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Growth performance and blood parameters of West African dwarf rams fed dried *Ficus thonningii* foliage as supplement to high quality cassava peel

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Abstract: *The study aimed to determine the response of West African dwarf (WAD) rams to dried Ficus thonningii (DFT) foliage as supplement to high quality cassava peel (HQCP). A feeding trial was conducted with 20 WAD rams assigned to four dietary treatments. Treatments consisted of HQCP as a sole diet offered* ad libitum *(T1) or supplemented with DFT foliage at 20(T2), 40(T3), and 60 per cent(T4). Feed intake and apparent digestibility coefficients of dry matter, crude protein, ether extracts, neutral detergent fibre, and acid detergent fibre were highest ($P < 0.05$) in rams fed 60 per cent DFT foliage and least for those fed the control diet. Rams fed the diet with DFT foliage gained weight while those in the control group lost weight. The highest gain was recorded in rams with 60 per cent of DFT foliage in the diet (42.38 g/day). The values for blood parameters were high in rams fed 60 per cent DFT foliage: 5.00 per cent, 6.15 g/dl, and 2.80 g/dl for monocyte, total protein, and globulin, respectively. These values for blood parameters except lymphocyte were within the normal range for healthy sheep production. The study concluded that DFT foliage fed up to the 60 per cent level with HQCP improved the total dry matter intake, nutrient digestibility, body weight, and blood parameters of the WAD rams. However the low lymphocyte count can be improved by giving the WAD rams the right treatment.*

Keywords: dried *Ficus thonningii* foliage, WAD ram, live weight gain, blood parameters

Small ruminants play a significant role in the food chain and overall livelihoods of smallholder farmers (Shittu et al., 2008). The rams in particular are favourite slaughter animals during Sallah festivals at which time rams command very high market prices (Oni, 2002). In spite of this importance a major problem for their improved production in tropical Africa is the unavailability of good quality feed or forage throughout the year. This is the main factor responsible for lower reproductive

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and growth performance, especially during the dry season (Legesse, 2008). The dry season is characterized by inadequacy of grazing resources as a result of which animals are not able to meet even their maintenance requirements and lose a substantial amount of their weight. According to Devendra (1987), there are three aspects of the feed problem: namely, the issue of increasing the efficiency with which the available feed is utilized (e.g. forages, crop residues, agro-industrial by-products and non-conventional feeds), the inability to make maximum use of the limited total feed resources, and the inadequate supplies of feed.

Cassava peel is an agro-industrial by-product which continues to be available in appreciable quantity in Nigeria, but most of it is disposed of as waste, thereby contributing nuisance to the environment (Ubalua, 2007). Several researchers have confirmed the suitability of cassava peel as a good source of energy in the ruminant diet but its widespread utilization is limited due to problems related to the high content of cyanogenic glucosides, concomitant rapid rate of deterioration as a result of high moisture content (Unigwe et al., 2014), and its low crude protein content. Past efforts to address the setbacks of cassava as ruminant feed have been based on preservation methods which include: soaking, boiling/cooking, fermentation, ensiling, and drying. Of all these methods, drying is the oldest and still the most important preservation method despite its dependence on suitable weather. It can be done with simple equipment and low costs other than labour; hence many small-scale farming systems adopt drying to ensure livestock feed through the lean season. Drying is practically impossible during the wet season (the period when cassava peel is produced in huge amounts) and it takes two to three days in the dry season to reduce the moisture content of fresh peels from about 60 per cent to 20 per cent or less – a marketable state (Okike et al., 2015). Therefore drying is more feasible and effective during the dry season of the year (Adesehinwa et al., 2011). Unlike other roots and tubers, cassava is a highly perishable commodity. In order to further explore the benefits from cassava as a ruminant feed resource as well as increase its use as a feed ingredient it must be processed into a stable product to increase the shelf life (preserve excess produce in the wet season for dry season feeding), facilitate transportation and marketing, reduce cyanide content, and improve palatability. The low nutritional status of cassava, especially the crude protein (CP) content, calls for a supplementary source of nitrogen.

Scientists at the International Livestock Research Institute developed a novel technology for processing the wet cassava peel into a new product called high quality cassava peel (HQCP) (Okike et al., 2015). The technology dramatically reduced the drying time of the fresh peel from two to three days to about six hours, resulting in improvement of the product in terms of quality and quantity (Okike et al., 2015). This new product coupled with browse trees, which are available as a cheap protein supplement, can be used to bridge the feed scarcity gap during the dry season and farmers can get good returns.

