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Original Contribution

EFFECTS OF FEEDING TANNIN-CONTAINING FORAGE IN VARYING PROPORTION WITH CONCENTRATE ON THE VOLUNTARY INTAKE, HAEMATOLOGICAL AND BIOCHEMICAL INDICES OF GOATS

O. A. Olafadehan[1*], M. K. Adewumi[2], S. A. Okunade[3]

[1]Department of Animal Science, University of Abuja, Abuja, Nigeria
[2]Department of Animal Science, University of Ibadan, Ibadan, Nigeria
[3]Department of Animal Production Technology, Federal College of Wildlife Management, New Bussa, Niger State, Nigeria

ABSTRACT

Twelve healthy Red Sokoto male goats (7-8 months old, liveweight (LW) 12.0 ± 0.68 kg) were randomly allocated to one of three treatment groups comprising condensed tannins (CT) containing-forage, *Ficus polita* (FP), mixed with concentrate to produce three total mixed rations (TMR): 700:300 g/kg, 600:400 g/kg and 500:500 g/kg forage:concentrate (F:C) ratios in a 84-day experiment. Daily intakes of dry matter, crude protein, organic matter, total carbohydrate, non-fibre carbohydrate and hemicellulose linearly increased ($p<0.01$) but that of lignin and CT linearly decreased ($p<0.01$) as the ratio of F:C decreased. Whereas intake of ash linearly increased ($p<0.05$), intakes of acid detergent fibre and cellulose decreased both linearly ($p<0.01$) and quadratically ($p<0.05$) as the concentrate proportion increased. Packed cell volume (PCV), white blood cell (WBC), lymphocytes, serum urea and glucose linearly increased ($p<0.05$) but mean corpuscular haemaoglobin concentration linearly decreased ($p<0.05$) as the ratio of F:C decreased, while other haematological and serum parameters were similar among diets. Dietary CT intake (g/kg LW) was negatively correlated to PCV, MCHC, WBC, lymphocyte, urea and glucose. The results indicate that tanniniferous FP forage can be incorporated up to 700 g/kg in a TMR (700:300 g/kg F:C ratio) without compromising the body immunity system and health of the animals.

Key words: *Ficus polita***,** forage:concentrate ratio, goats, haematology, intoxication, serum metabolites, tanniniferous forage, total mixed ration

INTRODUCTION

The use of tree and shrub fodders in the nutrition of ruminant in developing countries is popular primarily due to their high protein profile and all year round availability. They are an important source of supplementary protein, vitamins and minerals (1). They play a significant role in reducing cost of feeding and ensuring all year round availability of fodders unlike grasses that become unavailable in dry season. Tree and shrub fodders, therefore, play an important role in insuring ruminant feed and also guarantee sustainable ruminant production. There are, however, many reports on the adverse effects of tree leaves when fed as a sole diet in sheep (2) and goats (3). The inclusion of concentrates in ruminant diets is aimed to increase dietary energy, proteins, minerals and vitamins, optimize the feed utilization efficiency and consequently performance. However, due to high cost of concentrates, they are used sparingly in ruminants' diets in developing countries. Feeding varying combinations of tree leaves with concentrate in a total mixed ration (TMR) may help to mitigate the effects of antinutritional factors in tree leaves. This is because the secondary metabolites, particularly condensed tannins (CT), in tree fodders could produce

***Correspondence to**: *O. A. Olafadehan, Department of Animal Science, University of Abuja, Abuja, Nigeria, oaolafadehan@yahoo.com; Tel.:+234 805 7035 527*

intoxication if consumed in excess. It, therefore, becomes imperative to determine the appropriate combination of tanniniferous forage with concentrate, forage to concentrate (F:C) ratio, that will optimize ruminant production without any deleterious effect on the health of the animals. Previous studies on effect of F:C ratio on ruminants focused mostly on performance but not haematological and biochemical indices, which have been used to assess humans and animals health status. Normal physiological processes are affected long before death of an organism, hence the need for physiological and biochemical indicators of health and sub-lethal toxicant effects on livestock consuming feeds that contain toxicants (4). Blood constituents provide valuable media for clinical investigations and nutritional evaluations of an animal. The serum biochemical and haematological features have attracted many workers to look at their indices in order to make clinical predictions of the health status of a particular animal. This is because one of the fastest means of ascertaining toxicity of ingested feed in animals is by assessment of the blood (4).

