INTAKE AND BLOOD CONSTITUENTS OF RED SOKOTO GOATS FED TOTAL DIETS CONSISTING OF HAY MEAL AND PROCESSED BY-PRODUCTS

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Abstract: The intake and blood constituents of Red Sokoto (RS) goats fed total diets consisting of *Andropogon tectorum* hay meal and two agro-industrial processed by-products; brewer's dried grains (BDG) and malted sorghum sprouts (MSP) were evaluated. Four diets designated T1, T2, T3 and T4 were formulated to contain varying proportions of BDG and MSP (40:10, 30:20, 20:30 and 10:40). The diets were offered to twenty-four (24) RS goats in a completely randomised design (CRD) experiment for 56 days. Daily feed intakes (g/d) and weekly body weight (kg) changes were measured. Blood samples were collected via jugular vein puncture before and after the experiment for analyses. All the parameters on intake and body weight changes were non-significant (P>0.05); though goats on T4 showed numerical superiority among the other treatments. Apart from the mean corpuscular volume (MCV), white blood cells (WBC) and direct bilirubin which were statistically affected (P<0.05) before the introduction of the experimental diets, all the other blood constituents measured were statistically similar (P>0.05). After the trial, the packed cell volume (PCV), haemoglobin (Hb), red blood cells (RBC), MCV, mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and WBC showed significant differences (P<0.05) among the treatment means while the differential WBC counts were not affected (P>0.05). Goats on T3 and T4 had similar (P>0.05) PCV and Hb values (32.23%; 31.74% and 11.46g/dl; 11.51g/dl). The PCV of goats on T1 (28.99%) and T2 (28.29%) were statistically similar (P>0.05) while their Hb values (9.06g/dl and 9.93g/dl) differed (P<0.05). The WBC counts followed similar trend as the PCV values across the treatments with a range of 12.30×10^3/µl – 16.95×10^3/µl. RBC counts were superior for goats on T4 (18.50×10^6/µl) than the other groups. Blood glucose levels, total bilirubin and creatinine values remained statistically unchanged while blood urea and direct bilirubin values were significantly different (P<0.05) among the treatment means. The glucose values ranged from 58.56mg/dl (T1) – 63.48mg/dl (T2). Higher urea (19.85mg/dl) was recorded for goats on T3 followed by goats on T4 (17.49mg/dl) while goats on T1 had the least urea value (15.22mg/dl). From these findings, it could be deduced that the four dietary treatments did not alter performance and health status of the animals with T4 being adjoined as the best; hence, the use of these agro-industrial processed by-products to support production during periods of forage scarcity should be adopted.

INTRODUCTION

Forages constitute the bulk of the feed consumed by ruminant animals. Seasonal fluctuations in the quantity and quality of forages especially, annual species often lead to considerable loss in production and in severe cases, death of the animals due to malnutrition. One of the options available to ruminant farmers for sustainable production is to supplement poor quality forages with industrially processed by-products of agricultural origin.

Brewer's dried grains (BDG) and malted sorghum sprouts (MSP) are two agro-industrial by-products produced by the brewery, food and allied industries in large quantities. While BDG has long been fed to ruminants (Murdock *et al*., 1981) MSP appears to be relatively new in the feed industry (Oduguwa *et al*., 2006). The idea of feeding BDG arose primarily from the desire to investigate cheap and alternative feed for livestock (Adebowale and Ademosun, 1981). It is recognised as an excellent protein and energy source due to its high digestible fibre content and ruminal escape protein (Martin Aregheore and Ng'ambi, 2007) and water soluble vitamins (Westendorf and Wohlt, 2002). The level of usefulness of MSP as a feedstuff generated some interest and antecedent studies with rats (Oduguwa *et al*., 2006). Findings revealed that its nutritive value in rats is low (Oduguwa *et al*., 2001; Aning *et al*., 1998).