Indigenous browse species contribute significantly to agro-biodiversity in developing countries; however, the level of utilization of indigenous browse species for improving quality of fibrous feedstuff is low compared with improved forage species and processed feed (Balehegn and Eniang, 2009). Research efforts have focused on

the use of browse species like *Gliricidia sepium*, *Leucaena leucocephala*, *Phyllanthus discoideus* (Osakwe et al., 2000; Fasae et al., 2005), *Grewia pubescens* (Arigbede et al., 2005), *Danielli oliveri* (Osakwe et al., 2004), *Terminalia cattapa* and *Acalypha wilkesiana* (Esugbohungbe and Oduyemi, 2002), *Tephrosia* spp. (Babayemi et al., 2002), *Pterocarpus santalinoides* and *Enterolobium cyclocarpum* (Arigbede et al., 2005) as supplements to grass based diets or crop residues in the feeding of ruminants.

Ficus thonningii is a neglected and underutilized indigenous browse fodder species. In areas where it is used, farmers have appreciated its diverse merits such as: acceptable nutritive content (Berhe and Tanga, 2013), high biomass production (Balehegn et al., 2012), fast growth rate, easy propagation, drought resistance, and adaptation to diverse edaphoclimatic conditions (Balehegn and Eniang, 2009).

In Nigeria, *Ficus thonningii* forms an integral part of the home garden system serving as an ornamental plant and a source of shade. Generally the utilization of browse fodders is usually limited by high lignin content and the presence of anti-nutritional factors which may be toxic to ruminants (Sanon, 2007); however their utilization can be improved if the fresh forage is wilted or dried before feeding (De Kock, 2001). This study therefore aims to furnish basic information on the suitability of dried *Ficus thonningii* (DFT) foliage in the West African dwarf (WAD) ram diet and the optimal level of supplementation of foliage with high quality cassava peel (HQCP) on WAD ram growth performance, haematology, and serum biochemical indices.

Materials and method

Location and climate of study area

The study was conducted in the Small Ruminant Experimental Unit, College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta (FUNAAB) Nigeria. Abeokuta is located 76 m above sea level, falls within latitudes 7° 5.5′–7° 8.0′ N and longitudes 3° 11.2′–3° 12.5′ E. The climate is humid and is located in the derived savannah zone of south-western Nigeria. It receives a mean annual precipitation of 1,037mm, mean annual temperature of 34.7°C and mean relative humidity of 82 per cent (source: Agro Meteorology Department, FUNAAB).

Sources of feed materials

Foliage (leaf blade + twig) of DFT was harvested by pruning the branches of the tree from the University environs. The harvested fresh foliage was wilted in the sun for three to four hours (Photo 1) and dried under shade to avoid bleaching and loss of nutrients. The air-dried foliage was then packed in polythene bags and stored (Photo 2).

The HQCP was obtained from the Cassava Peel Processing Demonstration Factory of International Livestock Research Institute (ILRI) within International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (Photo 3).

Photo 1 Wilting of harvested fresh foliage in the sun

Experimental animals and their management

Twenty WAD rams aged 10–12 months with a mean body weight in the range 14–15 kg purchased in a local market within Abeokuta in Ogun State were used for the experiment. The rams were adapted to the experimental area for 21 days during which they were dewormed and administered medications to improve their immune system. During adaptation all rams were fed HQCP supplemented with cowpea haulms and fresh water offered *ad libitum*.

Photo 2 Dried foliage in polythene bags

After adaptation, animals were housed intensively in well-ventilated individual pens (2-m^2 floor space) in an open-side type of house with corrugated aluminium roofing sheets and wooden slatted floor. The animals were allowed a 14 day adjustment period in the experimental pen during which time they were fed experimental diets in order to get them adapted to the feeds prior to the commencement of the actual experiment (Photo 4).

Photo 3 Bags of HQCP obtained from ILRI

Experimental treatments, design and feeding of animals

The 20 experimental animals were divided into four groups of five rams, balanced for body weight and randomly allotted to the experimental dietary treatments in a completely randomized design.