The objectives of the study are to compare the voluntary intake, haematological indices and serum biochemical components of goats fed diets containing varying ratios of tanniniferous forage, *Ficus polita* (FP), and concentrate.

MATERIALS AND METHODS

Experimental site, animals and management

The experiment was carried out at the goat unit of the University of Abuja Teaching and Research Farm. The experimental site lies between latitude 8º 55'N and 9º 00'E and longitude 7º 00'Nand 7º 05'E. The mean annual rainfall and temperature range from 1100 to 1650 mm and 25.8 to 35.1ºC, respectively. Relative humidity is about 60% during raining season and 30% during dry season. The dry season lasts for 6 months starting from November to April.

Twelve clinically healthy Red Sokoto male goats about 7 to 8 month of age, with an average initial liveweight (LW) of 12.0 ± 0.68 kg, were used for the assay. They were stratified by BW, such that the animals in each treatment group had similar average initial BW, and randomly allocated to one of three experimental treatment groups (n = 4). Two weeks prior to the procurement of the experimental goats, the pens and the surrounding environment were thoroughly cleaned and disinfected with anti-septic (Morigad). The goats were given prophylactic treatment consisting of intramuscular injection of antibiotics (oxytetracycline LA) at the rate of 1 ml/10 kg BW, dewormed with levamisole at the dosage of 1 ml/10 kg BW and dipped against ectoparasite with diazintol. They were kept in open well-ventilated pens; each goat was individually penned and fed. Feed was given once daily *ad libitum* at 09:00 h. The feeding trial lasted for 12 weeks including two weeks adjustment period after which blood samples were collected for haematological and biochemical analysis.

Experimental diet and feeding

F. polita fodder was harvested before flowering from several stands of the tree in the school premises. The leaves were plucked and were gradually cured in the sun to dry. The cured leaves were subsequently chopped into smaller sizes of 10 mm in order to disallow feed selection, and mixed at different ratios with concentrate ration to produce three total mixed rations (TMR). The three complete diets consisted of Ficus leaf meal and concentrate with forage:concentrate (F:C) ratios of 700:300, 600:400 and 500:500 g/kg. Low (300 g/kg) to medium (500g/kg) concentrate level in the TMR was used so as to develop a sustainable feeding strategy or package. Record of daily voluntary intake was kept.

Blood sample collection

On the last day of the experimental feeding trial period, two sets of blood samples were taken from the four goats in each treatment via jugular venipuncture using a 5m1 syringe. 5 ml blood sample was collected into labelled sterile bottles containing ethylenediamine tetra acetic acid (EDTA) as anticoagulant for the determination of haematological parameters. Blood samples for serum analysis were collected into anticoagulant free bottles, allowed to coagulate at room temperature and centrifuged at 1500 x g for 10 minutes. The supernatant sera were then collected and stored in a freezer for subsequent biochemical analysis.

Chemical analysis

The chemical composition of the FP and the experimental diets was determined according to the procedures of AOAC (5). Fibre components of the diets were analysed according to the

methods of Van Soest et al. (6). Cellulose and hemicellulose were estimated as differences between acid detergent fibre (ADF) and lignin and neutral detergent fibre (NDF) and ADF, respectively. Tannins were determined by the methods of Makkar [7]. Packed cell volume (PCV) and haemoglobin (Hb) concentration determination followed the procedures outlined by Dacie and Lewis (8). Red blood cell (RBC) and total white blood cell (WBC) as well as the differential WBC counts were determined using the Neubauer haemocytometer after appropriate dilution. Mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV) were calculated from RBC, Hb and PCV values as described by Dacie and Lewis (8). Serum total protein and its components were obtained by the buiret method (9), and serum urea and creatinine by modified method of Valrey et al. (10). Mineral elements were estimated with an atomic absorption spectrophotometer, Model 490 (Gallenkamp and Co. Ltd., London). The activities of the enzymes alanine transaminase (ALT) and aspartate transaminase (AST) were measured using the method of Reitman and Frankel (11) and alkaline phosphate (ALP) by the methods of Roy (12).