One of the major constraints in feeding these processed by-products to ruminants is the presence of toxins in them. Mycotoxins caused by fungi infestation of brewer's spent grains have been reported in poorly processed BDG. Due to high moisture and fermentable sugar contents (Mussatto, *et al*., 2006) as well as polysaccharide and protein contents

(Stojeeska *et al*., 2008), brewers spent grains is a very unstable material and liable to deteriorate rapidly as a result of microbial activity. Isaac *et al*. (2014) isolated 14 fungal species belonging to 9 genera from spent sorghum grain exposed to drying. Tannin and hydrogen cyanide (HCN) have been identified in MSP. Oduguwa *et al*. (2006) reported the tannin and HCN contents of MSP as 1.0g/kg and 0.10g/kg respectively while Oduguwa and Fafiolu (2004) reported 15.18g/kg HCN in the same product.
Church *et al*. (1984) stated that ingested food components have measurable effects on blood constituents and the effects of dietary treatments on performance and physiological functions of the animal can be monitored through blood examination (Olorunnisomo *et al*., 2012). To evaluate the tolerable level of these toxins in the feedstuffs, measuring their intakes and the blood constituents of animals consuming them become essential; hence the study.

MATERIALS AND METHODS

The feeding trial was conducted in the Sheep and Goat Unit of the Michael Okpara University of Agriculture, Umudike, Teaching and Research Farm while the laboratory evaluation of blood was carried out in the College of Veterinary Medicine Laboratory of the same University.
Twenty-four (24) intact Red Sokoto (RS) goats; all bucks aged 10–12 months and weighing between 12–15 kg were supplied from the northern agro-ecological zone of Nigeria by a major ruminant livestock dealer in Obinze, along Owerri–Portharcourt express way, Imo State, Nigeria. On arrival, they were put in a thoroughly sanitized house for 21-day quarantine. Initially, the animals were fed groundnut vines and wheat offal. Gradually, components of the experimental diets were introduced. Water was also provided *ad-libitum*. Prophylactic treatments of the bucks included the injection of long-acting oxytetracycline intramuscularly at the rate of 0.10ml/kg body weight repeated 48 hours later. Levamisole injection was administered subcutaneously (s/c) at the rate of 1 ml per buck to control endo-parasites while ivermectin injection given s/c was used to manage common ecto-parasites. They were vaccinated against Peste des petit ruminants (PPR) towards the end of the 21 days quarantine.
Four diets as shown on Table I were formulated and mixed from the following ingredients: *Andropogon tectorum* hay meal (ATHM), BDG, MSP, Palm Kernel meal (PKM), molasses, bone meal and common salt. 250g of vitamin-mineral premix was added per 100kg of each diet in order to supply the micro-nutrient needs of the goats. The grass hay used in this study was processed from *Andropogon tectorum* harvested from uncultivated lands around Ahuwa – Oboro in Ikwuano L.G.A., Abia State, Nigeria. The grass was cut between September and October, chopped into 3 cm length and sun dried for 5–7 days. The dried grass was later ground in a local mill to form ATHM. This was thoroughly mixed together and stored in an air proof condition until required for feed mixing. Other ingredients were procured from livestock feed dealers in Umuahia and Aba, Abia State, Nigeria.

Table I: Composition of experimental diets

Ingredients	Diets			
	T1	T2	T3	T4
Andropogon tectorum hay meal	31	31	31	31
Brewers Dried Grains	40	30	20	10
Malted Sorghum Sprout	10	20	30	40
Palm Kernel Cake	10	10	10	10
Molasses	5	5	5	5
Bone Meal	3	3	3	3
Common Salt	1	1	1	1
Total	100	100	100	100

The twenty-four (24) bucks were randomly divided into four groups of six (6) bucks per group, housed in sanitized pens according to their groups, with feeders and drinkers provided. The bucks were assigned in a completely randomized design (CRD) to the four treatment diets in three replicates with two (2) bucks per replicate. Feed intakes were measured daily while live weight changes were monitored weekly throughout a period of 56-days (8 weeks).
Blood samples were collected from the twenty-four bucks according to their groups via jugular vein-puncture using 5 ml syringes and needles. 1 ml each of the blood samples collected was transferred into an ethylene diamine tetra-acetic acid (EDTA) treated bottles for haematology studies. The remaining 4mls were transferred into sterile anti-coagulant free bottles. These samples were allowed to coagulate at room temperature and centrifuged at 3000 rpm for 10 minutes. The supernatant sera were harvested and stored in the freezer for biochemical studies. The blood was collected twice; at the beginning of the study and at the end of the 8 weeks feeding trial.