DFT foliage was offered as supplement to HQCP at graded levels of 0, 20, 40 and 60 per cent, and each supplemental level served as treatment T1, T2, T3, and T4, respectively. The control diet (T1) was enriched with 2 per cent urea (to satisfy the minimum protein requirement for optimum rumen microbial functions). The urea was dissolved in water following the procedure of Finangwai and Dafur (2015) and the solution sprinkled over the peels and mixed thoroughly before feeding.

Photo 4 Ram in a pen feeding on the experimental diet

The daily feeding of the supplementary diet (DFT foliage) was offered at 3 per cent of the animal body weight at 09.00 and the basal diet (HQCP) and fresh water was offered *ad libitum* an hour later in a separate feeding trough.

Data collection

The body weights of the animals were taken at the beginning of the experiment and on a weekly basis before feeding in the morning. The feed offered and feed refusal were also taken to compute the feed intake. At the end of the feeding trial, the animals were transferred into metabolic cages for a digestibility trial which lasted for 7 days. Subsamples of daily feed offered, refusals, and faeces voided per ram was collected and weighed. At the

end of the collection period, the faeces collected from each ram over the period were thoroughly mixed, and two subsamples were taken. One of the samples was used for estimating dry matter by oven-drying at 105°C for 24 hours, while the second sample was oven-dried till a constant weight was attained and milled for chemical analysis.

Blood samples (5 ml) were collected from the jugular vein of each experimental animal in the morning prior to feeding on the first day and last day of the trial using hypodermic syringes into sample bottles containing anticoagulant, ethylene-diaminetetraacetic acid (EDTA), for the determination of haematological parameters which include: red blood cell (RBC), lymphocyte, neutrophil, monocyte, eosinophil, mean corpuscular haemoglobin (MCH), and mean cell volume (MCV). Another 5 ml was emptied into plain bottles without anti-coagulant for the serum analysis: namely, total protein, albumin, globulin, glucose, urea and creatinine.

Chemical analysis

The proximate composition of the feeds and faeces was determined (AOAC, 1995). The dry matter was determined by oven drying at 65 °C for 24 hours, crude protein (CP) by the Kjeldahl method, and fat by the Soxhlet fat extraction method. The concentration of neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) both in feed and faecal samples were also determined by the method of Van Soest and Robertson (1985). The metabolizable energy was calculated using the formula

$$\text{ME (MJ/kg DM)} = 13.5 - 0.15 \times \text{ADF\%} + 0.14 \times \text{CP\%} - 0.15 \times \text{Ash\%}$$

according to MAFF (1984: 85).

Tannin content was determined using the Vanillin-HCl method as described by Price and Butler (1977). Phytate content was determined by the photometric method of Latta and Eskin (1980). Oxalate was estimated using the methods of Munro (2000). Saponin content was determined according to the methods of Obdoni and Ochuko (2001). Hydrocyanide content was determined by the alkaline titration method (AOAC, 1995).

Statistical analysis

Data collected were subjected to one way analysis of variance in a completely randomized design (SAS, 2002). Significant means were separated using the Duncan multiple range test (Duncan, 1955).

Results and discussion

The chemical composition of the experimental diets is shown in Table 1. The high dry matter content and the difference in the proximate composition of the DFT foliage used in this study compared to past reports (Bamikole and Ikhatua (2010), Bamikole et al., 2004, Ajayi et al., 2005 and Balehegn and Hintsa (2015) could be attributed to the season, stage of maturity at lopping, drying process and proportion of leaf to stem in the foliage. The dry matter content of DFT foliage

Table 1 Chemical and proximate composition of experimental diets

Parameters	*Proximate composition (%)*		
	DFT foliage	*HQCP*	*HQCP + urea*
Dry matter	90.00	90.00	87.53
Organic matter	87.62	97.30	96.28
Crude protein	10.12	1.99	10.35
Ether extract	12.60	0.67	4.35
Ash	12.38	2.70	3.72
Non fibre carbohydrate	27.11	72.14	55.71
Fibre fractions			
Neutral detergent fibre	37.80	22.50	19.53
Acid detergent fibre	20.40	14.40	13.09
Acid detergent lignin	6.00	7.80	6.51
Hemicellulose	17.40	8.10	6.44
Cellulose	14.40	6.60	6.58
ME (MJ/Kg/DM)	9.99	11.21	12.43
Anti-nutritional factors			
Tannin (mg/100g)	5.60	4.80	4.00
Saponin (%)	4.00	4.50	4.00
Phytate (mg/100g)	0.46	0.23	0.21
Oxalate (mg/100g)	8.80	5.94	4.84
Hydrocyanide (mg/kg)	–	1.32	1.02