Data analysis and calculation

Data were analysed by the analysis of variance procedure of SPSS (15) for a completely randomized design. Linear and quadratic effects were determined utilising polynomial orthogonal contrasts for equally spaced treatments. The statistical model is shown below:

$$Yij = \mu + FCi + eij$$

Where Yij = dependant variables; μ = population mean; FCi = effect of forage:concentrate ratio on the feed intake, haematological and biochemical components and eij = random error assumed to be normally and independently distributed.

Simple linear regression analysis was used to establish relationship between CT intake (g/kg BW) and only significantly affected haematological and serum indices. Relationship between DM intake and CT intake and fibre fractions intake was determined using multiple regressions as applicable to parametric analyses. The statistical model used was:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon$$

where Y = DM intake; X_1 = CT intake, X_2 = NDF intake; X_3 = ADF; X_4 = ADL intake; β_0 = the intercept; β_1,β_2, β_3 and β_4 are the slopes and ε the error. The R^2 and P values were used to indicate the importance of the significances.

RESULTS

The chemical composition of the experimental diets and FP is presented in **Table 1**. The crude protein (CP), ether extract (EE), ash, NDF, ADF, lignin, cellulose and CT decreased slightly with decreasing forage level in the F:C ratio, whereas the OM, NFC and hemicellulose marginally increased with increasing concentrate level in the F:C ratio. The CP and CT contents of the FP fodder were on the high side. The CP content of the feeds is enough to stimulate rumen microbial activity with resultant high intake of feed and optimal supply of protein to the animal. In this context, all the diets contained higher nitrogen for normal rumen function.

There was a positive linear ($p<0.01$) effect on intakes of DM, CP, OM, TC, NFC and hemicellulose, while intakes of lignin and CT (g/day) or CT expressed relative to liveweight were linearly negatively ($p<0.01$) affected as the F:C ratio decreased **(Table 2)**. Ash or mineral intake progressively increased ($p<0.05$) with declining F:C ratio. Cellulose and ADF intakes decreased as the proportion of concentrate increased in the TMR, leading to significant ($p<0.01$) linear and quadratic trends; whereas, intake of NDF decreased from 700:300 g/kg F:C ratio to 600:400 g/kg F:C ratio and then increased as the level of F:C ratio increased to 500:500 g/kg, resulting in a significant quadratic ($p<0.05$) trend. No treatment effect was observed ($p>0.05$) in EE intake. Dry matter intake was highly significantly ($p < 0.0001$) and positively correlated ($r = 0.9999$) with CT intake (X1), NDF intake (X2) ADF intake (X3) and lignin intake (X4), with about 99.98% ($R^2 = 0.9998$) of variation in DM intake being attributable to these independent variables. The regression equation is $Y = - 0.7159 - 0.4388X1 + 5.179X2 – 4.993X3 + 3.396X4$. However, CT intake had a more pronounced contribution ($R^2 = 0.8885$) to DM intake than NDF intake ($R^2 = 0.845$), ADF intake (0.7843) and lignin intake ($R^2 = 0.7555$).

Table 1. *Composition of the experimental diets*

Item	***Forage:concentrate ratio (g/kg)***			
	700:300	***600:400***	***500:500***	***Ficus polita***
Ficus hay	700	600	500	
Maize	100	100	100	
Corn bran	90	190	290	
Soybean meal	65	65	65	
Urea	10	10	10	
Limestone	10	10	10	
Salt	10	10	10	
Vitamin-mineral premix*	15	15	15	
Analyzed content (g/kg DM)				
Crude protein	174.0	171.4	169.0	141.0
Organic matter	918.6	926.0	933.0	939.0
Ether extract	38.4	36.0	34.2	40.0
Ash	74.0	67.0	61.0	91.4
Total carbohydrate	713.6	725.6	735.8	727.6
Non-fibre carbohydrate	316.3	358.2	387.2	240.3
Neutral detergent fibre	397.3	367.4	348.6	487.3
Acid detergent fibre	265.0	230.0	205.5	339.1
Lignin	84.8	78.0	69.7	114.0
Cellulose	180.2	152.0	135.8	225.1
Hemicellulose	132.3	137.4	143.1	148.2
Condensed tannins	48.4	41.3	34.1	68.0