The PCV was determined using the micro-haematocrit method according to Coles (1986). Hb was analysed following the Cyanomethaemoglobin method as described by Kachmar (1970). The Haemocytometer method described by Schalm *et al*. (1975) was used to determine the RBC and WBC as well as the differential WBC counts after appropriate dilutions. Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated from the formulae as shown.

$$\text{MCV (fl)} = \frac{\text{PCV} \times 10}{\text{RBC count}}$$

$$\text{MCH (fmol)} = \frac{\text{Hb} \times 10}{\text{RBC count}}$$

$$\text{MCHC (\%)} = \frac{\text{Hb} \times 100}{\text{PCV}}$$

The blood glucose level was established using the Accu-check ® active diabetes monitoring kit based on the glucose oxidase method (Roche Diagnostic, 2005). The blood urea was analysed through the modified method of Berthelot-Searcy for the in-vitro determination of urea in serum using Quimicaclinica Applicada (QCA) enzymatic urea test kit (QCA, Spain) as described by Fawcett and Scott (1960). Serum bilirubin was determined following the Jendrassik-Grof method described by Doumas *et al*. (1973). The total and direct bilirubins were evaluated as shown below.

Total bilirubin = Absorbance of sample × 43.2

Direct bilirubin = Absorbance of sample × 57.6

Serum creatinine was determined using the modified Jaffe method according to Blass *et al*. (1974).

Data generated from the study were subjected to analysis of variance (ANOVA) appropriate for CRD using SPSS base for windows. Treatment means showing statistical differences at a probability of 5 % were compared using the Duncan's multiple range procedures of the same package.

RESULTS AND DISCUSSION

Feed intake and live weights of RS goats (Table II) fed the diets did not vary statistically ($P>0.05$) for the four treatment groups.

The total weight gains were lower than those reported for a similar breed in earlier studies (Makun *et al*. 2008; Olorunnisomo *et al*. 2012). Makun *et al*. (2008) recorded 4.10 kg of total weight gain for RS goats in the Guinea Savannah ecological zone of Nigeria while Olorunnisomo *et al*. (2012) obtained gain of 3.1–7.7 kg for the same breed in Ibadan, Nigeria. Average daily weight gains were lower than the value of 170g/day recommended by Aduku (1993) for goats but outweighed the value of 0.02±0.009kg/day in RS goats fed 7.5% dried sweet orange peel meal in their diet (Yashim *et al*., 2016).

Table II: Feed intakes and live weights of RS goats fed total diets consisting of a hay meal and processed by-products

Parameter	Diets				SEM
	T1	T2	T3	T4	
Total feed intake (kg)	30.85	28.13	28.33	29.98	1.17
Average daily intake (g/d)	553.30	505.30	506.70	536.70	0.02
Initial live weight (kg)	13.53	13.83	13.83	14.00	0.25
Final live weight (kg)	16.00	16.33	16.75	17.17	0.32
Total weight gain (kg)	2.47	2.50	2.92	3.17	0.12
Average daily weight gain (g/d)	44.05	44.64	52.08	56.55	2.21

SEM: Standard error of mean

The haematology profiles of the experimental goats before and after introducing the dietary treatments are presented on Table III. Only the MCV and WBC counts varied statistically ($P<0.05$) across the treatments at 0-week. The variability could be as a result of earlier exposure

of the animals to mange mites as observed during the period before experimentation. This was promptly treated using ivermectin injection.

