palm kernel cake (PKC)	-	20	20	20
Cassava peels	-	20	20	20
Total (%)	**100**	**100**	**100**	**100**

T1=Guinea grass only), T2= Mulato II + Palm kernel cake + cassava peels, T3= Congo grass +Palm kernel cake + cassava peels, T4= Guinea grass +Palm kernel cake + cassava peels

Haematological and biochemical analysis

Blood samples were collected at the end of the feeding trial. A new hypodermic needle and syringe (for each animal to avoid cross-contamination) were used to collect a 10 mL blood sample via the jugular vein from three randomly selected goats from each treatment. The blood samples were then discharged into a sterile plain bottle (5 mL) and an EDTA bottle (5 mL). For haematological analyses, blood samples were collected in vacutainers containing EDTA as an anticoagulant. For the serum biochemical analysis, blood samples were collected into vacutainers without anticoagulants, and serum was separated by centrifugation at 750 *g* for 15 min and stored in a freezer at -20 °C until use. Haematological analyses, packed cell volume PCV by the microcentrifuge method, haemoglobin, red blood cell count, white blood cell count, platelet count, lymphocytes, heterophils, monocytes, and eosinophils were analysed. For differential leukocyte counts, blood smears were prepared and stained with Giemsa (Jain, 1986). The total protein was measured by the Biuret method, albumin by the bromcresol green method, total globulin by the difference of total protein and albumin, and cholesterol by a modified Abell-Kendall/Levey-Brodie (A-K) method. Triglyceride was measured by the enzymatic procedure of McGowan *et al.* (1983), glucose by the glucose oxidase method, AST and ALT activities by the colourimetric method of Reitman and Frankel, LDH by the Sigma colourimetric (Cabaud-Wroblewski) method, and ALP by the modified method of Bowers and McComb.

Data Analysis

Data on haematology and serum biochemistry were analysed using a General Linear Model (GLM) with Type III Analysis of Variance (ANOVA) (SAS, 2010). Differences among means were separated using Tukey's honest significant difference (HSD).

RESULTS AND DISCUSSION

Haematology of West African Dwarf Goats (WAD) Fed Guinea grass, Mulato II and Congo grass Supplemented with Palm Kernel Cake and Cassava Peels

The results of haematology are presented in Table 1, which shows that there were significant differences in some haematological parameters, including packed cell volume (PCV), haemoglobin (Hb), white blood cell (WBC) count, and Platelet Count. The experimental animals were fed Guinea grass only in Treatment 1(control), Mulato II supplemented with Cassava peels and Palm Kernel Cake (T2), Congo grass supplemented with Cassava peels and Palm Kernel Cake (T3), and Guinea grass supplemented with Cassava peels and Palm Kernel Cake (T4). In terms of PCV (%), treatment 1 (Guinea grass fed only) recorded the highest value of 27.0, while in HB, treatments 1, 2, and 3 shared similar significant values of 9.5, 8.8, and 8.2, respectively. Furthermore, the result showed that treatment 4 showed the highest significant values in WBC and platelets. However, there were no significant differences in Lymphocytes, heterophils, monocytes and eosinophils among the experimental treatments. Ajayi *et al.* (2021) and Ezenwa *et al.* (2023) linked higher WBC with improved immune function in supplemented ruminants. There was no significant difference ($P < 0.05$) in lymphocytes, heterophils, or eosinophils, indicating no immune suppression across treatments. Red blood cell counts (RBC) between 7.75-13.82 x 10^6/mm^3 have been observed in goats fed similar diets, indicating healthy erythropoiesis (Falola and Olufayo (2024); Jonah *et al.,* 2024), and the values observed in the current study fall between the range there by indicating healthy erythropoiesis in the experimental animals in all the treatments. Falola and Olufayo (2024) and Jonah *et al.* (2024) further revealed that a White blood cell count (WBC) ranging from 9.78 to 13.48 x 10^3/mm^3 suggests a healthy immune system. Jonah *et al.* (2024) studied the haematological parameters of West African Dwarf goats fed a mixture of cassava sievate with groundnut husk supplement and reported improved haematological indices in goats fed a diet containing 50% Guinea grass and 27% cassava peels.

This showed that cassava peels supplementation improves haematological indices as observed in this study. Both the reported literature and the current studies demonstrate that West African Dwarf goats can tolerate diets supplemented with palm kernel cake and cassava peels, with haematological parameters within normal ranges.

Table 1: Haematology of West African Dwarf Goats Fed Guinea grass, Mulato II and Congo grass Supplemented with Palm Kernel Cake and Cassava Peels.

Parameters	Treatments				*P-value*	SEM
	T1	T2	T3	T4		
PCV (%)	27.0^{a}	26.0^{ab}	24.0^{c}	25.0^{bc}	0.031	0.289
HB (g/dL)	9.5^{a}	8.8^{a}	8.2^{a}	6.4^{b}	0.013	0.252
RBC ($\times 10^{6}$/µL)	3.64	4.21	3.82	3.12	0.519	0.250
WBC ($\times 10^{3}$/µL)	15600^{c}	16800^{b}	14400^{d}	18100^{a}	0.001	55.902
PLATELET ($\times 10^{3}$/µL)	130000^{b}	117000^{c}	128000^{b}	182000^{a}	0.004	763.763
LYM (%)	60.0	60.0	54.0	53.0	0.326	1.627
HET (%)	26.0	30.0	33.0	33.0	0.345	1.465
MON (%)	3.0	3.0	3.0	3.0	1.000	0.289
EOS (%)	4.0	5.0	4.0	6.0	0.112	0.289

Means on the same row with different superscripts were significantly (P<0.05) different.