* supplied the following per kg of complete diet: Vitamin A 4,000,000 IU; Vitamin D3 2,000,000 IU; Vitamin E 7,000 IU; Vitamin B2 4,000 mg; Nicotinic acid 15,000 mg; Calcium D-pentothenate 8,000 mg; Biotin 40 mg; Vitamin B12 10 mg; Mn 20,000 mg; Fe 50,000 mg; Zn 100,000 mg; Cu 10,000 mg; Iodine 750 mg; Co 3,000 mg

Table 2. *Dry matter and nutrient intakes (g/day) of goats fed forage:concentrate ratio*

Item	***Forage:concentrate ratio (g/kg)***			***SEM***	***Probability[a]***	
	700:300	***600:400***	***500:500***		***L***	***Q***
Dry matter intake	575.45	604.26	643.27	6.14	**	NS
Crude protein intake	100.14	103.57	108.71	1.14	**	NS
Organic matter intake	528.61	559.54	600.17	10.85	**	NS
Ether extract intake	21.75	22.00	22.01	0.56	NS	NS
Ash intake	39.24	40.49	42.58	0.36	*	NS
Total carbohydrate intake	410.64	438.45	473.32	4.41	**	NS
Non-fibre carbohydrate intake	182.02	216.45	249.07	2.05	**	NS
Neutral detergent fibre intake	228.63	222.01	224.24	2.44	NS	*
Acid detergent fibre intake	152.50	138.98	132.20	1.54	**	*
Acid detergent lignin intake	48.80	47.13	44.84	0.50	**	NS
Hemicellulose	76.13	83.03	92.05	0.86	**	NS
Cellulose	103.70	91.86	87.36	1.04	**	*
Tannins intake	27.62	24.96	21.94	0.28	**	NS
Tannins intake (g/kg BW)	2.06	1.75	1.53	0.20	**	NS

[a]Probability level for linear (L) and quadratic (Q) trends. *P<0.05,**P<0.01, NS: not significant.

The PCV, WBC and lymphocytes increased linearly (p<0.05) but MCHC decreased linearly (p<0.05) as the level of concentrate in the diet increased. No effect of dietary treatment (p>0.05) was found on RBC, Hb, MCV, MCH, neutrophils, basophils and eosinophils **(Table 3)**.

Table 3. *Haematological indices of the goats fed forage:concentrate ratio*

Item	***Forage:concentrate ratio (g/kg)***			***SEM***	***Probability[a]***	
	700:300	***600:400***	***500:500***		***L***	***Q***
PCV (%)	25.58	26.65	27.90	0.70	*	NS
RBC (x 10^{12}/L)	13.95	14.62	15.04	1.01	NS	NS
Hb (g/dL)	84.86	85.09	85.50	1.50	NS	NS
MCV (fl)	18.47	18.26	18.58	0.68	NS	NS
MCH (fmol)	6.13	5.83	5.70	0.37	NS	NS
MCHC (%)	33.18	31.93	30.68	0.74	*	NS
WBC (x10^{9}/L)	10.12	11.90	12.77	0.94	*	NS
Lymphocytes (%)	60.62	64.04	66.40	2.12	*	NS
Neutrophils (%)	44.00	45.79	46.29	1.43	NS	NS
Basophils (%)	0.12	0.13	0.14	0.02	NS	NS
Eosinophils (%)	3.77	4.03	3.97	0.75	NS	NS

[a]Probability level for linear (L) and quadratic (Q) trends. *P<0.05, NS: not significant.

Except for serum urea and glucose which linearly increased (p<0.05) with decreasing F:C ratio, all other serum metabolites, including major serum minerals, were not affected (p>0.05) by the dietary treatments **(Table 4)**.