Table III: Haematological profile of RS goats fed total diets consisting of a hay meal and processed by-products

Parameters	Diets				SEM
	T1	T2	T3	T4	
At 0-week					
PCV, %	32.97	29.28	29.52	31.74	0.65
Hb, g/dl	10.18	9.93	9.67	10.19	0.10
RBC, $\times 10^6$/µl	10.18	9.93	9.67	10.19	0.17
MCV,fl	19.08^{a}	16.96^{b}	16.83^{b}	17.92^{ab}	0.36
MCH,fmol	5.89	5.75	5.51	5.75	0.09
MCHC,%	30.86	33.91	32.79	32.45	0.83
WBC, $\times 10^3$/µl	17.47^{a}	17.86^{ab}	18.38^{a}	16.29^{b}	0.28
Neutrophils,%	27.33	30.00	33.33	31.33	1.24
Lymphocytes,%	66.33	65.00	62.33	63.67	1.19
Monocytes,%	2.33	2.67	2.35	2.65	0.15
Eosinophil,%	2.67	3.00	2.00	2.33	0.23
At 8-week					
PCV, %	28.79^{b}	28.29^{b}	32.23^{a}	31.74^{a}	0.60
Hb, g/dl	9.06^{c}	9.93^{b}	11.46^{a}	11.51^{a}	0.33
RBC, $\times 10^6$/µl	16.79^{b}	17.30^{b}	17.29^{b}	18.50^{a}	0.23
MCV,fl	17.15^{b}	16.36^{b}	18.65^{a}	17.33^{b}	0.28
MCH,fmol	5.40^{c}	5.74^{c}	6.63^{a}	6.22^{b}	0.15
MCHC,%	31.49^{b}	35.09^{a}	35.55^{a}	36.28^{a}	0.58
WBC, $\times 10^3$/µl	12.62^{b}	12.30^{b}	16.95^{a}	16.66^{a}	0.73
Neutrophils,%	29.67	31.00	32.33	32.33	1.21
Lymphocytes,%	65.67	64.67	63.67	63.00	1.25
Monocytes,%	2.33	2.33	2.00	2.33	0.25
Eosinophil,%	2.33	2.00	2.00	2.00	0.19

^{a,b,c,} means on the same row with different superscripts are significant ($P<0.05$)
SEM: Standard error of mean

After the dietary treatments (at the end of the 8 weeks feeding trial) all the haematological parameters evaluated differed ($P<0.05$). The PCV of RS goats on T3 and T4 were similar ($P>0.05$) and higher than the PCV of those on T1 and T2, which were the same. Mean haemoglobin (Hb) values of goats on T4 was the highest but similar to the mean Hb value for RS goats on T3. This was followed by the Hb value of RS goats on T2. The lowest Hb value was recorded for goats on T1.
The RBC counts were higher ($P<0.05$) for goats on T4 but similar ($P>0.05$) for the other 3 groups. MCV and MCH values were higher for RS goats on T3. MCV of the other groups were statistically similar ($P>0.05$) while the MCH of RS goats on T1 and T2 were similar but lower than the MCH of RS goats on T4. MCHC of RS goats on T1 was the lowest and differed ($P<0.05$) from the other 3 groups. Bucks on T3 and T4 recorded significantly higher ($P<0.05$)

WBC counts when compared with bucks on T1 and T2. The differential WBC counts, however, were similar (P>0.05) across the four treatments.

Most of the observed haematological profiles were within the ranges reported by previous researchers. The PCV values obtained in the current study are comparable to the values obtained by Olorunnisomo *et al*. (2012) but slightly higher than the value of 25.70% reported in apparently healthy RS goats (Tambuwal *et al*., 2002). These values however, were within a normal range of 21–35% established by Daramola *et al*. (2005). Hb values of the goats were also within the established Hb range of 7–15g/dl (Daramola *et al*., 2005). The significantly higher Hb values observed in T3 and T4 were similar to the values obtained by Olorunnisomo *et al*. (2012) while those of T1 and T2 were similar to the values obtained by Olafadehan (2011).