PCV=Parked cell volume, HB=Hemoglobin, RBC=Red blood cell count, WBC=White blood cell count, PLATELET=Platelet count, LYM=Lymphocytes, HET=Heterophils, MON=Monocytes, EOS=Eosinophils

T1=Guinea grass only), T2= Mulato II + Palm kernel cake + cassava peels, T3= Congo grass +Palm kernel cake + cassava peels, T4= Guinea grass +Palm kernel cake + cassava peels, SEM=Standard error of mean.

Serum Biochemistry of West African Dwarf Goats Fed Guinea grass, Mulato II and Congo grass Supplemented with Palm Kernel Cake and Cassava Peels

The results of the serum biochemistry are presented in Table 2. The result revealed that there was significant difference (P<0.05) in the serum biochemistry which treatment 2 recorded the highest significant values in glucose (Gluc), alanine aminotransferase (ALT), albumin (ALB), cholesterol (CHOL), UREA and alkaline phosphatase (ALP) as 196.7, 21.3, 1.1, 158.0, 4.5 and 108 respectively. There was a statistical similarity between treatments A and B in terms of ALT and CHOL; furthermore, treatments 1 and 3 showed a similarity in high-density lipoprotein (HDL). However, treatment 1 recorded the highest significant difference in creatinine and low-density lipoprotein (LDL), at 1.0 and 30.4, respectively. There was no significant difference (P > 0.05) between all treatments in terms of total protein (TP) and globulin (GLOB). The values are optimal, indicating a well-functioning liver and metabolic status, as revealed by Gabriel *et al.* (2023) and Jonah *et al.* (2024). Creatinine was higher in T1 (1.0 mg/dl), possibly due to lower protein intake and metabolic inefficiency. There was no significant difference (P > 0.05) in total protein and globulin across all treatments. The results of this study aligned with the findings of Ogunbosoye *et al.* (2022), who reported that PKC and cassava peels improve protein metabolism and liver enzyme regulation. Another survey by Adebisi *et al.* (2023) reported enhanced serum metabolites in West African Dwarf rams fed *Panicum maximum* supplemented with *Cajanus cajan* foliage hay.

Table 2. Serum biochemistry of West African Dwarf Goats Fed Guinea grass, Mulato II and Congo grass Supplemented with Palm Kernel Cake and Cassava Peels.

Parameters	Treatments				*P-value*	SEM
	T1	T2	T3	T4		
Glucose (mg/dL)	180.0^{ab}	196.7^{a}	170.0^{b}	174.0^{b}	0.058	3.008
Aspartate (U/L)	172.0	184.0	175.0	184.0	0.157	2.051
ALT (U/L)	22.0^{a}	21.3^{a}	18.0^{b}	19.0^{b}	0.002	0.264
Total protein (g/dL)	5.1	4.3	3.8	4.0	0.449	0.289
Albumin (g/dL)	1.0^{ab}	1.1^{a}	0.8^{c}	0.9^{bc}	0.014	0.025
Cholesterol (mg/dL)	159.0^{a}	158.0^{a}	140.0^{b}	150.0^{ab}	0.037	2.051
Globulin (g/dL)	4.2	4.0	3.8	3.6	0.894	0.289
Urea (mg/dL)	4.0^{ab}	4.5^{a}	3.1^{ab}	2.15^{b}	0.083	0.289
ALP (U/L)	94.0^{c}	108^{a}	98.0^{b}	28.0^{d}	0.001	0.289
Creatinine (mg/dL)	1.0^{a}	0.8^{b}	0.6^{c}	0.6^{c}	0.003	0.022
HDL (mg/dL)	23.0^{a}	19.0^{c}	24.0^{a}	21.0^{b}	0.001	0.289
LDL (mg/dL)	30.4^{a}	28.1^{b}	27.2^{b}	26.3^{b}	0.005	0.289

Means on the same row with different superscripts were significantly (P<0.05) different.
ALT=Alanine aminotransferase, UREA=Blood urea nitrogen, ALP=Alkaline phosphatase, HDL=High density lipoprotein, LDL= Low density lipoprotein, T1=Guinea grass only), T2= Mulato II + Palm kernel cake + cassava peels, T3= Congo grass +Palm kernel cake + cassava peels, T4= Guinea grass +Palm kernel cake + cassava peels, SEM=Standard error of mean.

CONCLUSION AND RECOMMENDATION

Feeding West African Dwarf goats with Mulato II, Congo grass, and Guinea grass, supplemented with palm kernel cake and cassava peels, significantly improved haematological indices and serum biochemical parameters, which reflect an enhanced immune response and protein metabolism. The use of PKC and cassava peels as alternative feed resources offers a cost-effective and nutritionally viable strategy for improving the health and productivity of WAD goats. Such interventions hold significant potential for promoting sustainable small ruminant production systems in Nigeria. Farmers should be encouraged to supplement goat feed with grasses like Mulato II or Congo, or guinea, with diets containing palm kernel cake and cassava peels to improve their health status. Research on optimal feed combinations and farmer training in sustainable practices could also be prioritised. This approach enhances nutrition while reducing reliance on expensive feeds. Adopting these strategies will boost productivity and support resilient goat farming systems

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