Note: DFT: dried *Ficus thonningii*, HQCP: high quality cassava peel

(90.00 per cent) obtained in this study was higher than 40.61 per cent (Tegbe et al., 2006, 44.64 per cent (Berhe and Tanga, 2013) and 78.62 per cent reported by Yousuf and Ogundun (2005) for shed *F. thonningii* leaves.

The crude protein content (10.12 per cent) recorded for DFT foliage was low compared with 18.51 per cent reported by Tegbe et al. (2006) and 14.7 per cent reported by Bamikole et al. (2004) but still in line with the report of Roothaert (2000), who observed a much lower value and indicated that there were differences in the crude protein contents of tree foliage between agro-ecologies and seasons. Crude protein is an important requirement that supports optimum microbial growth in the rumen and the crude protein content observed for DFT foliage in this study exceeded the critical level of 7 per cent CP (McDonald et al., 1981) and 6 per cent CP for tropical forages (Minson, 1990) at which the feed intake of the animal is depressed.

The values for ether extract and ash recorded for DFT in this study were higher than the values reported by Tegbe et al. (2006) and Berhe and Tanga (2013). On the other hand, the values for NDF and ADF were lower than those reported by Yousuf and Ogundun (2005). The ADL value was also lower than the 7.78 per cent reported

by Yusuf and Muritala (2013). The nutrient content of DFT foliage in this study was further compared with nutritional contents of different tree fodder foliages in the study by Lukhele and Van Ryssen (2003) and differences were observed in the compared parameters (crude protein, neutral detergent fibre, acid detergent fibre, acid detergent lignin, ether extract, and tannin). These differences observed (not based on statistical analysis) could be due to the environmental variation in the agro-ecology of existence of the tree fodders, the stage of maturity of harvest of foliages for nutritional analysis, species differences of trees, or mode of preservation, or improvement of foliage.

The high dry matter content (90.00 per cent) observed for the HQCP in this study was a result of drying. In addition, its low nutritive value compared with the whole cassava peel (Bawala et al., 2007; Sogunle et al., 2009; Kortei et al., 2014; Lukuyu et al., 2014) was a result of the processing method.

Changes that were observed in the nutrient composition of HQCP after it was enriched with urea (HQCP +urea) could be attributed to the contributive effect of the nitrogen from urea, which is known to contain about 45 per cent nitrogen.

The metabolizable energy values recorded for DFT foliage in this study were higher than the 5.80 MJ/kg DM for *F. thonningii* reported by Ogunbosoye and Babayemi (2010). On the other hand, metabolizable energy of HQCP and HQCP+urea was lower than the 15.06 MJ/kg DM reported for cassava peel by Bawala et al. (2007). It was observed in this study that the diets with higher fibre level recorded the lowest values of metabolizable energy. Metabolizable energy is a good index for measuring the quality of feeds, particularly forages and the values recorded in this study were within the recommended levels (6–13 MJ/kg DM) for maintenance and production for small ruminants (Steele, 2006).

The higher values of anti-nutritional factor contents observed for DFT foliage compared with HQCP were similar to the report of Isah et al. (2011) who reported higher values of anti-nutritional factor in browse species than agro by-products. The tannin (5.60 per cent), saponin (4.00 per cent), and oxalate (8.80 per cent) contents recorded for DFT foliage in this study were higher than the values reported by Nkafamiya and Manji (2006) for *Ficus sycomorus*. On the other hand, phytate (0.46 mg/100 g) content in this study was lower than the 1.98 mg/100 g reported by the same author. The variation in this anti-nutritional factor could be as a result of the species, stage of maturity, and part of foliage of the *Ficus* used in this study.

The anti-nutritional factors recorded for HQCP in this study were generally low compared with those reported in the literature (Adegbola et al., 1990; Bawala et al., 2007). This could be attributed to the effect of processing of the peel and further reduction observed in HQCP +urea could have been due to its enrichment with urea.