RBC counts were superior to the value of 10.9×10^6/µl given by Tambuwal *et al*. (2002). MCV, MCH and MCHC values compare favourably with the values obtained elsewhere (Sirois, 1995). The observed white blood cell counts were higher than the value of 10.6×10^3/µl given by Tambuwal *et al*. (2002). Significantly higher WBC counts in T3 and T4 could be as a result of the increasing levels of tannin and hydrogen cyanide in the diets as the level of MSP increased since the young shoots in MSP contain these compounds (Oduguwa *et al*., 2006). Olorunnisomo *et al*. (2012) reported that leukocyte count is an indication of pathogenic infection or presence of antigens in the organism. Differential WBC counts were within the ranges reported by Daramola *et al*. (2005).

The serum biochemical scores of RS goats are presented on Table IV. Only the direct bilirubin showed statistical variance (P<0.05) among the other parameters evaluated before subjecting the goats to the treatments. Mange mite infestation prior to this period could be responsible for the observed differences. At end of the 8-weeks feeding trial, only blood urea and direct bilirubin levels were statistically affected (P<0.05). The blood urea level was statistically higher (P<0.05) in T3 when compared with T1 and T2 but similar to those of T4. Direct bilirubin value was statistically different (P<0.05) in T1 but similar (P>0.05) in the other treatments.

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Table IV: Serum biochemical values of RS goats fed total diets consisting of a hay meal and processed by-products

Parameters	Diets				SEM
	T1	T2	T3	T4	
At 0-week					
Blood glucose, mg/dl	55.60	57.57	61.51	60.03	1.14
Blood Urea, mg/dl	16.39	12.57	17.68	17.49	1.04
Total Bilirubin, mg/dl	2.11	1.91	1.91	2.13	0.05
Direct Bilirubin, mg/dl	0.53^{b}	0.43^{b}	0.85^{a}	0.57^{ab}	0.06
Creatinine, mg/dl	1.15	1.31	1.14	0.66	0.11
At 8-week					
Blood glucose, mg/dl	58.56	60.03	59.54	63.48	0.89
Blood Urea, mg/dl	15.22^{b}	15.31^{b}	19.85^{a}	17.49^{ab}	0.65
Total Bilirubin, mg/dl	2.11	1.90	2.12	1.91	0.05
Direct Bilirubin, mg/dl	1.10^{a}	0.43^{b}	0.28^{b}	0.42^{b}	0.10
Creatinine, mg/dl	0.61	0.65	0.81	0.49	0.07

[a,b] means on the same row with different superscripts are significant (P<0.05)

SEM: Standard error of mean

The observed glucose levels are comparable to the values obtained earlier (Olorunnisomo *et al*., 2012; Olafadehan, 2011). These values are close to and within the lower range of 60–100mg/100ml of blood (Tambuwal *et al*., 2002; Zubcic, 2001). The urea levels were below the range of 3.5–10.7 mmol/litre suggested by Sirois (1995) but fell within the range of 0.8–9.7 mmol/litre reported in West African Dwarf (WAD) goats (Daramola *et al*., 2005). Total bilirubin and direct bilirubin values were higher than the values obtained elsewhere (Okonkwo *et al*., 2010; Singh, 2004). These values should have indicated liver malfunction/diseases since earlier workers (Okonkwo *et al*., 2010) had implicated raised blood bilirubin to liver diseases and blocked blood vessels. However, research has indicated that in the absence of liver disease, individuals with high levels of total bilirubin may experience various health benefits (Sedlak and Snyder, 2004). Studies have also shown that the levels of serum bilirubin are inversely related to risk of certain heart diseases in man (Novotný and Vítek, 2003). Since the RS goats did not show any signs of liver problem as observed during the feeding trial, the raised bilirubin level could be an indication of health benefit as an inherent or acquired adaptive mechanism to the new environment.

Creatinine values were similar to the mean value of 0.73mg/dl reported in Marwari goats (Sharma and Puri, 2013) and within the normal range of 0.6 – 2.0mg/dl for goats (Peake and Whiting, 2006). Since creatinine levels relate to renal health as a measured by-product of muscle metabolism excreted unchanged by the kidney, the values obtained in the current study showed that muscle conformation and meat characteristics of the RS goats as a meat type breed were not affected by the treatments.