Table 4. *Serum metabolites of the experimental goats fed forage:concentrate ratio*

Parameter	***Forage:concentrate ratio (g/kg)***			***SEM***	***Probability[a]***	
	700:300	***600:400***	***500:500***		***L***	***Q***
Urea N (mmol/L)	4.78	4.91	5.40	0.83	*	NS
Creatinine(µmmol/L)	116.75	114.38	115.54	3.22	NS	NS
Glucose (mmol/L)	1.12	2.09	2.92	0.50	*	NS
Total protein (g/L)	68.32	69.95	71.61	3.48	NS	NS
Albumin (g/L)	32.59	33.57	34.84	3.91	NS	NS
Globulin (g/L)	35.73	36.38	36.77	0.73	NS	NS
Cholesterol (mmol/L)	1.75	1.72	1.70	0.09	NS	NS
AST (IU/L)	56.60	54.72	52.98	3.25	NS	NS
ALP (IU/L)	14.37	13.10	12.91	1.92	NS	NS
ALT (IU/L)	12.34	11.86	11.43	1.45	NS	NS
Calcium (mmol/L)	2.27	2.32	2.30	0.17	NS	NS
Potassium (mmol/L)	4.59	4.62	4.68	0.11	NS	NS
Phosphorus (mmol/L)	4.40	4.42	4.37	0.05	NS	NS
Sodium (mmol/L)	143.61	141.85	140.82	5.88	NS	NS

[a]Probability level for linear (L) and quadratic (Q) trends. *P<0.05, NS: not significant.

Intake of CT (g/kg BW) was significantly and negatively correlated to PCV (r = - 0.75, p = 0.02), MCHC (r = -0.84, p = 0.004), WBC (r = -0.63, p = 0.04), lymphocyte (r = -0.71, p = 0.03), urea (r = -0.59, p = 0.05) and glucose (r = - 0.77, p = 0.001) **(Table 5)**.

Table 5. *Linear relationships between condensed tannins intake (X) and other significantly affected blood variables (Y)*

Dependent variable	***Regression equation***	***R***	***R^2***	***SE***	***P-value***
Packed cell volume	Y = 33.89 – 4.03X	-0.752	0.566	1.333	p<0.0193
MCHC	Y = 40.60 – 4.87X	-0.843	0.711	1.175	p<0.0043
White blood cell	Y = 18.15 – 3.55X	-0.630	0.397	1.654	p<0.0390
Lymphocytes	Y = 82.04 –10.31X	-0.707	0.500	3.898	p<0.0332
Urea	Y = 6.48 – 0.815X	-0.205	0.042	1.473	p<0.0497
Glucose	Y = 8.23 – 3.47X	-0.774	0.599	1.075	p<0.0014

MCHC: Mean corpuscular haemoglobin concentration

DISCUSSION

The chemical composition of FP shows that the fodder has a good nutrient profile that can guarantee better productive performance in goats. However, the CT content was higher than the low to moderate concentrations of <55 g/kg, which have beneficial effects in ruminants (14). The nutrient composition of FP is consistent with the values earlier reported (15) except that the EE and NDF were lower. The declining CP, EE, ash, NDF, ADF, lignin, cellulose and hemicellulose and CT concentrations with decreasing F:C ratio is a reflection of the higher contents of these components in the FP fodder relative to the concentrate, whereas the increasing OM, TC and NFC with decreasing F:C ratio suggests higher levels of these components in the concentrate than the FP fodder.

The linearly increasing DM intake with declining forage level in the TMR agrees with previous reports (16, 17), and is primarily due to progressive decrease in fibre fractions and CT content of the diets. High dietary fibre generally reduces feed intake as fibre forms bulk, fill the gut and slows down the rate of passage of the ingesta through gastrointestinal tract, whereas CT reduce palatability, digestibility and consequently feed intake due to its astringent property. This result is validated by negative correlation between the intake of DM and the CT and fibre fractions. However, the result of the multiple regression analysis shows that CT intake was the major determinant of feed intake as its effect on feed intake was more pronounced than each of the three fibre fractions intake. The DM intake is similar to the intake reported for growing goats (18). The linearly increasing intakes of CP, OM, ash, TC, NFC and hemicellulose as the F:C ratio in the diet decreased, and the declining intakes of ADF, lignin, cellulose and CT as the proportion of forage in the TMR decreased show that there is a direct relationship between the contents of these nutrients in the diets and their intakes by the goats.