Anti-nutritional factors are compounds which reduce the nutrient utilization in feed and they play a vital role in determining the use of plants by animals (Soetan and Oyewole, 2009). The levels of anti-nutritional factors obtained in this study were within the range which is not likely to affect the nutritional potential of the diet. According to Bamikole et al. (2001), *Ficus* species have low anti-nutritional factor contents and are well accepted by the animals. It was reported by Ogbonna (1991) and Taiwo et al. (2003) that cassava peels do not contain any chelating agents

Table 2 Performance indices of WAD rams fed different levels of DFT foliage

Parameters	*Treatment (% DFT foliage)*				*SEM*
	0	*20*	*40*	*60*	
DMI of DFT foliage (g/day)	0.00^{d}	58.09^{c}	90.87^{b}	137.16^{a}	4.40
DMI of HQCP (g/day)	247.94	258.90	225.82	239.83	28.32
Total DMI (g/day)	247.94^{b}	316.99^{ab}	316.69^{ab}	377.00^{a}	31.18
Average initial weight (kg)	14.84	14.20	14.49	14.33	0.16
Average final weight (kg)	12.49	17.20	17.49	17.89	0.16
Average weight gain (kg)	2.35^{c}	3.00^{b}	3.00^{b}	3.56^{a}	0.01
Average daily weight gain (g)	27.98^{c}	35.71^{b}	35.71^{b}	42.38^{a}	1.71
Metabolic weight ($W^{0.75}$)	–	14.71^{b}	14.71^{b}	16.61^{a}	0.51

Note: SEM: standard error of the mean
^{abc}: Means along the same rows with different superscripts are significant ($p < 0.05$).

(such as phytate, tannin, silica, or lignin) that can bind the nutrients and also the hydrocyanide recorded was well below the lethal dose of 2.0–4.0 mg per kg body weight reported for cattle and sheep in the literature.

Dry matter intake (DMI) increased with increasing level of DFT foliage in the diets, despite the lack of any difference in the intake of HQCP (Table 2). Consequently, the DFT foliage functioned as a true supplement and there was no substitution of HQCP. The slightly higher feed intake of 316.99 g/day observed at 20 per cent DFT foliage, though similar ($P > 0.05$) to the intake of 316.69 g/day for rams fed 40 per cent DFT foliage, could be a means of compensatory mechanism for the ram to meet its requirement at a lower level of the DFT foliage supplementation. This observation corroborated the report of Obioha et al. (1984) that diets low in energy make the animal consume more feed in order to meet their energy requirement.

Rams fed 60 per cent DFT foliage as supplement had a higher ($P < 0.05$) value (377.00 g/day) of feed intake while those fed zero per cent had the lowest value (247.94 g/day). This observation can be explained by the improved supply of both N and readily available carbohydrates to the ruminal microbes which increased the rate of degradation of the basal diet, microbial growth and the fractional outflow of liquid matter from the rumen (Aregheore and Perera, 2004a). Bawala et al. (2007) also reported an increase in total dry matter intake when cassava peel was supplemented with rumen epithelial waste and opined that increased CP content of the diet could be responsible for increased intake of feed in the animals.

Supplementing a low to medium quality forage with degradable protein in the form of forage legumes often results in improved growth performance in ruminants (Mupangwa et al., 2000). The highest average daily gain, however, will be obtained by supplementation with both forage legumes and an energy source (Aregheore and Perera, 2004a,b). In this study all rams fed DFT foliage gained weight while those on solely HQCP lost weight.

Rams fed 60 per cent DFT foliage had the highest ($P < 0.05$) average daily gain (42.38 g) followed by a similar value of 35.71 g for rams fed 20 and 40 per cent DFT foliage, and the lowest ($P < 0.05$) value of 27.98 g for rams fed the control diet. The variations

Table 3 Apparent nutrient digestibility coefficients (%) of WAD rams fed different levels of DFT foliage

Parameters	*Treatment (% of DFT foliage)*				*SEM*
	0	*20*	*40*	*60*	
Dry matter	65.34^{d}	71.08^{b}	66.24^{c}	71.82^{a}	1.58
Crude protein	45.97^{d}	58.32^{b}	66.05^{b}	69.97^{a}	4.07
Ether extract	29.98^{c}	38.06^{bc}	46.24^{b}	59.97^{a}	1.43
Ash	29.82^{d}	38.41^{c}	43.16^{b}	52.67^{a}	0.23
Neutral detergent fibre	50.65^{c}	62.55^{b}	60.15^{c}	66.84^{a}	3.30
Acid detergent fibre	51.06^{d}	54.61^{c}	60.73^{a}	67.64^{a}	0.54
Acid detergent lignin	24.41^{d}	35.35^{c}	38.29^{b}	47.80^{a}	1.01