CONCLUSION

In the absence of clinical signs of ill-health and toxicity as well as the established blood constituents of the Red Sokoto goats used in this investigation, it was concluded that feeding them different combinations of BDG and MSP as processed by-products in total diets containing *Andropogon tectorum* hay meal could support their productivity during the periods that lush forages are scarce.

REFERENCES

Adebowale, E.A. and Ademosun, A.A. (1981). Studies on the utilisation of brewers dried grains by sheep and goats. 1. Growth studies. *Bull. Anim. Health and Prod.*

Aduku, A, O. (1993). Tropical feedstuff analysis table. Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Samaru-Zaria, Nigeria.

Aning, K.G., Ologun, A.G. Onifade, A., Alokan, J.A., Adekola, A.I., and Aletor, V.A. (1998). Effect of replacing dried brewers' grain with sorghum rootlet on growth, nutrient utilization and some blood constituents in the rat. *Anim. Feed Sci. and Technol*., 71:185–190.

Blass, K.G., Thiebert, R.J. and Lam, L.K. (1974). A study of the mechanism of the Jaffe reaction. *J. Clinical Chem. and Clinical Biochem*., 12: 336–343.

Church, J.J., Judd, C.W., Young, J.L. and Kim, W.W. (1984). Relationship among dietary constituents and specific serum clinical components of suggested eating self-selected diets. *Amsterdam J. Clinical Nutr*., 40: 1344–1388.

Coles E.H. (1986). Determination of packed cell volume. In: Coles E.H. eds., Veterinary Clinical Pathology. Pp. 17–19.

Daramola, J. O., Adeloye, A. A., Fatoba, T.A. and Soladoye, A. O. (2005). Haematological and biochemical parameters of West African Dwarf goats. *Livestock Res. for Rural Dev.*, 17.

Doumas, B.T., Perry, B.W., Sasse, E.A. and Straumford, Jr. J.V. (1973). Standardization in bilirubin assays: Evaluation of selected methods and stability of bilirubin solutions. *Clinical Chem.*, 19: 984–993.

Fawcett, J.K. and Scott, J.E. (1960). A rapid and precise method for the determination of urea. *J. Clinical Pathol*., 13: 156–159.