Haematological indices are an index and a reflection of the effects of dietary treatments on animals in terms of the quality of feed ingested and nutrients available to an animal to meet its physiological requirements. In the present study, the experimental goats, particularly those consuming 700:300 g/kg F:C ratio, which had the highest concentration and intake of CT, did not show clinical signs of ill health or signs of tannin toxicity such as head pressing, generalized depression, grinding of teeth, foaming at the mouth and twitching and jerking of the body reported by Odenyo et al. (19). The absence of signs of tannin toxicity, morbidity and mortality in these animals confirms the non-toxic level of CT in the diet. However, the lowest PCV value for goats fed 700:300 g/kg F:C ratio may be attributed to the relatively high concentration and consumption of CT that have been reported to have antinutritional action (20, 21). This is validated by the negatively significant relationship between CT intake (g/kg BW) and PCV. However, these values were within the range of 20 - 28% PCV reported for clinically healthy goats (22). Parallel results were obtained by Olafadehan (4), who observed significantly depressed PCV for goats fed tannin-rich *Pterocarpus erinaceus* fodder. The normal PCV indicates the absence of normocytic anaemia which is reportedly characterized by a normal MCV and MCH and only detected by a decreased number of RBC or PCV (23). Though RBC value was lower in 700:300 g/kg F:C ratio relative to other treatments, the insignificantly

affected RBC, which was within the normal physiological range of 8 - 17 x 10^{12} L (22), further elucidated the absence of haemolytic anaemia and showed that the goats did not suffer from depressed erythropoiesis. Though Hb, an iron-containing conjugated protein that performs the physiological function of transporting oxygen and carbon dioxide, was lowest in the diet with highest forage proportion, it was not significantly different from other dietary treatments. The results suggest that the animals on that diet did not suffer depressed respiratory capability and the diet had no effect on circulatory system of the animals. Similarly, the normal Hb concentrations, which were within the physiological range of 80 - 140 g/L indicated by Sirois (22) for goats, suggest absence of microcytic hypochromic anaemia caused by iron deficiency and improper utilization for the formation of Hb. Determination of erythrocytic indices such as MCV, MCH and MCHC is helpful in classifying certain anaemias (24). Except for MCHC which was significantly elevated in 700: 300 g/kg F:C ratio compared to other treatments, the other two erthrocytic indices were similar among treatments. Higher MCHC of goats fed highest forage lowest concentrate ration was due to its relatively higher CT intake than the other diets. This is confirmed by the significant negative correlation between CT intake and MCHC. However, the levels of these erythrocyte indices were within the normal ranges of 16 - 25 fl, 5 - 8 fmol and 28 - 34%, for MCV, MCH and MCHC, respectively, (22). These normal values in all the groups further confirms the absence of anaemia, particularly a hypochromic microcytic type, since the Hb levels of the goats alongside MCV, MCH and MCHC were within the normal physiological ranges. Though WBC and lymphocyte counts were lower in goats fed highest forage lowest concentrate TMR, the occurrence of the values within the normal physiological ranges of 4 - 13 x 10^9 L and 50 - 70%, respectively, (22) ruled out the possibility of leucocytosis, a usual body response to an underlying pathophysiological condition, or leucopenia and lymphocytosis or lymphopenia. This could be an important indication of the health status of the experimental animals and consequently confirms the conjecture that the concentration of CT in the diet was below the level that could have produced intoxication or ill health in the animals. The result suggests that the diet supported haemopoietic tissue with resultant production of adequate leukocyctes. The lower WBC and lymphocyte counts, which were significantly negatively correlated to the CT intake (g/kg BW), respectively, for the goats fed 700:300 g/kg F:C ratio diet may be attributed to the CT intake. Toxic substance in feed tends to suppress haemopoietic tissues with consequent production of low WBC count (4, 25). Depressed leukocyte and lymphocyte counts were previously reported in sheep and goats fed tanniniferous diets (4, 25, 26). The lack of treatment effect on neutrophils, basophils and oesoniphils is in consonance with earlier studies (4).