Note: SEM: standard error of the mean
^{abcd}: Means along the same rows with different superscripts are significant ($p < 0.05$).

in average daily gain of the experimental rams could therefore be attributed to variation in nutrient supply from the diets (Oddy and Sainz, 2002). The highest average daily gain obtained at 60 per cent DFT foliage supplementation could be due to efficient feed utilization occasioned by the DFT foliage which induced significantly higher dry matter and crude protein consumption in these rams.

The reduction in live-weight growth of rams fed solely HQCP was not unexpected as it has been reported in the literature that animals cannot meet their maintenance need on grass or cassava peels alone but require supplementary diets for higher physiological performance (Adegbola et al., 1985). This observation therefore reveals the evidence of the feed value of browse fodder (DFT foliage) as being superior to urea as a sole supplement to low quality crop by-products.

Results showed that digestibility values differed ($P < 0.05$) among the treatments (Table 3). Protein contents of diets supplemented with DFT foliage played a significant role in improving digestibility and this supports the fact that digestion of feed in ruminant animals is highly influenced by the level of protein and fibre in the diet (Peyraud and Astigarraga, 1998). In this study it was observed that increasing consumption of DFT foliage resulted in an improvement in apparent digestibility of dry matter, crude protein, neutral detergent fibre, acid detergent fibre, and acid detergent lignin. Fasae et al. (2014) observed similar improvements in apparent digestibility when West African dwarf sheep were fed forage legume supplemented with maize cobs.

There were differences ($P < 0.05$) in the blood parameters of WAD rams fed experimental diets (Table 4). Except for lymphocyte, all values were within the normal range for healthy sheep. Also note, the normal range of blood parameters presented in Table 4 were based on the Merck Manual (2012). Blood is an important and reliable medium for assessing the health status of animals (Ramprabhu et al., 2010). The comparison of an animal's haematologic and biochemical values with a reference interval provides evidence for numerous conditions such as infection, malnutrition, and stress (Clifford and Briggs, 2007); hence, laboratory tests on blood are vital tools to detect any deviation from the normal in the animal body (Alemede et al., 2010). Togun et al. (2007) reported that when the haematological values fall within the normal range reported for the animal it is an indication that diet did not have any adverse effect on haematological