Isaac, A.O., Chike, I.C., Chukwu, O.O.C. and Collins, C.E.O. (2014). Occurrence of potentially hazardous fungi exposed brewers spent sorghum grains. *European Sci. J.*, 10: 449–457.
Kachmar, J.F. (1970). Determination of blood haemoglobin by the cynomethaemoglobin procedure. In: Fundamentals of Clinical Chemistry; W. B. Sanders Company, Philadelphia. Tietz N.W. ed. Pp. 268–269.
Makun, H.J., Ajanusi, J.O., Ehoche, O.W., Lakpini C.A.M. and Otaru, S.M. (2008). Growth rates and milk production potential of Sahelian and Red Sokoto breeds of goats in Northern Guinea Savannah. *Pakistan J. Biol Sci*., 11: 601–606.
Martin Aregheore, E. and Ng'ambi, J.W. (2007). Water intake of Fiji Fantastic sheep fed a basal diet of Batiki grass (*Ischaemum aristatum var. indicum*) supplemented with dried brewer's grains. *American-Eurasian J. Agric. and Envt. Sci*, 2: 479–485.
Murdock, F.R., Hodgson, A.S. and Riley, R.E. (1981). Nutritive value of wet brewer's grains for lactating dairy cows. *J. Dairy Sci.*, 64:1826–1832.
Mussatto, S.I., Dragone, G. and Roberto, I.C. (2006). Brewers' spent grain: generation, characteristics and potential applications. *J. Cereal Sci.*, 43: 1-14.
Novotný, L. and Vítek, L. (2003). Inverse relationship between serum bilirubin and atherosclerosis in men: A meta-analysis of published studies. *Exptal Biol. and Med*., 228: 568–571.
Oduguwa, O.O. and Fafiolu, A.O. (2004). Utilization of malted sorghum sprouts in the diets of starting chicken. Proceedings of 9th Annual Conference, Animal Science Association of Nigeria. September, 13–16, Ebonyi State University, Abakiliki, Pp. 67–69.
Oduguwa, B.O., Jolaosho, A.O., Babayemi, O.J., Aina, A.B.J. and Adu, I.F. (2006). Nutritive value of Malted Sorghum Sprout in West African Dwarf sheep fed soybean stover based diets. *J. Anim. and Vet. Adv.*, 5: 901–906.
Oduguwa, O.O., Fanimo, A.O., Oduguwa, B.O., Iyayi, E.A. and Oyadotun, A.I. (2001). Effect of enzyme supplementation on the nutritive value of MSP in the rat. *Trop. J. Anim. Sci.*, 4:189– 195.
Okonkwo, J.C., Omeje, I.S., Okonkwo, I.F. and Umeghalu, I.C.E. (2010). Effects of breed, sex and source within breed on the blood bilirubin, cholesterol and glucose concentrations of Nigerian goats. *Pakistan J. Nutr*., 9: 120–124.
Olafadehan, O.A. (2011).Changes in haematological and biochemical diagnostic parameters of Red Sokoto goats fed tannin-rich *Pterocarpous erinaceus* forage diets. *Vet. Archives*, 81: 471–483.
Olorunnisomo O.A., Ewuola E.O. and Lawal T.T. (2012).Intake and blood metabolites in Red Sokoto goats fed Elephant Grass and Cassava Peel Silage. *J. Anim. Prod. Adv.*, 2: 420–428.
Peake, M. and Whiting, M. (2006). Measurement of serum creatinine: Current status and future goals. *The Clinical Biochem. Rev*., 27: 173–184.
Roche Diagnostic (2005). Oxido-reductase mediator reaction method. *Clinical Chem.*, 51:1573–1576.
Schalm, O.W., Jain, N.C. and Caroll, E. J. (1975). Veterinary Haematology, 3rd ed. Lea and Febiger, Philadelphia. Pp. 19–25.
Sedlak, T.W. and Snyder, S.H. (2004). Bilirubin benefits: cellular protection by a biliverdin reductase antioxidant cycle. *Paediatrics*, 113: 1776–1782.
Sharma, A.K. and Puri, G. (2013). Effect of extreme hot condition on serum biochemical constituents in Marwari Goats. *Livestock Res.*, 1(1): 23–28.
Singh, S.P. (2004). Practical Manual in Biochemistry, 5th ed. Satish Kuma Jain, India, Pp. 203–255.
Sirois, M. (1995): Veterinary Clinical Laboratory Procedure. Mosby year book, Inc. St Louis, Missouri, USA.
Stojeeska, V., Ainsworth, P., Plunkett, A. and Ibanoglu, S. (2008). The recycling of brewery processing by-product into ready-to-eat snacks using extrusion technology. *J. Cereal Sci*., 47: 469–479.
Tambuwal, F.M., Agaie, B.M. and Bangana, A. (2002). Haematological and Biochemical Values of apparently healthy Red Sokoto goats. Proceeding of 27th Annual conference, Nigerian Society of Animal Production (NSAP), March, 17–21, FUTA, Akure, Nigeria. Pp. 50–53.
Westendorf, M. L. and Wohlt, J.E. (2002). Brewing by-products: their use as animal feeds. *Vet. Clinics: North America Food Anim. Prac.*, 18:233–252.
Yashim, S.M., Adekola, S.T., Abdu, S.B., Gadzama, I.U. and Hassan, M.R. (2016). Feed intake, growth performance and nutrient digestibility in growing Red Sokoto bucks fed diets containing graded levels of dried sweet orange peel meal. *Anim. Research Intl*., 13(1): 2328–2337.
Zubcic, D. (2001). Some biochemical parameters in the blood of grazing German improved farm goats from Istria, Croatia. *Archives*, 71: 237–244.

Ethics approval and consent to participate

The experimental and management procedures involving animal studies were performed by trained personnel in accordance with Michael Okpara University of Agriculture, Umudike guidelines for experimental animal right protection.

Conflict of interest

The authors hereby affirm that they do not have any conflict of interest.

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