Plasma or serum clinical chemistry parameters reveal pathophysiological states and, therefore, lead to identification of pathogenesis and causes of disease. The linear increase in plasma urea concentration with increasing concentrate proportion agrees with earlier observations (17, 18, 27), reflecting increased DM intake and thus higher CP intake. The result, however, contradicts that of Olafadehan (4). Increased plasma urea N suggests increased rumen ammonia concentration as the concentrate level increased in the TMR. Lower urea N of 700:300 g/kg F:C ratio may be due to the comparatively higher CT intake, which was negatively significantly correlated to urea N. The serum urea N levels were, however, within the normal established range 3.5 - 10.7 (mmo/L) for goat (22). The insignificantly affected creatinine values, which were within the normal range of 100 – 200 μmmol/L reported for healthy goats by Sirois (22), suggest absence of wasting or catabolism of muscle tissues, and that the animals were not surviving at the expense of the body reserve (28). It appears that increasing the level of tanniniferous FP fodder up to 700 g/kg in the TMR did not have deleterious effect on the lean mass tissue of the growing goats. In agreement with previous reports (17, 18), the linear increase in plasma glucose concentration reflects the increased DM intake with increasing concentrate proportion. Also, this is probably a reflection of the energy status of the diets which obviously would increase with increasing concentrate proportion in the TMR diets. Lower serum glucose level of 700:300 g/kg F:C relative to other treatments could be attributed to higher CT intake which reduced feed intake and

consequently available energy. This conjecture is confirmed by negative significant correlation between CT intake and serum glucose level. However, the normal range of blood glucose level (1.1 - 3.0 mmol/L) (29) tends to suggest that the depressed serum glucose level of goats fed diet containing tanniniferous FP fodder at 700 g/kg in the TMR is not due to hypoglycaemia and tannic acid intoxication. Similar cholesterol levels of all the animals indicate absence of hypocholesterolemia and agree with the findings of Olafadehan (4). The insignificantly varied dietary protein quality indices, which were within the ranges of 56 – 96 g/L and 18.9 – 44.5 g/L for total protein and albulmin, respectively, (29), indicate absence of proteinuria and hypoproteinaemia. The lack of treatment effect on serum proteins of goats on relatively high CT concentration corroborates earlier findings (4, 18). The unaffected serum enzymes (ALT, AST and ALP) among the treatments fell within normal physiological ranges of 7 - 24 IU/L, 43 – 132 IU/L and 7 – 30 IU/L, respectively, (22). This implied no damage to the liver and kidney of the goats, particularly those consuming relatively higher concentration and intake of CT. Serum enzyme activities above the normal ranges are abnormal and are an indication that the animals might have suffered liver and/or kidney damage. These findings agree with earlier observations (4, 30). The insignificantly varied cholesterol values for all the goats further confirmed the absence of hepatocellular damage. The values obtained for Ca, P, K and Na were within established values of 8.8 – 9.8 mg/dl, 4.2 – 7.6 mg/dl, 3.6 – 4.8 mEq/L and 143 -157 mEq/L, respectively, (31). Lack of decrease in serum mineral concentration below the normal values implies that CT intake of 2.10 g/kg, as obtained in 700:300 g/kg F:C ratio, did not interfere with dietary mineral availability and absorption.

CONCLUSION

The impressive voluntary intake, absence of clinical signs of morbidity and tannin intoxication symptoms, and the normal physiological values of the haematological and biochemical indices suggest that tanniniferous *F. polita* fodder can be incorporated up to 700 g/kg in a TMR containing 300 g/kg concentrate without posing any danger to the health of goats. It is concluded that tannins intake of 2.10 g/kg BW, as obtained in 700:300 g/kg F:C ratio, was well tolerated by goats.

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