Table 4 Blood parameters of WAD rams fed different levels of DFT foliage

Parameters	*Normal range*		*Treatment (% of DFT foliage)*				*SEM*
			0	*20*	*40*	*60*	
Haematology							
RBC (10^{12}/L)	9.00–15.00	Initial	8.26^{c}	10.20^{b}	8.07^{c}	11.88^{a}	0.41
		Final	10.37^{b}	11.00^{ab}	9.77^{c}	11.98^{a}	0.30
		Difference	2.11^{a}	0.80^{ab}	1.70^{b}	0.10^{b}	0.42
Lymphocyte (%)	40.00–75.00	Initial	59.00^{b}	34.00^{b}	36.50^{c}	54.00^{b}	1.17
		Final	31.00	38.00	35.00	34.50	2.74
		Difference	–28.00^{c}	4.00^{a}	1.50^{a}	19.50^{b}	3.91
Neutrophil (%)	10.00–50.00	Initial	30.00^{d}	68.00^{a}	56.50^{b}	39.00^{c}	0.84
		Final	65.00	58.50	60.50	57.00	3.07
		Difference	35.00^{a}	10.00^{c}	4.00^{c}	18.00^{b}	2.91
Monocyte (%)	0.00–6.00	Initial	3.00^{b}	2.00^{c}	1.00^{d}	5.00^{a}	0.22
		Final	6.00^{a}	3.00^{b}	3.00^{b}	5.00^{a}	0.22
		Difference	3.00	1.00	2.00	0.00	0.41
Eosinophil (%)	0.00–10.00	Initial	1.00^{b}	1.00^{b}	2.00^{a}	2.00^{a}	0.11
		Final	3.00^{a}	1.00^{c}	1.50^{b}	2.00^{b}	0.17
		Difference	2.00^{a}	0.00^{b}	0.50^{c}	0.00^{b}	0.06
MCH (%)	8.00–12.00	Initial	8.35^{c}	8.95^{c}	9.65^{a}	9.40^{ab}	0.12
		Final	9.45	9.50	9.45	9.55	0.16
		Difference	0.60^{a}	0.55^{a}	-0.20^{b}	0.15^{ab}	0.18
MCV (%)	28.00–40.00	Initial	28.30^{b}	30.10^{a}	31.30^{a}	30.40^{a}	0.40
		Final	31.05^{bc}	31.45^{b}	32.45^{a}	29.80^{c}	0.68
		Difference	2.75^{c}	1.35^{b}	1.15^{b}	0.60^{a}	0.28
Serum biochemistry							
Total protein (g/dl)	5.90–7.80	Initial	6.45^{b}	7.50^{a}	5.95^{b}	6.55^{b}	0.18
		Final	4.40^{c}	5.30^{b}	4.70^{c}	6.15^{a}	0.14
		Difference	2.05^{b}	2.20^{b}	1.25^{ab}	0.40^{a}	0.32
Albumin (g/dl)	3.20–5.00	Initial	2.80^{b}	2.65^{b}	3.30^{a}	3.60^{a}	0.12
		Final	2.40^{c}	4.00^{a}	2.90^{ab}	3.35^{bc}	0.17
		Difference	0.40^{b}	1.35^{a}	0.40^{b}	0.25^{b}	0.25
Globulin (g/dl)	2.70–2.80	Initial	3.65^{b}	4.85^{a}	2.65^{c}	2.95^{bc}	0.27
		Final	2.00^{b}	1.30^{d}	1.80^{c}	2.80^{a}	0.03
		Difference	1.65^{b}	3.55^{c}	0.85^{a}	0.15^{a}	0.23
Glucose (mg/dl)	44.00–81.00	Initial	72.00^{b}	88.50^{a}	86.00^{a}	76.00^{b}	2.07
		Final	79.00^{c}	104.00^{a}	85.00^{bc}	90.50^{b}	0.01
		Difference	7.00^{ab}	15.50^{b}	1.00^{b}	14.50^{a}	4.36

(Continued)

Table 4 (Continued)

Parameters	*Normal range*		*Treatment (% of DFT foliage)*				*SEM*
			0	*20*	*40*	*60*	
Urea (mg/dl)	10.00–26.00	Initial	10.55^{b}	11.70^{b}	11.75^{b}	15.85^{a}	0.36
		Final	14.05^{a}	12.30^{b}	10.90^{c}	11.70^{bc}	0.29
		Difference	3.50^{a}	0.60^{b}	0.85^{b}	4.15^{c}	0.65
Creatinine (mg/dl)	0.90–2.00	Initial	1.35^{b}	1.15^{b}	2.15^{a}	1.70^{ab}	0.17
		Final	2.10^{a}	1.50^{b}	2.25^{a}	1.40^{b}	0.12
		Difference	0.75^{a}	0.35^{ab}	0.10^{c}	0.30^{c}	0.16

Note: SEM: standard error of the mean
^{abc}: Means with different superscripts letters along the row are significantly different ($P < 0.05$)

parameters during the experimental period. However, when the values fall below the normal range, it is an indication of anaemia.

The values of red blood cell (RBC) counts observed in this study were higher than the range of values (2.3–3.3×10^{6}/µl) reported by Hyelda et al. (2017) for red Sokoto goat and the value of 2.7±0.1×10^{6}/µl reported by Opara et al. (2010) and 1.80±0.9–2.10±1.2 ×10^{6}/µl values reported by Okunlola et al. (2015). The highest RBC counts observed for rams fed 60 per cent DFT foliage could be linked to the high iron and zinc profile of the browse forage as well as the crude protein content of the forage. This observation was in line with the report of Adeyemi et al. (2008) who reported that red blood cells and haemoglobin are positively correlated with protein quality and protein level in the diet and that any decrease in the red blood cell counts could be associated with protein deficiency in the diet.

Neutrophils and eosinophils counts recorded across dietary treatments in this study were within the range obtained by Maigandi et al. (2003) and Taiwo and Ogunsanmi (2003). The neutrophils values recorded were higher than the result of (38.50± 3.76 per cent) obtained for Red Sokoto goat and (39.46±3.89 per cent) for West African dwarf goats reported by Ezenwenyi (2011). Lymphocytes are known to play key roles in the immune defence system of both humans and animals (Ameen et al., 2007). The lymphocyte count observed for rams in this study, which were not within the range recommended for healthy sheep, could be attributed to stress and immune response to the environment (Kannan et al., 2000), which harbours various detectable parasitic and or bacterial organisms. The lymphocytes values observed were lower than the range of 40–70 per cent reported by NseAbasi et al. (2014). The values of MCH and MCV recorded were within the normal range for healthy sheep.

Serum biochemistry is a generalized medium of assessing the health status of animals. The observed values of some of the initial and final serum biochemical parameters of the WAD rams in this study, which fell within the normal range, indicated the positive effect of diets on health of the rams. On the other hand, the decrease observed in the final serum parameters of the rams could be associated with the experimental diets (sole forage) which could be inferior to what the rams were fed prior to purchase.

The values of total serum protein observed at the end of the experiment were comparable to the values of 5.41±0.06 and 5.77±0.09 g/l for West African dwarf goats

and Sokoto Red goats reported by Ezenwenyi (2011), the mean value of 6.3±0.7 g/l reported by Oduye and Adadevoh (1976) for West African dwarf sheep, and the value of 4.4±1.5 g/l reported by Tambuwal et al. (2002) for Sokoto red goats. Daramola et al. (2005) reported a higher mean value (7.1±0.1 g/l) for West African dwarf goats (note: values were not converted to the same unit as the values of this study). The highest serum protein observed for WAD rams fed 60 per cent DFT foliage could be ascribed to the nutrient status of the diet as supported by Akinwunmi and Oke (2002) and Babayemi et al. (2003), that the higher the values of the total protein the better the quality of the ingredients and that total protein of an animal is a reflection of the state of the animal. Serum proteins are important in osmotic regulation, immunity, and transport of several substances in the animal body (Jain, 1986) and reflects good performance characteristics of the animals. The final globulin values obtained across dietary treatments were low except for the 60 per cent DFT treatment. The low values observed may suggest compromised immune systems of the rams since globulin is involved in the immune system (Charles, 2001).

The significant differences observed in the final albumin and glucose values across dietary treatments, with the 20 per cent DFT foliage recording the highest, could be related to the nutrient occasioned by the diet. Albumin is the most abundant protein in the blood and accounts for 50 to 60 per cent of the total blood protein content (Contreras et al., 2000). It is also an important constituent of protein metabolism and a relevant indicator of the protein nutritional status (Agenas et al., 2006).

Glucose concentration after the trial at the 20 per cent DFT foliage supplementation was higher than for other diets. This could be due to increased carbohydrate metabolism as a result of higher dry matter intake of the HQCP by rams on this treatment which confirmed the report of Hadley (1984) that high intake of energy supply increased serum glucose concentration. Furthermore, the difference in glucose concentration could also be as a result of levels of nutrition and the metabolic activity of individual animals (Devendran et al., 2008).

Blood urea is necessary for proper functioning of the kidneys and liver of the animals. The diets in this study did not significantly affect the final urea levels in the serum of the WAD rams, thus indicating the safety of the dietary treatment. The higher blood urea value observed in rams fed zero per cent DFT foliage indicated inferior protein quality compared with rams fed the DFT diet (Eggun, 1970).

The creatinine values observed in this study were within the normal range across dietary treatments even though the difference between final and initial values was highest and lowest in the control and in the diet with 60 per cent DFT foliage, respectively. Creatinine is a chemical waste molecule that is generated from muscle metabolism. According to Prvulovic et al. (2012) creatinine level in serum has a direct correlation with muscle mass and kidney function in animals.

Conclusion

Based on the findings of this study: DFT foliage was acceptable to the WAD rams and feeding it as a supplement up to 60 per cent of dry matter intake improved total DMI, digestibility of nutrients, and body weight and did not pose any threat

to the blood parameters of the WAD rams except for lymphocyte. The threat to the lymphocyte count can be improved by subjecting the WAD rams to less stress or administering the right treatment to boost the immune system.

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